Increasing Market-oriented Vegetable Production in Central Asia and the Caucasus through Collaborative Research and Development

Workshop Proceedings; 25–27 April 2005; Tashkent, Uzbekistan

C. George Kuo,
Ravza F. Mavlyanova,
and Thomas J. Kalb, editors

AVRDC
The World Vegetable Center

CGIAR
CAC–PFU
INCREASING MARKET-ORIENTED VEGETABLE PRODUCTION IN CACII
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Foreword

Central Asia and the Caucasus (CAC) has been encountering many challenges after the collapse of the Soviet Union. Transition from large collective and state farms to small privately owned farms mean that the entire vegetable system, including research and development (R&D), in these CAC countries must be reorganized in order to be responsive and effective in the economic transition. As well, national agricultural leaders’ mentalities, objectives, procedures, processes, and programs of the vegetable systems that were centrally planned during the former Soviet Union must be re-oriented to those that serve national needs and a demand-driven economy. In this connection, the impressive national agricultural research system (NARS) that was cloistered in the former Soviet Union needs to evolve and extend its partnership with a wider world.

From a different angle, the CAC region as a whole provides diverse agro-ecological conditions for complementary vegetable production by different CAC countries. Also the region is the center of origin for many important vegetable crops, including onion, spinach, carrot and melons. Collection, improvement and utilization of indigenous genetic resources will have a great impact on the overall development in the region. Furthermore, globalization, trade liberalization and the increased demand for diverse vegetables in European Union, West Asia, South Asia, East Asia and North Africa are creating new market opportunities for vegetable producers and processors in the CAC region.

With the above as a background, AVRDC – The World Vegetable Center has initiated targeted programs in the CAC region. AVRDC is pleased to join the CGIAR Collaborative Research Program for Sustainable Agriculture Development in Central Asia and the Caucasus. Through this alliance, we look forward to working closely with the CGIAR, NARS, development organizations and interested donors to improve the livelihoods of people in the CAC region. And to strengthen this alliance, we have opened an office in Tashkent in collaboration with the CGIAR-CAC Program (www.icarda.org/cac). Also AVRDC has sponsored a workshop for vegetable scientists in Central Asia in 2003 (www.avrdc.org/pdf/cac.pdf).

Given the constraints in resources in each of the CAC countries, mutual advantage and benefit can be gained in acting in concert, in sharing and in collaboration with each other within and outside the region in trying to advance the production, consumption and marketing of vegetables, and the development of improved varieties and commercial seed production in the region. Under this moving spirit and philosophy, AVRDC was proud to organize the workshop on “Improved Income and Nutrition in Central Asia and the Caucasus through Enhanced Market- and Trade-oriented Vegetable Systems Research and Development” in Tashkent, Uzbekistan, 25–27 April 2005, in collaboration with the Program Facilitation Unit of the CGIAR-CAC Program. The presentations at the workshop encompassed a range of issues from the socio-economic context of vegetable systems, natural resources for vegetable growing, production and consumption of vegetables, and the status of research and development efforts in CAC countries. Combined with the other resource papers, this proceedings presents a broad picture of the
vegetable sector and collaborative research opportunities in CAC. Given the shortage of published information on the vegetable sector in the eight CAC republics, especially in English, this publication will serve as a useful benchmark document for some time to come. I hope the publication will be of interest not only to policymakers and researchers in the vegetable system, but also to anyone with an interest in the overall development of the CAC region.

Thomas A. Lumpkin
Director General
AVRDC – The World Vegetable Center
Acknowledgements

AVRDC – The World Vegetable Center and the Program Facilitation Unit (PFU) of the Consultative Group on International Agricultural Research (CGIAR) Collaborative Research Program for Sustainable Agriculture Development in Central Asia and the Caucasus are grateful to the Asian Development Bank (ADB), the German Technical Cooperation Agency (GTZ), the Japan International Cooperation Agency (JICA), and the Ministry of Foreign Affairs of the Republic of China (Taiwan) for providing the financial resources to hold this important workshop, and to publish and distribute this proceedings. Special thanks go to the Honorable Abdushukur Khonazarov, Deputy Minister of Agriculture and Water Management, the Republic of Uzbekistan, for officially opening the workshop. Moreover, both AVRDC and PFU are grateful to all participants for sharing their expertise in presentations and candid opinions in deliberations. Their contributions made this workshop successful.

Special thanks go to Ms. Kitty Hong of AVRDC headquarters for handling the administrative and financial matters of the workshop, and Ms. Sumbula Mukhammadieva of AVRDC Regional Office for Central Asia and the Caucasus, and the PFU secretariat staff for their secretarial support of the workshop.

Thanks are extended to the authors of the papers in this document as well as the researchers who have provided valuable survey data. We also recognize Ms. Elena Pashkova and Mr. Artur Ambartsumyan for their help in the translation of Russian papers into English, and English papers into Russian. A word of thanks is due to staff of AVRDC’s Communication and Training Office and International Cooperation Office for their various aspects of support in the workshop and publication of this proceedings, especially Ms. Kitty Hong, who spent considerable efforts on improving papers translated from Russian and typesetting of the Russian version of this proceedings, and Mr. Chen Ming-che, who put the final touches to the map and photo galleries and for designing the cover.
Map of Central Asia and the Caucasus
Summary and Recommendations

Ravza Mavlyanova and George Kuo

The purposes of this regional consultation workshop, held on 25–27 April 2005 in Tashkent, Uzbekistan, were to 1) review recent developments in the vegetable system, particularly as regards to efforts that enhance its sustainability in Central Asia and the Caucasus (CAC); 2) gain a comprehensive understanding of priorities in vegetable systems research and development (R&D) within each CAC country and in the region as a whole; 3) suggest strategies on the priorities and mechanisms for collaborative vegetable R&D efforts that will mutually benefit all member countries of CAC; and 4) propose R&D subject areas and action plans that will merit the support of the national governments and the donor community. It was an attempt to band together the national agricultural research system (NARS) in the CAC region into a cohesive and singularly effective group which addresses the strategic R&D needs on vegetables of the region as a whole. AVRDC – The World Vegetable Center and the Program Facilitation Unit (PFU) of the Consultative Group on International Agricultural Research Collaborative Research (CGIAR) Program for Sustainable Agriculture Development in Central Asia and the Caucasus organized this workshop.

The workshop brought together policymakers, research managers, leading experts in vegetable systems, and key stakeholders from all eight CAC countries. Representatives of international, regional and nongovernmental organizations, as well as the private industry also shared their perspectives on the potential of vegetable systems to enhance the well being of CAC countries and their peoples. In total, there were 74 participants from 61 organizations based in Afghanistan, Armenia, Azerbaijan, Georgia, Germany, Kazakhstan, Korea, Kyrgyzstan, Mongolia, Philippines, Taiwan, Tajikistan, Thailand, Turkey, Turkmenistan and Uzbekistan. Sixty-one of the 74 participants were male.

This workshop presented country reports on the social and economic context of vegetable systems, and the status of vegetable R&D in the CAC national programs. Reports on indigenous genetic resources, seed production, integrated pest management, and post-harvest technology of vegetables were also presented to provide an adequate background from a regional perspective. In addition, a number of resource papers touched on the substantive issues and collaborative research opportunities that will affect the development of the vegetable system in the CAC region. Moreover, a paper aggregated and analyzed the individual country trends of the vegetable sector to provide an overview of dynamics of vegetables in the CAC region based on the data collected through a survey conducted with a pre-designed questionnaire from policymakers and key researchers in each CAC country. Together, these papers set the tone for the working groups to deliberate on collaborative vegetable R&D in the CAC region and priorities for collaborative efforts, and paved the way for developing appropriate recommendations and endorsing in principle the proposed collaborative network.
The presentations revealed that the availability of vegetables in the region ranges from 75 to 225 kg per capita per annum. Most production is located in peri-urban areas and occurs from June to September. Vegetable consumption is largely limited to only a few vegetables such as tomato, cabbage, onion, melons and cucumber. This limited diversity, along with high seasonality of vegetable availability, has predisposed both rural and urban populations to micronutrient deficiencies, especially vitamin A and iron. Strong interest was expressed in developing the vegetable sector for export markets.

During the workshop, the participants were shown a series of research activities being conducted at the Uzbek Research Institute of Vegetables, Melons Crops and Potato, and Tashkent State Agrarian University, and vegetable production and marketing in the vicinity of Tashkent. They observed several vegetable varieties developed and agricultural machineries modified by the Uzbek scientists. And they were extremely impressed with the biological control activities being conducted at the Tashkent State Agrarian University.

The participants were divided into four working groups. Group 1 tackled issues of network modalities: objectives, functions or responsibilities, mechanisms of collaboration, management functions, roles of and contributions of regional and international institutions, ways of formalizing the network, and other related issues. Groups 2–4 dealt with the issues of national priorities: collection and conservation of indigenous genetic resources, improvement of existing production technologies, improvement and extension of indigenous vegetables, testing and selection of varieties, improvement of variety development including hybrid breeding, improvement of the seed sector, development of integrated pest management and related good agricultural practices, use of geographic information systems for pest management, and policy and strategy development to promote post-harvest processing and marketing potentials of vegetables.

The participants agreed that networking would be the most effective means of sharing human and technical resources to enhance market- and trade-oriented vegetable systems as a development goal in CAC. Pooling of resources allows them to give greater attention to a number of R&D issues that are strategically common to all NARS in the CAC region. It could also reinforce the quality of research programs. The participants resolved to formalize a CAC network for vegetable systems R&D. Below is a combined summary of the recommendations proposed by each working group:

- Introduction and testing of non-traditional and less-utilized vegetable crops to diversify existing cropping systems.
- Organization of coordinated regional trials of promising varieties of vegetable and melon crops.
- Adoption of modern, low-cost technologies for the improvement of existing vegetable production systems.
- Development of geographic information systems for monitoring major insect pests and diseases of vegetable crops.
• Development of integrated crop management practices for tomato and cucumber for both open-field and protected shelter systems.

• Development of standardized good agricultural practices to ensure quality and safe products of vegetable crops.

• Improvement of germplasm collection, exchange, and management that leads to better conservation and utilization of indigenous vegetable and melon crops.

• Enhanced utilization of indigenous germplasm in the varietal improvement program for a wider adaptation of vegetable crops to environments unique in the region.

• Line selection for the development of open-pollinated (OP) and hybrid varieties of vegetable and melon crops.

• Improvement of the existing seed production systems for OP and hybrid varieties of major vegetable and melon crops.

• Policy and strategy development analyses to promote value-added, post-harvest processing and marketing potentials.

• Capacity building to expedite the above R&D efforts, especially training of young scientists either within or outside the region.

The participants have also drafted the logframe for the above R&D themes as the basis for project preparation, agreed to share information for the establishment of a database, and invited the private sector to participate in the network. They deemed that variety testing and selection could be the first step of this collaborative effort. At the conclusion of the joint discussion, the participants invited AVRDC to serve as a facilitator in the CAC network on vegetable R&D, and determined that the national coordinators should meet again soon to move forward this collaborative network.

During the final session, Dr. Thomas A. Lumpkin, Director General of AVRDC, expressed his hope that interaction among CAC partners continues to increase, as the world is increasingly recognizing the importance of vegetables for healthy diets and economic development. He said that AVRDC can serve as an unbiased facilitator for collaborative vegetable R&D in the region. Dr. Raj Paroda, PFU Head, expressed his desire for greater interactions with AVRDC in its efforts in the CAC region. He shared Dr. Lumpkin’s positive view of the future in the region and stated, “Let’s move forward with confidence.”
Economic and Social Context of the Vegetable System in Armenia

Rubik Shakhasisyan1, Ashot Oganesyan2, and Agwan Saakyan3

1Scientific Center of Vegetable, Melons and Industrial Crops, Darakert, Masis district, Ararat region, 378372, Armenia; 2Department of Science, Ministry of Agriculture, 48 Nalbandian Str., Yerevan, 375010, Armenia; 3Scientific Center of Agrobiotechnology, Darakert. Masis district, Ararat region, 378372, Armenia

Introduction

Armenia is a landlocked country with limited natural resources. It is located in the Caucasus region, and essentially made up of high rolling plateaus and wide river valleys, together with sharp mountain ridges from the southern edge of the Caucasus range. Agriculture generates 23% of Armenia’s gross domestic product (GDP) and employs more than 43% of the labor force (World Bank 2006). These numbers, however, do not reflect the constraints of the agriculture sector caused by limited agricultural resources. Indeed, the republic is facing several challenges to improve the food security for its population of 3.1 million, 64% of whom reside in urban areas.

Natural Resource Base

The average elevation in Armenia is about 1,650 m. The climate is continental with hot summers and cold winters, and annual rainfall varying between 300 mm in the low-lying Ararat plains to about 600 mm in the rest of the country. The mean air temperature varies from –2.7°C (Aragats) to 13.8°C (Megra). January is the coldest month; July and August are the hottest months. The lowest and highest recorded temperatures are –46°C and 43°C, respectively. In lowlands and piedmont districts, the summer lasts five months, while in upland areas only two months. The solar intensity is in the range of 1.39–1.56 cal/cm², and sum of direct radiation on ground surface in the range 150–170 kcal/cm².

Eight distinct altitude landscape zones have been described within a relatively small territory of Armenia: arid subtropical (up to 800 m), arid sharply continental, arid continental (900–1,300 m), temperate-continental (1,500–1,700 m), temperate hot (900–1,300 m), temperate (up to 2,400 m), cold-alpine (up to 3,500 m), and subniveal (over 3,500 m). Because of mountainous ranges, about 40% of the total territory is not suitable for agriculture. The total land area suitable for agriculture amounts to 1,350,000 ha at altitudes from 800 m to 2,000 m, of which 58.2% is arable land, 21.0% grassland, and 16.8% pasture.

Armenia has limited water resources for the available area of arable land. The water resources and demand for water are unbalanced and it is necessary to re-distribute river flows from water-abundant regions to water-shortage areas. The main resources are
surface waters. The river system density amounts to 0.8 km/km². During the growing season, only 15–20% of the water resources can be used; the rest flows out of the country. In the Ararat Valley and foothills, agriculture relies on artificial irrigation; while in the upland districts, crops are mainly cultivated on bogharic lands. Currently, irrigated areas account for less than 10% of total agricultural land while nearly 85% of total crop production is produced with irrigation.

Armenia is characterized as well by a diversity of vegetation covering deserts, semi-deserts, steppes, forests, meadow-steppe areas, sub-alpine and alpine meadows. The richness of flora is conditioned by the four phytogeographical regions of Armenian Plateau, Central Caucasus, Iranian, and Karabakh. Some 3,500 species of vascular plants, among them 125 species of endemic plants, have been recorded, giving a density of higher plants that is one of the highest in the world. Armenia is an important center of diversity for wild relatives of several domestic crops, including beet, spinach, carrot, coriander, mint, asparagus and leek, and has long been a center for breeding and selection of cultivated plants.

Farm Characteristics

Armenia’s agricultural land resources were privatized in 1991–1992, when 70% of land was transferred to private ownership. There are, as a result, more than 330,000 family-owned farms, which currently produce about 98% of the total agricultural product. The average farm size is 1.37 ha of agricultural land. It is estimated that 88% of the farms are smaller than 2 ha (32% of them less than 1.0 ha) and they use 77% of the total land area. The average farm size varies according to the areas. Over 78% and 55% of the farms in Ararat and Armavir, respectively, are around 1.0 ha.

Leasing of farmland is widespread, 15% of all the farmers in the country lease state land from the respective community councils. This figure may vary depending on the size and quality of the public land. Both Ararat and Armavir have high percentages of farm leasing.

Based on the level of efficiency, the farms of all marzas (regions) can be divided into three categories: 1) generating more than US$2,800/ha in Ararat and Armavir; 2) generating between US$1,400–1,900/ha in Lori, Tavush, and Kotaik; and 3) generating less than US$1,400/ha in Gegarkunik, Syunik, Vaiots, Dzor, Aragatsotn and Shirak. High level of efficiency in Ararat and Armavir is mainly realized through effective marketing channels. In marzas located at high elevations, a significant portion of farm produce is for home use.

Cropping Areas and Values

The officially reported cropped area in recent years (2001–2003) is lower than in 1991, reflecting the difficult situation of many farmers, progressive loss of soil fertility, as well as the increased incidence of crop damage by stresses. In recent years, however, the
areas under cereals and potato increased, whereas those under forage crops decreased. Cereals occupy about 46% of cropped areas, whereas forage crops and potato occupy about 42%. The share of fruit and vegetable crops is small but on an uptrend in recent years. Cereals and potato are generally cultivated in the Ararat Plateau, piedmont zones and mountainous districts with warmer climate. Production of vegetables and melons is mainly concentrated in the Ararat Plateau. In 2003, Armenia’s aggregate volume of agricultural products was valued at around 410.1 billion dram.

### Vegetable Production

Armenia’s overall area under vegetables reached 25,300 ha with a total production of 714,000 t in 2004 (FAOstat data 2006). About 52% of the area under vegetables is concentrated in Ararat and Armavir marzas, which contributes to 69% of the total volume in the republic. Currently, the domestic production of vegetables satisfies the domestic need of maintaining a per capita per annum supply of 137 kg (FAOstat data 2006). Major vegetables include tomato, cucumber, onion, cabbage, eggplant, sweet pepper, and watermelon. Production of these crops significantly increased in the past five years, and accounted for 76% of total vegetable production area in 2003. In 2002, the share of vegetable production area of these major vegetable crops reached 55%, with 71% share of the overall production (Tables 1 and 2). Apart from these crops, vegetable marrow, beet, carrot, cauliflower, garlic, and different leafy greens are also widely grown. Production of leafy greens (cilantro, garden cress, dill, tarragon, basil and parsley) have remained relatively stable in recent years. Pea, chili pepper, shallot and cauliflower are cultivated but in small amounts.

In recent years, production areas under tomato, eggplant, pepper and cucumber have expanded, especially after winter wheat and through the use of early maturing varieties under film. One of the factors that contributed to this expanded production is the processing industry. The protected vegetable production technology was introduced in the 1970s and took off in the 1990s. Large specialized collective and state farms produced 85% of vegetables and 98% of melons. Currently, private enterprises operate about 100

| Table 1. Production area (000 ha) of the major vegetable and melon crops in Armenia |
|-------------------------|----------------|----------------|----------------|
| Crop                    | 2001           | 2002           | 2003           |
| Beet                    | 0.54           | 0.49           | 0.62           |
| Cabbage                 | 3.02           | 3.21           | 3.29           |
| Carrot                  | 0.85           | 0.72           | 0.89           |
| Cauliflower             | 0.21           | 0.21           | 0.21           |
| Cucumber                | 1.97           | 1.95           | 2.60           |
| Eggplant                | 1.00           | 0.95           | 1.00           |
| Garlic                  | 0.75           | 0.68           | 0.76           |
| Leafy greens            | 0.48           | 0.50           | 0.50           |
| Melons                  | 1.16           | 1.23           | 1.30           |
| Onion                   | 1.98           | 2.12           | 1.85           |
| Pea                     | 0.20           | 0.19           | 0.08           |
| Pepper, hot             | 0.11           | 0.11           | 0.12           |
| Pepper, sweet           | 0.95           | 1.00           | 0.98           |
| Pumpkin                 | 0.10           | 0.10           | 0.11           |
| Shallot                 | 0.21           | 0.23           | 0.22           |
| Tomato                  | 5.35           | 5.65           | 7.24           |
| Vegetable marrow        | 0.10           | 0.36           | 0.26           |
| Watermelon              | 1.96           | 2.16           | 2.39           |
| Other vegetables        | 2.26           | 2.08           | 3.36           |
| Total                   | 23.10          | 24.10          | 27.20          |
ha of hothouse vegetable production in the Ararat Valley and piedmont districts.

In the period 2001–2003, mean vegetable yield was 24.2 t/ha, with a range of 12.0–34.0 t/ha (Table 3). Mean vegetable yields have recently been generally low, 10% less than a decade ago, even though the republic’s agro-ecological conditions were favorable. This is in part because input supplies under the Soviet Union, although not optimal, were much better than they are presently and more stable from year to year. However, for some advanced farms, yields can be impressive: tomato (70–90 t/ha), pepper (30–40 t/ha), cucumber (25–30 t/ha), cabbage (35–50 t/ha), and melons (35–40 t/ha). This clearly indicates there is much room for improving vegetable productivity in Armenia through the use of improved varieties and other technologies.

### Table 2. Production (000 t) of the major vegetable and melon crops in Armenia

<table>
<thead>
<tr>
<th>Crop</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet</td>
<td>8.21</td>
<td>7.83</td>
<td>10.63</td>
</tr>
<tr>
<td>Cabbage</td>
<td>80.36</td>
<td>82.69</td>
<td>96.54</td>
</tr>
<tr>
<td>Carrot</td>
<td>14.11</td>
<td>12.42</td>
<td>11.81</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>3.80</td>
<td>3.61</td>
<td>4.40</td>
</tr>
<tr>
<td>Cucumber</td>
<td>35.43</td>
<td>36.58</td>
<td>35.20</td>
</tr>
<tr>
<td>Eggplant</td>
<td>34.00</td>
<td>32.30</td>
<td>33.00</td>
</tr>
<tr>
<td>Garlic</td>
<td>6.68</td>
<td>5.12</td>
<td>6.50</td>
</tr>
<tr>
<td>Leafy greens</td>
<td>2.22</td>
<td>2.15</td>
<td>2.15</td>
</tr>
<tr>
<td>Melons</td>
<td>16.99</td>
<td>27.32</td>
<td>34.62</td>
</tr>
<tr>
<td>Onion</td>
<td>32.98</td>
<td>37.32</td>
<td>33.52</td>
</tr>
<tr>
<td>Pea</td>
<td>0.74</td>
<td>0.62</td>
<td>0.23</td>
</tr>
<tr>
<td>Pepper, sweet</td>
<td>11.88</td>
<td>12.00</td>
<td>11.76</td>
</tr>
<tr>
<td>Pepper, hot</td>
<td>2.53</td>
<td>2.75</td>
<td>2.98</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>0.96</td>
<td>1.00</td>
<td>1.10</td>
</tr>
<tr>
<td>Shallot</td>
<td>2.91</td>
<td>2.72</td>
<td>2.83</td>
</tr>
<tr>
<td>Tomato</td>
<td>158.33</td>
<td>180.01</td>
<td>225.30</td>
</tr>
<tr>
<td>Vegetable marrow</td>
<td>1.23</td>
<td>2.39</td>
<td>4.67</td>
</tr>
<tr>
<td>Watermelon</td>
<td>35.62</td>
<td>59.30</td>
<td>75.02</td>
</tr>
<tr>
<td>Other vegetables</td>
<td>61.89</td>
<td>57.84</td>
<td>92.56</td>
</tr>
<tr>
<td>Total</td>
<td>510.80</td>
<td>555.70</td>
<td>684.80</td>
</tr>
</tbody>
</table>

### Table 3. Yields (t/ha) of the major vegetable and melon crops in Armenia

<table>
<thead>
<tr>
<th>Crop</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>26.6</td>
<td>25.8</td>
<td>29.3</td>
</tr>
<tr>
<td>Cucumber</td>
<td>18.0</td>
<td>18.8</td>
<td>17.4</td>
</tr>
<tr>
<td>Eggplant</td>
<td>34.0</td>
<td>34.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Melons</td>
<td>16.5</td>
<td>23.3</td>
<td>28.4</td>
</tr>
<tr>
<td>Onion</td>
<td>16.7</td>
<td>17.6</td>
<td>18.1</td>
</tr>
<tr>
<td>Pepper</td>
<td>12.5</td>
<td>12.0</td>
<td>12.0</td>
</tr>
<tr>
<td>Tomato</td>
<td>29.7</td>
<td>30.3</td>
<td>31.2</td>
</tr>
</tbody>
</table>

**Plant Protection and Safety**

The vegetable production systems are subject to abiotic stresses, light frosts in early spring and autumn, temperatures above 37°C in summer, and dry winds. On top of that, aphids, spider mite and Colorado potato beetle are the major pests damaging the vegetables grown in the Ararat Valley. In the republic’s piedmont and upland zones, however, the damage caused by these pests is relatively low. Colorado potato beetle attacks potato, eggplant and tomato. Its spread throughout the republic shows how harmful the uncontrolled importation of seeds and planting materials may be. Powdery mildew, downy mildew, Fusarium wilt, gray mold and wire stem are prevalent in the Ararat Valley and piedmont zone, the predominant vegetable growing area in the republic.

In the past decade, pesticides and other plant protection means were imported from countries of the Commonwealth of Independent States (CIS), China and European Union by a variety of private entrepreneurs who often lacked appropriate qualifications, and the
materials were often of limited quality. Over the past five years, however, the situation has improved. In 2001, an inter-agency commission was established for testing and registration of appropriate products and recommendations for their utilization to farmers. As profits increase, farmers are willing to buy expensive but high-quality pesticides, which subsequently contribute to the effective pest and disease control.

There are institutions in the republic to develop integrated pest management strategies and biological controls of diseases and insect pests. They target mostly on protected vegetable production, but the extent of their use is still limited. Furthermore, organic vegetable farming systems for safe products have yet to be developed. One of the obstacles is the small farm size. However, this situation is being improved with recent development of farm amalgamation. Part of the organic vegetable production could be targeted for markets in Europe and other industrialized countries.

**Plant Breeding and Seed Supply**

Until the 1990s, Armenia had various organizations for variety improvement and seed production. Primary variety improvement was conducted in scientific research institutes and seed production was the responsibility of state seed production farms in various agricultural zones. After land privatization, almost all variety improvement facilities were dissolved and the country was, in fact, deprived of primary seed production. In 2003, farmers produced 85 t of vegetable and melon seeds from around 100 ha of cropped areas. This domestic supply is currently inadequate and seeds are imported from Holland, Israel, Russia and the USA. However, imports of low quality seeds have taken place due to insufficient controls at the border. To overcome these challenges, the government is set to: 1) regulate the testing and protection of the new varieties of crop plants; 2) encourage the cooperation between public and private seed production sectors; and 3) determine the specific areas of activities for the development of the private seed production sector.

**Mechanization and Input Supply**

Due to the small size of vegetable farms, the farmers are forced to share the use of the equipment with others. Multi-farm use, mostly through a system of owner-operators contracting for machinery services on a commercial basis, is beginning to evolve. Moreover, joint ownership and operation of multi-functioned machineries on a cooperative basis are on the rise.

The major expenses associated with vegetable production are comprised of labor wages and the cost of seeds, fertilizers, pesticides, irrigation water, harvesting, and transportation. Labor wages account for less than 20% of the total expenditure. Armenian agriculture is almost totally dependent on costly imports for most of its inputs and equipment (chemicals, energy, fertilizers, machinery, etc.). To increase vegetable farming profitability, there is a need to improve access of farmers to less expensive inputs.
Processing Industry

As the republic has shifted from large collective farms to small private farms in the early 1990s, this has led to the disintegration of agricultural production and breakdown of the former marketing systems. The processing industry had been previously designed, in several sub-sectors including vegetables, so that it could export sizeable quantities of food products to the rest of the Soviet Union. Therefore, its capacity in those export sub-sectors was set beyond the domestic demand. The collapse of the Soviet Union together with the opening up of competing markets, which were previously closed, were detrimental to the exports of the processing industry. Together with the loss of former domestic channels, the fragmentation of agricultural production, the economic blockade and the energy crisis, this has inexorably led to the stoppage of processing facilities. Since 1996, however, Armenia has started to recover from its energy and economic crises. There are now 12 canneries in operation to produce intermediate products. Production of tomato paste represents 70% of their output.

For exports of the processed outputs, the industry faces the constraints of inadequate marketing and price policies. Given the limited output, Armenia is a price-taker and has to adjust to the price levels of the main competitors. Moreover, while costs of raw material and labor are low in international comparison, there are high transport costs compared with competitors of Europe and high unit labor and packaging costs (due mainly to low production levels).

Marketing and Development of Trade

It is estimated that on average farmers sell 40–50% of their outputs on the market; the rest is consumed on-farm. Small farms are mainly subsistence-based while large farms are commercially oriented. Farmers rely on two channels for marketing their products: direct sales to consumers and sales to private traders and commercial firms. In general, the vegetable growers are not in a good position to market their products with weak leverage to negotiate prices with traders or processing companies. Moreover, there is no market information system, with the result that many vegetable farmers in an area tend to produce the same crops if they were previously profitable, causing a glut. In addition, the lack of capacity in post-harvest handling or storage implies that most vegetable farmers must sell their products during the short period of time, causing low prices. Farmers could obtain better prices if they had access to the marketing information, and facility to properly handle and store their products after harvest.

In view of the practical absence of primary post-harvest handling facilities at the village level, small-scale vegetable farmers in Armenia today are highly dependent on seasonal marketing operations, and local consumers’ preference. Under the current situation, varieties with high yielding and quality potentials for different growing seasons and resistance/tolerance to stresses are desirable.

The contribution of the agriculture sector to the international trade of the republic has considerably changed since the early 1990s. Exports have shrunk while imports have
surged. As a result, the agriculture sector in the early 2000s has contributed to one-third of the republic’s trade deficit. Although trade of fresh vegetables is negligible, there is an increasing trend of importing greenhouse tomato, cucumber and pepper products in recent years, amounting to near 800 t in 2002.

**Prospects for Vegetable Systems Development**

Effective development of marketing, processing and agri-business is the key to future vegetable systems development in Armenia. A wide range of efficient marketing agents (producer associations, traders, agri-business enterprises, agro-processors, markets, and trades) provide the best platform for transmitting clear price signals to farmers on what they should produce. Toward this end, Armenia has mapped out the priority directions in which to develop a market-oriented vegetable system (Ministry of Agriculture 2002). The main elements of the strategy are as follows:

- Foster amalgamation of small farms and large-scale cooperatives and associations.
- Transform subsistence production systems into market-oriented, value-added production systems.
- Broaden the production base and reduce reliance on imported products.
- Provide technical assistance, information and technical training.
- Enhance the vegetable seed production sub-sector.
- Strengthen the service sub-sectors related to input supply and marketing information.
- Establish post-harvest handling facilities and marketing infrastructure.
- Enhance credit systems with the financial sector.

The implementation of all the planned measures and reforms, as well as the country’s integration into the world trade system will be conducive to sound market-oriented vegetable systems in Armenia.

**Literature Cited**


Research and Development of the Vegetable System in Armenia

Galust G. Aslanyan¹ and Arevik B. Lokyan²
¹Scientific Center of Vegetables and Industrial Crops, Darakert, Masis district, Ararat region, 378372; Armenia; ²Vanadzor Pedagogical Institute, Vanadzor, 378000, Armenia

Introduction

The soils and climate of Armenia are favorable for vegetable production throughout much of the republic, but most (65%) of its vegetable and nearly all (98%) of its melon production can be found in Ararat and Armavir of the Ararat Valley (Table 1). In the Ararat Valley and piedmont areas, vegetable production relies on irrigation, while in the mountainous districts production is on bogharic lands. Since 2000, work has been underway to modernize the republic’s irrigation systems and increase production levels. However, risk of mild frosts in April and early frost in September in the Ararat Valley and piedmont zones are potential constraints.

The major vegetables and melon crops traditionally grown in Armenia, listed in order of production area, include tomato, melons, cabbage, cucumber, onion, eggplant and pepper (Table 2). Watermelon, hot pepper, shallot, vegetable marrow, cauliflower, garlic, carrot, pumpkin, table beet, pea, leafy greens, green beans, and pulses are also grown to a great extent. Data indicate production areas of both major and minor vegetables and melons tending to increase in recent years, likely due to the steady rise in consumption and the development of processing industries. Average yields have also increased since 1999. This

<p>| Table 1. Area under vegetable and melon crops across marzas (districts) |
|-----------------------------|-------------------|----------------|------------------|</p>
<table>
<thead>
<tr>
<th>Marza</th>
<th>Sown area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armavir</td>
<td>9,318</td>
</tr>
<tr>
<td>Ararati</td>
<td>8,362</td>
</tr>
<tr>
<td>Gegarkunik</td>
<td>1,497</td>
</tr>
<tr>
<td>Kotaik</td>
<td>1,363</td>
</tr>
<tr>
<td>Lori</td>
<td>1,335</td>
</tr>
<tr>
<td>Shirak</td>
<td>1,220</td>
</tr>
<tr>
<td>Aragatsotni</td>
<td>1,184</td>
</tr>
<tr>
<td>Tavush</td>
<td>1,169</td>
</tr>
<tr>
<td>Syunik</td>
<td>959</td>
</tr>
<tr>
<td>Vaiots Dzor</td>
<td>501</td>
</tr>
<tr>
<td>Erevan</td>
<td>395</td>
</tr>
<tr>
<td>Total</td>
<td>27,303</td>
</tr>
</tbody>
</table>

<p>| Table 2. Area, production level, and yield of major vegetable and melon crops in Armenia (2003) |
|------------------------------------------|-----------------|-----------------|-----------------|</p>
<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (000 ha)</th>
<th>Production (000 t)</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>3.29</td>
<td>96.5</td>
<td>29.3</td>
</tr>
<tr>
<td>Cucumber</td>
<td>2.02</td>
<td>35.2</td>
<td>17.4</td>
</tr>
<tr>
<td>Eggplant</td>
<td>1.00</td>
<td>33.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Melons</td>
<td>4.06</td>
<td>115.4</td>
<td>28.5</td>
</tr>
<tr>
<td>Onion</td>
<td>1.85</td>
<td>33.5</td>
<td>18.1</td>
</tr>
<tr>
<td>Pepper</td>
<td>0.98</td>
<td>11.8</td>
<td>12.0</td>
</tr>
<tr>
<td>Tomato</td>
<td>7.24</td>
<td>225.3</td>
<td>31.1</td>
</tr>
</tbody>
</table>
can be attributed to introduction of advanced cultivation technologies and improved varieties.

**Challenges in Vegetable Production**

A lack of financial resources in the government has resulted in the elimination of nearly all subsidy programs in the vegetable system. With the collapse of input supply channels, dissolution of state farming systems, and overall decreases in farm income, the use of agricultural inputs has fallen substantially.

There are more than 330,000 private farmers. Vegetable farmers’ landholdings typically range from one-half to one hectare, often comprised of smaller, non-contiguous parcels. As a result, farming these small plots is very inefficient. Nowadays, however, the consolidation of land via acquisition or formation of cooperatives into larger operating units is taking place. State-run enterprises sell fertilizers. The farm crediting system is gradually improving. Processing enterprises are modernizing. All these activities are conducive to vegetable-based economic development.

Before the dissolution of the former Soviet Union, cropping systems to protect against hail damage were in place. Today, these systems are not functioning but research has been renewed since 2004. Poor transport conditions also hampers the improvement of the vegetable production sector.

Traditionally, Russia’s northern regions are major consumers of Armenia’s fresh and processed vegetables. The lack of direct rail links makes the exportation of perishable vegetables difficult and high transport costs often make the exportation of vegetables unprofitable. Nevertheless, some exportation does occur and the demand for tomato paste is steadily growing outside the republic. Concentrated in the Ararat Valley, the local canneries have increased their production capacities recently. Apart from tomato paste, they turn out a variety of ketchups and marinades of every description. Over the past three years, deep freezing of vegetables has been widely practiced. Rapid growth of the national processing industry has led to the establishment of certain requirements on both quality and assortment of vegetables. Varieties capable of meeting the industrial processing requirements are valued most of all.

Since 1995, the republic has privatized the state-run seed production system and liberalized trade. This has led to uncontrolled importation of vegetable seeds with variable qualities. Most imported seeds did not go through variety trials and failed to meet market requirements. Fortunately, recent governmental measures regarding seed importation, seed production and breeder’s rights have been enacted to reverse this trend. Appropriate state authorities efficiently oversee the home seed market, trying their best to prevent the importation of low quality seeds to the republic. Additional legislation is now being considered to encourage the development of entrepreneurial seed production farms.
Major crop pests include melon aphid, cabbage aphid, spider mite and Colorado potato beetle. Among plant diseases, the most prevalent are powdery mildew, downy mildew, Fusarium wilt and wire stem (*Rhizoctonia* spp.). The most severe levels of damage are caused to crops in the Ararat Valley. In the piedmont and mountainous areas, pests and diseases are less widespread.

The management of pests and diseases is a pressing problem. Pesticides are mainly imported from the other Commonwealth of Independent States (CIS), China and Europe. In most cases, they are of low quality, thus doing more harm than benefit. Today, certain organizational measures are being taken to execute tougher restrictions over the importation of agricultural chemicals. State authorities supervise import operations to prevent the importation of low quality chemicals. As profits earned by local farmers grow, the demand for higher quality chemicals from Europe has increased, which has helped to effectively control pests and diseases.

During the past five years, the cultivation of safe vegetables has gained attention. This has led to the linkage of organic vegetable production with livestock production. Research is in progress to produce organic fertilizers from animal waste. Efforts are also underway to classify lands for organic production and to increase public awareness for safe vegetables. As the population’s purchasing capacity grows, so does their demand for safe vegetables. Armenia stands a good chance for producing safe vegetables not only for domestic markets but also export markets.

**Vegetable Research and Development**

Armenia is one of the world’s ancient centers for certain vegetables and melons. Many unique varieties of melon, watermelon, kidney bean, onion, and cucumber have been widely grown for ages. Before 1950, landraces occupied about 90% of all the vegetables grown. A great number of landraces of *Beta, Spinacia, Coriandrum, Daucus, Satureja, Falcataria, Rumex, Malva, Portulaca, Cucumis*, and the Solanaceae have survived to the present day. Currently there is a national program dedicated to collecting, conserving and utilizing these valuable resources. Both indigenous and introduced germplasm are used in variety improvement.

The situation of vegetable production in Armenia has changed dramatically with recent economic development. New urban centers and agri-food industries have spurred on the development of advanced production technologies. Toward this end, the Armenian Vegetable Improvement and Seed Production Station, established in 1949, has released more than 15 varieties of several types of vegetables and melons. The station has been developing new cultivation technologies since 1981. In 1993, the station was re-organized as the Research Institute of Vegetables and Melon Crops, and in 1998 as the Scientific Center of Vegetables and Industrial Crops (SCVIC) under the authority of the Ministry of Agriculture.

SCVIC, located in Darakert and Aigavan, is improving varieties for modern markets with modern breeding methods, organizing science-based seed production systems, and
developing cultivation technologies for both open-field and protected cropping systems. Currently, SCVIC has four divisions: varietal and production improvement and seed production of vegetables; varietal and production improvement and seed production of melons; protected production; and biochemistry, biotechnology, physiology and processing technology. Since its inception as a breeding station, SCVIC has made a sizable contribution to the agricultural development in the republic.


SCVIC is collaborating with similar institutions across the CIS. It maintains good linkages with the All-Union Research Institute of Vegetable Breeding and Seed-Growing in Russia and the Ukrainian State Commission on Variety Trial and Release of Vegetable and Melon Crops. Over the past five years, several varieties of tomato and eggplant have been evaluated and released in these republics. Seeds of these varieties are exported and sold via appropriate channels. SCVIC is also engaging in production of elite seeds of vegetables. For the time being, however, the Center’s capacity is inadequate to meet the domestic demand. Increased cooperation with the private seed sector is needed to fulfill this demand.

SCVIC’s research and development (R&D) is directed toward increasing yields, production systems for both open-field and protected systems, and overcoming biotic and abiotic stresses of vegetable production. R&D areas include germplasm management; conventional breeding, mutagenesis, interspecific crosses, and biotechnology for developing both open-pollinated and hybrid varieties; plant protection; biochemical analysis and technological assessment; physiology of growth and development; cultivation technologies; seedling production; and seed production. Currently, anther culture is employed for developing haploids to accelerate breeding cycles, while growth regulators and micronutrients are used to increase seedling and plant growth, and new vegetables are being studied to diversify cropping systems. From 2002 to 2004, SCVIC took part in seven projects, five with state funding and two with SCVIC’s own funding.

SCVIC, in collaboration with the Research Institute of Toxicology and Hygiene, is conducting research on the use of processed sewage residues from the Yerevan sewage purification station. SCVIC is studying the proper dosage of processed sewage on differ-
ent vegetables, while the Research Institute of Toxicology and Hygiene evaluates heavy metals and pathogenic organisms. SCVIC also cooperates with the private sector in fertilizer-coated zeolite and perlite. Promising results obtained in the course of this cooperative activity ensure their wide utilization in crop production.

SCVIC is composed of over 50 well-trained research staff; however, modernization of research laboratories, production of seeds, and participation in joint research programs remain problematic. Nowadays, the most topical problem facing SCVIC is preliminary processing and packaging of seeds. The lack of finances prevents the Center to purchase modern equipment for purification, granulation, treating and packaging of seeds, which impedes its full participation in the seed market. SCVIC has developed the method of growing seedlings in plastic cells and flower pots, but to organize mass production of high quality variety seedlings requires special equipment, which SCVIC cannot afford to buy.

Apart from SCVIC, the Armenian Agriculture Academy (AAA) and Gyumry Breeding Station at the Research Center for Farming and Plant Protection are also tackling a range of issues related to vegetable production. AAA is training specialists in vegetable production. Research done there focuses on variety description of both local and foreign origins, and development of herbicides and growth regulators. The Gyumry Breeding Station specializes in breeding, seed production and cultivation technology for carrot, cabbage, table beet and bean. Numerous varieties developed there have been successfully released and now widely grown by farmers.

**Vegetable Research and Development Support**

Prior to 2004, the system of theme (contract) financing for R&D was in place in the republic. In this system, the scientific councils of different institutions decided priority themes for approvals by corresponding ministries. Later these councils assessed the submitted projects and recommended project funding. Decisions made by these councils could be appealed. The approved project leaders signed contracts with the Ministry of Education and Science, which provided funding toward project implementation. The projects were usually for one to three years. The project’s budget was comprised of wages (18,000 drams per staff), social deductions (5,000 drams per staff) and operational expenses. Starting in 2005, along with the theme financing, a system of base financing has been introduced. The latter is designed to provide the funding toward the major directions of research, while the former aims to extend the most important aspects of research projects. Volumes of financing have increased (22,000 drams per staff); however, operational expenses have remained almost unchanged.

The republic’s research institutes are encouraged to participate in grant programs run by various foreign, governmental and public organizations. However, the amount of funds generated through these grant programs are low and cannot resolve the problems faced by the republic. Low levels of funding provided by the state also limit the R&D activities. Low remuneration makes it impossible to attract young scientists. Shortage of where-
withal hampers the acquisition of advanced technologies, new equipment and chemicals. There are also certain obstacles in the way of establishing individual contacts with foreign research institutions. If provided with sufficient funding, Armenia’s research institutions can develop R&D programs in cutting-edge fields of agricultural science and transfer its newly advanced technologies to the vegetable sector.
Economic and Social Context of the Vegetable System in Azerbaijan

Alisoltan G. Babaev
Azerbaijan Research Institute of Vegetable Production, Village Pershagi, Baku, 1098, Azerbaijan

Introduction

Azerbaijan is situated in the southeast part of the Caucasian isthmus between the continents of Europe and Asia. It has an area of 86,600 km², stretching between 38°24' and 41°54' latitude N, and between 44°46' and 50°21' longitude E. The republic borders with Russia in the north, Georgia in the northwest, Armenia and Turkey in the west, and Iran in the south. The border covers 2,849 km, including 825 km of coastline. Azerbaijan has 1.8 million ha of arable land, of which 1.4 million ha is irrigated.

Azerbaijan’s population in 2003 was 8.4 million with about half living in the countryside. Annual population growth since 1991 has been 0.9%. The density of population is 95 inhabitants per km². About one million people were engaged in the agricultural sector in 2003, which was 25% of the total labor force (Mehraliev 2003). The agriculture sector accounted for 14.3% of the gross domestic product (GDP) in 2004.

Natural Resource Base

About 43% of the land area of Azerbaijan is situated above 1,000 m elevation. Apart from islands in the western part of the Caspian Sea, Azerbaijan is divided into four geographic regions: the Greater Caucasus, the Lesser Caucasus, and the Talysh Mountains, together covering about 60% of the republic; and the Kura-Araks Plain (with elevations less than 500 m) make up the other 40% of the country (Zavriev 1963).

All year round, the republic receives an abundance of solar heat and light. On average, there are 1900–2900 hours of sunshine annually (approximately 5–8 hours per day). The climate of Azerbaijan is under the influence of cold air currents coming from the north and the warm air currents coming from the south with moderating effects of the Caspian Sea (Suleimanov and Musaev 1963). The climate varies from subtropical and dry in central and eastern Azerbaijan, to subtropical and humid in the southeast, temperate along the shores of the Caspian Sea, and cold at the higher mountain elevations.

Because the republic is located far away from the ocean and is close to the dry steppe and desert areas, the relative humidity of its air humidity tends to be low. Average annual relative humidity ranges from 55 to 70%; sometimes it lowers to 32%. Annual precipitation in high elevations of the Caucasus and in the Lenkoran region in the far southeast exceeds 1,000 mm. Nevertheless, there is less than 400 mm of rainfall each year over 65% of the republic. The lowlands receive scant rainfall, about 250 mm annu-
ally. For most of the republic, the wettest periods are in spring and autumn, with summers being the driest.

Temperatures vary by season. In the southeast lowland, temperatures average 6°C in the winter and 26°C in the summer—though daily maxima typically reach 32°C. In the northern and western mountain ranges, temperatures average 12°C in the summer and –9°C in the winter. The average annual air temperature in the lowland is 9.5–13°C and the number of days with an average 10-day span of air temperature higher than 5°C constitutes 260–320 days per year.

Many basic soil types are present in Azerbaijan (Mamedov 2000). Mountain-meadow, mountain-peaty steppe soils, mountain-meadow grey, and mountain-meadow brown soils are widespread in the high mountains. In the medium mountain belt, mountain-meadow, mountain-forest grey, mountain-chernozems, grey-chestnut, chestnut, brown, and podzolized yellow soils are widespread. In the foothills, alluvial-meadow, forest, and grey-meadow soils dominate. In the plain forest areas, plain-forest, grey, brown, meadow-salinized grey, boggy, and sandy soils are widespread.

Approximately 4,500 species of higher plants are recorded in Azerbaijan, which represents around 65% of the floral diversity of the Caucasus region, and 11% of the world’s flora. A wide range of Azerbaijan’s flora is used as a source of food, and a range of wild plants are widely cultivated in gardens.

**Agricultural Sector**

Agriculture in Azerbaijan has a long history. Agriculture has been and continues to be very important for the country’s economy and its people. Until the dissolution of the Soviet Union in 1991, Azerbaijan was a supplier of tea, grapes and wine, citrus and other fruits, tobacco, cotton and early harvested vegetables to other Soviet republics. These crops were cultivated on large state or collective farms using intensive farming techniques. Imports from other Soviet republics covered its need for cereals, meat and several other agricultural products.

Following independence in 1991, many agricultural extension and advisory services to the farmers were no longer provided. Azerbaijan’s market links with other former Soviet republics were cut. As a result, all auxiliary infrastructures collapsed. The country was left with an agricultural specialization and products for which the demand was limited. Production of major products fell drastically, and the food industry collapsed. Deliveries of basic foodstuffs such as grains from other parts of the former Soviet Union ceased, which caused problems for food security. These dramatic changes negatively affected the economy of the republic and the living conditions of its population.

Agricultural production has recovered since 1998. Markets for agricultural products and inputs are fully liberalized, and the effects are generally positive. Azerbaijan has good potential to export fruits, nuts, vegetables and processed products. At present, poor product quality, inefficient transportation infrastructure, and lack of post-harvest tech-
nologies limit exports. Russia is still an important potential market, but it has been difficult
to establish regular deliveries across the border.

In 1996, Azerbaijan adopted the Land Reform Law to initiate farm restructuring and
set up private farms in the place of the former sovkhozes (state collective farms) and
kolkhozes (village collective farms). Guided by this law, the arable land of these collec-
tive farms was transferred to over 3 million rural inhabitants. There are at present about
870,000 family farms, which take up more than 90% of arable land and produce more
than 90% of crop products in the republic. Only 40 state farms, mainly research farms,
are still farming state land.

The trend among family farmers, on about 2 ha land per family, has been to move
away from traditional crops such as wheat and cotton and re-direct to fruits, vegetables
and nuts, which require less fertilization and mechanization and can be cultivated in small
plots and marketed directly. Despite reforms, unfortunately, family farming is character-
ized by producing mainly for subsistence and sale to the domestic market. It has not, as
yet, achieved broad growth or significant access to new markets for its products. This
impedes overall agricultural growth.

Land consolidation is now on the agenda as it is seen to be important for the develop-
ment of a more efficient and market-oriented agriculture. There are some signs of con-
solidation. About 2,600 larger peasant farms, 1,200 collective enterprises, 160 production
collectives and 370 small enterprises have been formed on the basis of voluntary agree-
ments among individual farmers. At present, several international organizations (e.g.,
World Bank, International Fund for Agricultural Development, and German Technical
Cooperation Agency) and agricultural research centers (e.g., International Center for
Agricultural Research in the Dry Areas and International Fertilizer Development Cen-
ter) are collaborating with the government to establish model farms in the republic so as
to stimulate the overall development of the agricultural sector.

The diversity of climates in Azerbaijan supports a variety of fruits and vegetables, and
mild temperatures support two open-field grown crops in most areas—three if green-
houses are used. However, agricultural production is far stronger in potential than in reality. Azerbaijan has the resources to be self-sufficient, but still imports more than 50% of its food. In recent years, foreign food products have flooded the local market and local products cannot compete. Much of this trade is in foods from crops that are grown in Azerbaijan but cannot be processed locally because the food-processing sector is not sufficiently developed.

Currently the agricultural sector lacks capital and credit opportunities, leading to low
levels of agricultural inputs and modern machinery within the sector. The lack of pro-
cessing capacities for agricultural products is another significant constraint for the devel-
opment of production, even if there are some new investments. A general trend is that
small-scale processing units are replacing larger units. Another problem is that the new
private farmers have limited access to information and technical advice. To reverse this
negative trend, government agencies have adopted state policies and programs on the
social and economic development of Azerbaijan for 2004–2008. These policies and programs help farmers to access soft credits from the state, and develop rural projects such as processing industries, agricultural service stations and seed production farms. Now all regions of Azerbaijan are in the second stage of these social and economic development programs.

Although there is some rainfed cultivation of cereals, potato and forage crops, crop production is difficult without irrigation as most of Azerbaijan’s arable land belongs to semi-desert and dry steppe zones. Irrigation using over 40,000 km of canals and pipelines covers 1.4 million ha, which is about 82% of the arable land. However, only 1.1 million ha can now be irrigated. This is due to poor maintenance of the irrigation system, and farmers’ lack of resources and capacity. Yield levels are generally low even on irrigated land. Since 1990, the structure of crop production has changed considerably—cereal, vegetable and potato production has increased, while cotton, tobacco and fruit production has plummeted. These trends reflect an adaptation to the needs of the national market and limited opportunities for export.

Current Situation of the Vegetable Production

Azerbaijan has 9 climatic zones among the 11 existing in the world. Together with diverse agro-climatic conditions, large tracts of fertile and irrigated land and the geostrategic location between Europe and Asia provide a potential for year-round vegetable production and exporting selected vegetables from Azerbaijan.

However, the vegetable sector suffered following Azerbaijan’s independence in 1991, as did the overall agricultural sector. The republic’s availability in vegetables and melons reached only 62% and 40% of the requirement, respectively, before the agricultural reformation in 1998 (Aliev 2004). As a result, the cases of nutrient deficiencies, cardiovascular diseases, diabetes and cancers were prevalent (Suhanov 2003). After the agricultural reformation in 1998, however, vegetable production increased. The volume of vegetable production reached 1.4 million t harvested from 108,000 ha in 2004. Much of this increase could be attributed to land privatization programs with an increasing trend of growing vegetables. Currently, more than 91% of vegetables are produced on family farms (Table 1). Subsequent to the increased vegetable production, the population’s annual consumption of vegetables and melons in 2003 reached 128 kg/person; that was a 193% increase from 1994. The upward trend is likely to continue with population growth and increased incomes anticipated from oil revenues. This could lead to efforts directed at attaining self-sufficiency in vegetable supplies, with exports as an additional option.

Nowadays, more than 23 species of vegetables with 84 registered varieties of both open-pollinated and hybrid types are cultivated in 60 districts of Azerbaijan. Most of them are concentrated in Lenkorano-Astarin, Cuba-Khachmas, Apscheron and Gyandja-Kazakh, which contribute 60% of the total production. The leading vegetables are tomato, watermelon, bulb onion, cucumber, cabbage, garlic and bean. Yields range from 6 t/ha to 27 t/ha with an average of 14 t/ha (Table 2). The relatively low yield of vegetables could be
attributed to lack of both crop rotation systems and integrated pest management practices. During 2001–2003, the production cost of 100 kg of vegetables ranged between US$6.4–7.2 with profitable margins ranging between 8.1–11.8%. The market prices of vegetables continue to fluctuate with seasons.

Table 1. Land area used for growing vegetables by different types of farms in Azerbaijan, 2003

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (ha)</th>
<th>Family farms</th>
<th>Peasant farms</th>
<th>State enterprises</th>
<th>Non-state enterprises</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet, table</td>
<td>390</td>
<td>2</td>
<td>8</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Cabbage</td>
<td>5,998</td>
<td>28</td>
<td>22</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Carrot</td>
<td>643</td>
<td>1</td>
<td>6</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Cucumber</td>
<td>10,696</td>
<td>52</td>
<td>8</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Garlic</td>
<td>2,339</td>
<td>6</td>
<td>16</td>
<td>54</td>
<td></td>
</tr>
<tr>
<td>Melons</td>
<td>29,928</td>
<td>188</td>
<td>101</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>Onion, bulb</td>
<td>11,708</td>
<td>150</td>
<td>28</td>
<td>268</td>
<td></td>
</tr>
<tr>
<td>Pea, green</td>
<td>502</td>
<td>2</td>
<td>7</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td>22,403</td>
<td>122</td>
<td>50</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>13,648</td>
<td>34</td>
<td>23</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>98,255</td>
<td>585</td>
<td>269</td>
<td>721</td>
<td></td>
</tr>
</tbody>
</table>

Source: State Statistic Committee

Table 2. Cultivated area, production and yield of vegetables in Azerbaijan

<table>
<thead>
<tr>
<th>Crop</th>
<th>Area (000 ha)</th>
<th>Production (000 t)</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet, table</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Cabbage</td>
<td>5.0</td>
<td>5.7</td>
<td>6.5</td>
</tr>
<tr>
<td>Carrot</td>
<td>0.4</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>-</td>
<td>2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>Cucumber</td>
<td>8.3</td>
<td>9.9</td>
<td>11.6</td>
</tr>
<tr>
<td>Garlic</td>
<td>2.8</td>
<td>2.4</td>
<td>2.3</td>
</tr>
<tr>
<td>Onion, bulb</td>
<td>9.2</td>
<td>11.3</td>
<td>13.0</td>
</tr>
<tr>
<td>Pea, green</td>
<td>0.3</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>Tomato</td>
<td>18.9</td>
<td>21.9</td>
<td>23.6</td>
</tr>
<tr>
<td>Others</td>
<td>11.6</td>
<td>13.7</td>
<td>13.8</td>
</tr>
</tbody>
</table>

Source: State Statistic Committee

The sheltered vegetable production system of cucumber and tomato is of importance. During the past five years, about 26,800–32,200 t of both vegetables per year were produced from greenhouses and plastic houses in Apsherion, Shamkir, Saliants, and Ali-Bayraml. Most F₁ hybrid varieties and technologies used in this system are imported from European countries and Israel. At present, average tomato yields per square meter
for non-heated plastic houses and heated greenhouses are 4.5–6.7 kg and 9.8–15.0 kg, respectively. For non-heated plastic houses and heated greenhouses, average cucumber yields were 5.8–7.0 kg and 8.6–11.0 kg, respectively.


F1 hybrids, most of them from abroad, are gaining popularity in recent years. Essentially, they are used in the protective production system. Popular tomato hybrids are ‘Revido TmC5VF2FrWi’, ‘Sumela’, ‘Marpha’, ‘Resento TmC5VF2FrWi’, ‘Caruzo TmC5F2’, ‘Rossia’, ‘Krasnaya Strela’, ‘Severnyiy Express TmC5F2’, ‘Solveig TmC5F2’ and ‘Blagovest’. Popular cucumber hybrids are ‘Fabrio’, ‘Corona’, ‘Cortena’, ‘Picobello’, ‘Danito’, ‘Blik’, ‘Strela’, ‘Aprelskiy’, ‘Zozulya’, ‘Manul’, ‘Maraphon’ and ‘Kristalnaya’. Popular sweet pepper hybrids are ‘Medeo Tm0’, ‘Fleir’, ‘Xoki ez F1’ and ‘Kalunqa ez F1’. Apart from various diseases and insect pests, the protected vegetable production system in the republic is being constrained by increasing costs of fuel, fertilizers and chemical pesticides.

Although vegetable production can flourish in Azerbaijan, the republic does not take full advantage of adding value to the products in the form of processed goods. Currently, only 2 out of the 43 canning factories in Azerbaijan are operating, and they produce primarily tomato paste and fruit juices. As a result of the reduced domestic and foreign demands, Azerbaijan’s canneries do not work to full capacity, and their equipment is outdated and in need of replacement. These canneries continue to use glass jars and bottles instead of plastic containers or other materials that are less susceptible to damage in transit, have greater shelf life and store better. For development of this sector, Azerbaijan needs to establish service structures and processing plants for packaging, preserving and transporting vegetables. There is a high demand for processing machinery for the preparation of vegetables as well as for cleaning, sorting and grading. Finally, machinery for filling, closing and sealing containers would fill an important gap in the area of food packaging.

Storage and transportation of harvested vegetables is problematic. There is a lack of adequate facilities, such as covered, protected and refrigerated storage areas, as well as aerators and pest/vermin control technologies. Transportation equipment is old and not well maintained. This causes bruising and other damage to produce in transit to food processing centers or markets. There is also a lack of refrigerated vehicles. The agribusiness market would benefit from the importation and establishment of adequate storing and freezing facilities.
Socio-economic Issues Related to the Vegetable Sector

In Azerbaijan, most family farms are still hesitant to invest in commercial vegetable farming operations. The farmers do not have sufficient knowledge concerning modern practices for vegetable production and protection. Most information known was provided during the former Soviet Union period and is not suitable for today’s demand-oriented farming activities.

Low quality seeds, poor production economics, lack of working capital, and inadequate access to output markets have further deterred the farmers from commercial vegetable farming. Product output markets are not fully developed. Grading and packaging facilities are lacking and farmer-managed collection points and wholesale markets or cold storage facilities do not exist. It is not the mere supply of modern agricultural inputs (e.g., fertilizer, seed, machinery and greenhouse technology) but the competitive production of and demand for standard quality that leads to an increased agri-input demand and a sustainable agricultural sector.

Strong ties need to be established among input suppliers, farmers, dealers and processors to foster the development of a commercial, demand-driven vegetable production system. The linkages will be strengthened by introducing the use of appropriate agronomic practices increasing both the productivity and income of farmers.

In Azerbaijan, the following core issues for the vegetable sector can be identified: 1) output productivity; 2) marketing of output products for fresh and processing markets; 3) extension support of respective farming groups; 4) financial initiatives to support respective farming groups; and 5) national framework conditions offering sound public policy support to the vegetable sector.

Future activities should focus on the following problem areas: 1) increase productivity through information exchange and networking, including knowledge transfer systems to improve agronomic practices; 2) provide appropriate agri-inputs at higher efficiency rates; 3) identify progressive farmers as agents of extending best agronomic practices; and 4) address relevant policy issues concerning agri-input supplies and marketing strategies.

Promotion of vegetable farming as an economically viable activity and income source requires the organization of producers’ groups to achieve efficiencies in purchasing inputs and marketing outputs. To build up the vegetable sector in Azerbaijan, which need to respond to the market economy, the following interventions are imperative:

- Train farmers on the appropriate use of inputs and agronomic packages of selected vegetables having a high gross margin in markets.
- Establish marketing databases on vegetables and input use in the republic and the region, potential demand by the republic and the region, supply sources from neighboring countries, and international prices.
- Train farmers and dealers on marketing basics including market planning, promotion, pricing, handling and storage, selling skills, and customer recordkeeping.
• Build associations for leasing services on farm machinery, equipment and storage facilities.
• Accelerate credit facilitation to farmers, dealers and processors with the support of suitable credit organizations.
• Strengthen extension services in production, post-harvest handling, processing, marketing and exporting.
• Encourage the private sector to engage in agricultural inputs, vegetable seeds, packing materials, and vegetable processing.
• Inform public authorities about needed policy changes for vegetable-related inputs and outputs, and research.
• Reinforce and modernize both private and public vegetable variety improvement programs.
• Allocate funds for improving vegetable research programs for both open-field and protected vegetable production systems.

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Research and Development of the Vegetable System in Azerbaijan

Lalazar Sadikhova
Azerbaijan Research Institute of Vegetable Growing, Sov. No. 2, pos. Pirshagi, Baku, 1098, Azerbaijan

Introduction

Crop production and livestock husbandry are the basic sectors of agriculture in Azerbaijan. Grain, cotton and vegetable cultivations prevail in the country. Azerbaijan has favorable climatic conditions for vegetable cultivation; however, this potential is not fully expressed and proper attention has not been paid to increasing production levels.

In the 1960s, special attention was focused on the cultivation of early maturing vegetables for markets in Moscow, Saint Petersburg, Baku and other large industrial centers of the former Soviet Union (Seidov 1968). Vegetable cultivation then was concentrated in Lenkoran-Astarinskaya and Guba-Khachmazskaya regions where more than 95% of vegetable production of the republic took place. During this period, a special emphasis was placed on the improvement of vegetable seed production, and eight state-run seed farms established to meet the demand for seeds of tomato, cabbage, onion, eggplant and other vegetable crops (Ismailov 1966). After that, the growing areas and average yields of vegetables maintained at more or less same levels.

Now more than 30 species of vegetables are widely cultivated with their 84 released varieties and hybrids. Priority vegetables in the country are tomato, onion, cucumber, cabbage, string bean, cauliflower, eggplant, sweet pepper, hot pepper, and leafy greens. Vegetable crops are cultivated practically all year-round in open fields and protected facilities. At present, vegetable crops are mainly produced in Gandzha-Kazakhskaya, Apsheronskaya, Guba-Khachmazskaya, and Lenkoran-Astarinskaya regions.

Vegetable Production and Research after Independence

In the early years of Azerbaijan’s independence, the republic suffered greatly from food deficiency. At that time, production levels of potato, vegetables and melons met only 33%, 62% and 40%, respectively, of the demand. After that time, a number of private farms, production cooperatives, small enterprises, and companies have started to produce vegetables in addition to home gardening. In 1997, there were 1,463 production cooperatives, 2,062 small enterprises, 17,974 private farms (Aliev 2004).

Having been granted with their share of land and property, the farmers were given an opportunity to decide what kind of farm management would be most advantageous to be engaged in. Many chose to focus on providing the urban population with a year-round
supply of vegetables. From 1994 and 2004, vegetable production area increased by 77,800 ha, average yields increased by 2.1 times, and annual production volumes have rose to 1,055,700 t.

Some positive changes have also taken place in the processing industry. In the first phase of agrarian reform, about 100 processing enterprises were privatized. Today the products processed by the domestic enterprises meet the international standards. These products are traded in local markets and exported to the Commonwealth of Independent States (CIS), Europe and the USA.

In the course of agrarian reform, considerable structural changes have taken place. The Azerbaijan Agrarian Scientific Center incorporated 14 other agrarian research institutes in 1999. The Center is dedicated to improving research efficiency and increasing agricultural production. Moreover, a grant system was set up to encourage priority research areas, including vegetables, and to ensure scientific results.

Besides educating students, the Agricultural Academy of Azerbaijan conducts research on production of vegetables such as bean, onion, greens, tomato, beet and cabbage. Program directions focus on breeding, cultivation technology, as well as the collection and evaluation of indigenous species and varieties.

One of the important factors that accelerated the development of the country’s vegetable farming was the importation of high-yielding varieties and greenhouse facilities, mainly from Israel, Holland and other European countries. Vegetables are now grown year-round, satisfying not only the needs of the local population but also being exported to foreign countries. The export of vegetables increased from 10,000 t in 1993 to 24,000 t in 2003. Greenhouse farming has appeared to be more profitable compared to open-field farming and the number of greenhouses in operation increases yearly.

Despite some progresses in vegetable growing in the past ten years, the cropping systems still lack proper machineries, fertilizers, pesticides, plant protection facilities, and micro-credit. Furthermore, research capacity in variety development, soil fertility management, and seed production need to be strengthened through information exchange and training. Above all, an improvement of the marketing system is imperative. Toward this end, it is necessary to: 1) improve the legislative foundation of agrarian sector; 2) organize marketing consultative agencies in villages; 3) create associations of rural commodity producers and marketing cooperatives of farmers; and 4) expand the network of wholesale trade structures dealing with procurement and realization of agricultural production and organize training courses for managers.

Genetic Resources

Nowadays the conservation of indigenous genetic resources of vegetables is an important task. From 1975–1985, due to insufficient storage conditions, the large portion of collected vegetables was transferred to the All-Union Institute of Plant Industry (now
the N.I. Vavilov All-Russian Research Institute of Plant Industry [VIR]). Some accessions disappeared because of inappropriate storage conditions in the republic. Now vegetable genetic resources are conserved in the Azerbaijan Research Institute for Vegetable Growing, the Agricultural Academy of Azerbaijan, and the Institute of Plant Genetic Resources (IPGR).

Since 1995, IPGR has been conducting collection, regeneration, multiplication and utilization of indigenous plant species and varieties, with considerable efforts on wild relatives of cereals, legumes and vegetables. The national genebank was established to carry out conservation of genetic resources of agricultural crops. Due to the lack of finances, however, it is not possible to conduct regular collection expeditions. IPGR has started inventory and documenting the gene pool available. Presently 910 accessions have been documented, including 89 local and 98 local ancient varieties, 132 varieties developed in the republic, 30 introduced accessions, and 49 wild species. Now 700 accessions are conserved in the working collection. The database has been created for existing accessions in accordance with international standards. The work on establishing an inventory and database continues.

Azerbaijan falls in the Front-Asian center of origin of plants such as grains, beans, vegetables and melon crops (Vavilov 1987, Aliev 1988). In particular, fennel, savory, melon, sorrel, borage, asparagus, leek onion, bulb onion, garlic, carrot, coriander, spinach, beet, chard, spearmint, basil, purslane, rhubarb, and others originated here. These crops grow wild in natural conditions, and at the same time they are grown in home gardens and farms. However, the area and number of their wild relatives are reducing, and the issue of crop conservation has a great theoretical and practical importance.

A large diversity of indigenous varieties possessing a complex of valuable treats is widely represented in the country. There are about 200 vegetable and melon varieties and most of them are used by local population.

**The Solanaceae family**


Winter cherry (*Physalis alkekengi* and *P. angulata*) grows wild, but *P. alkekengi* is cultivated in some places. They are used as medicinal plants.

*Solanum tuberosum* (potato) and *S. melongena* (eggplant) are widely cultivated, whereas *S. nigrum*, *S. persicum*, and *S. cornutum* grow wild. About 500 accessions of *S. melongena* are conserved, including released varieties of ‘Lenkoranskiy’, ‘Ahsuinskiy mestnii’, ‘Nakhichevanskiy mestnii’, ‘Atabeki’, ‘Idrisi’, ‘Zakhra’ and ‘Gandzha’.

Both sweet and hot peppers (*Capsicum annuum*) are cultivated. About 300 acces-
sions are conserved. Two released varieties have an identical name: ‘Apsheronskiy mestnii’ for sweet and hot pepper. Other released varieties include ‘Muradi’, ‘Shafo’ and ‘Yadigar’ sweet pepper; and ‘Nakhichevanskiy mestnii’ and ‘Gekgel’ hot pepper.

**The Brassicaceae family**


There are 100 accessions of cauliflower in the gene pool. Three out of four local varieties have disappeared and one variety is on the verge of disappearance. Root crops such as winter radish (*Raphanus sativus*) and turnip (*Brassica rapa*) are cultivated also.

**The Apiaceae family**

Parsnip (*Pastinaca sativa*) is cultivated throughout the country. Wild carrot (*Daucus carota*) could be found in all areas from lowland up to highland.

There are 117 accessions of table carrot (*Daucus sativus*) of diverse geographic origins in the collection. Among them are five released varieties (‘Apsheronskaya mestnaya’, ‘Apsheronskaya zimnaya’, ‘Jubileynaya’, ‘Mestnaya banovshei’, and ‘Nakhichevanskaya mestnaya’).

**The Chenopodiaceae family**

An interspecific hybrid of table beet (*Beta vulgaris* var. *conditiva*) and chard (*B. vulgaris* var. *cicla*) has purple pulp coloration and is high yielding. Its big, juicy, beautiful petiole is attractive to consumers. Perennial beet (*B. vulgaris* subsp. *maritima*), red goosefoot (*Chenopodium rubrum*), city goosefoot (*C. urbicum*), garden orach (*Atriplex hortensis*), and wild spinach (*Spinacia tetrandra*) can be found in the republic.

**The Alliaceae family**

There are 43 species of *Allium* in Azerbaijan and six from them are endemic. Almost all alliums are edible. Bulb onion (*A. cepa*) and ancient garlic (*A. sativum*) are cultivated throughout the republic.

an indigenous leek; and ‘Djalilabads’k’i mestnii’, ‘Ismaillinskiy mestnii’, and ‘Nakhichevanskiy mestnii’ are indigenous garlic varieties. The onion varieties (‘Kabakusarchaiskiy’, ‘Sabir’, and ‘Winter Kusarchaiskiy’), and garlic varieties (‘Djalilabads’k’i’ and ‘Kusarchaiskiy’) were developed. The recently released bulb onion varieties are ‘Govsianskiy’ (‘Apsheron’), ‘Khachmazski mestnii’, ‘Masallinskiy’, and ‘Sabir’; while garlic variety ‘Djalilabads’k’i’ is another recent release.

The Fabaceae family

String bean (Phaseolus vulgaris) is widely cultivated. The gene pool contains 1,000 introduced and local varieties, including 130 indigenous varieties. The widely cultivated varieties are ‘Chil piyada’ (bush bean) and ‘Chil atly’ (curling), and the recently released varieties are ‘Sevindj’ and ‘Zulal’.

There are 500 accessions of vegetable pea (Pisum sativum) in the collection, including three indigenous varieties, which are on the verge of extinct. One breeding variety, ‘Fidan’, has been recently released.

Other vegetables

There are other diverse vegetable greens in Azerbaijan such as dill (Anethum graveolens), head and leaf lettuce (Lactuca sativa var. capitata and var. secalina), spinach (Spinacia oleracea), garden cress (Lepidium sativum), asparagus (Asparagus officinalis), sorrel (Rumex acetosa), celery (Apium graveolens), and parsley (Petroselinum crispum).

Rhubarb (Rheum ribes and R. rupestre) is grown only in Nakhichevan. These two species were widely used in Arabia and Iran as food in ancient times.

There are 27 species of buckwheat (Polygonum) growing wild in Azerbaijan. Among them, P. heterophyllum with local names of ‘gyrh bugum’, ‘yolotu’ or ‘hyrman out’ is used as a condiment. Oxyria elatior grows wild and is used as sorrel, and Urtica dioica (nettles) as an herb plant.

Popular spicy plants include caraway (Carum narvi), anise (Pimpinella anisum), borage (Borago officinalis), mustard (Brassica juncea), white mustard (Sinapis alba), coriander (Coriandrum sativum), fennel (Foeniculum vulgare), basil (Ocimum basilicum), origanum (Origanum vulgare), hyssop (Hyssopus angustifolius), lemon balm (Melissa officinalis), tarragon (Artemisia dracunculus), and black mustard (Brassica nigra).

The aforementioned wild species and local varieties have been used for developing improved lines with resistance/tolerance to extreme abiotic conditions and biotic factors, high-yielding potentials, and other preferred qualities.
Vegetable Research Institutes

Plant protection is an important direction in republic. During 2001–2005, the Azerbaijan Research Institute of Plant Protection worked on five research themes on the development of integrated measures against insect pests, diseases and weeds.

The Azerbaijan Research Institute of Vegetable Growing (ARIVG) was established in 1965 under the coordination of the Agrarian Scientific Center and the National Academy of Sciences of Azerbaijan. ARIVG engages on research strategies for vegetable, melon and potato growing; development of new high-yielding varieties; integrated pest management; seed growing methods; and cultivation technologies that meet with soil-climatic conditions of diverse geographic zones of the republic. Priority crops for research include tomato, eggplant, cucumber, pepper, table beet, carrot, bean, pea, bulb onion, garlic, cabbage, cauliflower, lettuce, chard and greens, and fennel.

ARIVG has 11 separate labs of breeding, seed growing, agro-technology for open-field and protected cultivations, plant protection, agricultural chemistry, physiology, biochemistry, crop rotation, mechanization, potato growing, and post-harvest processing. There are three other groups working on resistance of crop plants, information and crop introduction. ARIVG has regional stations in Lencoranskaya, Kusarchaiskaya, Tayzskaya and Shamkirskya regions, and an experimental farm in Apsheron.

Breeding efforts focus on the development of high-yielding and disease-resistant varieties of tomato, cucumber, eggplant, pepper, onion, bean, cabbage, garlic and others for different eco-geographic zones. These efforts involve close cooperation among breeders, geneticists, physiologists, entomologists, biochemists and production technologists. So far, ARIVG has developed 50 varieties of vegetable and leguminous crops and released 35 varieties. Distinguished varieties are tomato (‘Elim’, ‘Ilkin’, ‘Veten-1’, ‘Leila’, ‘Venevsha’, ‘Zardabi’, ‘Ilyas’, ‘Shahin’, and ‘Elnur’), eggplant (‘Zakhra’ and ‘Gyandzha’), pepper (‘Murad’, ‘Gekgel’, ‘Shafa’ and ‘Yadigar’), cabbage (‘Erken’ and ‘Sakhil-104’), onion (‘Sabir’), bean (‘Zulal’ and ‘Sevindzh’), pea (‘Fidan’), and dill (‘Otello’), and fennel (‘Agdjabedy’). At present, 15 varieties of various crops are under state variety testing.

Research efforts of agricultural chemistry are to seek the optimum rates of organic and inorganic fertilizers for cabbage, table beet and carrot. The results revealed 20 t manure, 180 kg N, 160 kg P, and 100 kg K per ha were optimum, producing peak yields of beet at 42.6 t/ha and of cabbage at 38.0 t/ha.

The physiology lab researches on the effect of photosynthesis on quality and productivity of vegetable crops, salt and drought tolerance of tomato and eggplant, and microflora of sown vegetable seeds.

The agro-technology lab researches on the optimum sowing and cultivation methods of released varieties of cauliflower, tomato, eggplant, bean, pea, onion, pepper, cucumber and greens. New cultivation technologies were introduced to Lenkoran-Astarinskaya, Kuba-Khachmazskaya and Gyandzha-Kazakhskaya regions with high yields of tomato.
RESEARCH AND DEVELOPMENT OF THE VEGETABLE SYSTEM IN AZERBAIJAN

The agro-technology and mechanization labs have received 30 license certificates, and have published 10 volumes of scientific works, monographs, brochures, articles and 20 recommendations on vegetable crop cultivation.

ARIVG collaborates closely with VIR, Research Institute of Plant Protection, Research Institute of Breeding and Seed Growing of Vegetable Crops, Research Institute of Potato Farming in Russia, Moldavian Research Institute of Irrigated Agriculture and Vegetable Growing, Byelorussian Agricultural Institute, Ataturk Central Horticultural Research Institute in Turkey, International Potato Center (CIP), and Academy of Sciences of Azerbaijan.

The government is taking actions to improve research capacity of the republic. However, in comparison with other countries, the investment in agrarian research is insufficient in Azerbaijan. The total financing for vegetable research is around US$135,500. Although the World Bank provides some funds for vegetable research, more investment in the development of cultivation practices for open-field and protected cultivation and to modernize the seed production system is necessary.

Future vegetable system research and development should include collecting and exchanging genetic resources, screening of genetic resources for desirable traits, improving varieties, modernizing the seed production system, exchanging information and expertise with foreign research centers, training for modern research methodologies, and collaborating with the private sector. Moreover, the republic needs the following: set-up of specialized service agencies, provision of modern machines and equipment, establishment of modern production and processing systems, production of packing material and containers for processing industry, organization of private agricultural research centers, allocation of soft loans, and formation of joint production enterprises with foreign partners.

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Economic and Social Context of the Vegetable System in Georgia

Jemal Makharadze and Guram Gurgenidze
Institute of Economics and Agro-Industrial Complex Management, 82, Chavchavadze St., Tbilisi 380062, Georgia

Introduction

Georgia, with a total area of 69,490 km², is located in the Caucasus region in the southeast of Europe, stretching between 41° and 44° N latitude and 40° and 47° E longitude. The republic is bordered by Russia in the north, Azerbaijan in the southeast, Armenia and Turkey in the south, and the Black Sea in the west.

Georgia’s population is 4.7 million. About 48% of them were classified as rural. Agriculture plays an important role in the Georgian economy. In 2004, the sector contributed about 20% of the republic’s gross domestic product (GDP). Employment in the sector accounts for 54% of total employment. Agricultural exports, including limited quantities of fruits, tea, potato and tobacco, share 5.6% of total exports.

Natural Resource Base

Georgia is mountainous (Greater Caucasus and Lesser Caucasus) with lowlands and river basins. Land resources are divided into several territorial zones: I (up to 250 m above sea level [asl]) is an area in western Georgia where subtropical crops prevail; II (250–500 m asl) comprises gardening, vegetable farming, viticulture, and intensive maize production; III (500–1,000 m asl) includes grain crops, natural produce farming, and animal husbandry; IV (1,000–1,500 m asl) comprises pastures and hayfields, with field crop production somewhat developed; V (1,500–2,000 m asl) mainly comprises pastures and hayfields; and VI (over 2,000 m asl) where no arable farming is practiced. In terms of utilization, the Georgian territory can be divided into three parts: natural habitat with forests, bushes, pastures and hayfields (70.6%); arable lands (15.8%); and non-agricultural lands (13.6%). Of the 0.8 million ha of arable land, 44% is irrigated. Arable lands differ by zones of agricultural specialization. The highest share of cultivated lands is in the peri-urban areas of Tbilisi, Rustavi and Kutaisi (26% of the total). Currently, reclamation activities are conducted in western Georgia and programs to prevent soil erosion are ongoing in eastern Georgia.

The soils in Georgia are moderately fertile and easily tilled. Its climate is extremely diverse, considering the republic’s small size. But in general, the climate is reasonably mild with adequate heat units, day length and growing days to produce a wide variety of crops. There are two main climatic zones, roughly separating the eastern and western parts of the country. The Greater Caucasus Mountains play an important role in mod-
erating Georgia’s climate and protects the nation from the penetration of colder air masses from the north. The Lesser Caucasus Mountains partially protect the region from the influence of dry and hot air masses from the south. Georgia, with an average rainfall of 1,065 mm/year, can be divided into two climatic regions:

**Western Georgia.** Much of it lies within the humid subtropical zone with an annual precipitation ranging from 1,100-1,700 mm. The precipitation tends to be evenly distributed throughout the year, but can be heavy during the autumn months. Drainage of excess water is one of the main problems for agriculture in this part of the country. The climate of the region varies significantly with elevation. Much of the lowland areas are relatively warm throughout the year. Winter is mild and warm while summer is relatively hot. Average temperatures vary between 5°C in January and 22°C in July; the mean annual air temperature is 15°C. The foothills and mountainous areas experience cool, wet summers and snowy winters.

**Eastern Georgia.** It has a transitional climate ranging from humid subtropical to continental. The region’s weather patterns are influenced both by the dry, Central Asian/ Caspian air masses from the east as well as the humid, Black Sea air masses from the west. The penetration of humid air masses from the Black Sea is often blocked by several mountain ranges that separate the eastern and western parts of the nation. Annual precipitation is considerably less than that of western Georgia and ranges from 400–1,100 mm. The wettest periods generally occur from March to October, while winter and the summer months tend to be the driest. Drought periods are common. There is a need for irrigation in the areas where precipitation is less than 800 mm/year. Average temperatures vary between –1°C in January and 22°C in July. As in the western parts of the republic, elevation plays an important role in eastern Georgia as well, and climatic conditions above 1,500 m asl are considerably cooler than those of the low-lying areas. The regions that lie above 2,000 m asl frequently experience frost even during the summer months.

Georgia can be divided into two main river basin groups: 1) the Black Sea basin in the west with the main rivers running from north to south; and 2) the Caspian Sea basin in the east with the main rivers running from north to south. The base of its hydrographic network consists of small rivers, each with a length less than 25 km, and total length 50,480 km. Total natural river runoff from the territory of Georgia is 56.4 km³ and to the territory (from Armenia and Turkey) is 8.74 km³. Thus, total water supplies amount to 65.4 km³.

Because of its varied natural conditions, Georgian flora is known for its diversity with 4,200 to 4,500 species of vascular plants. Of all vascular plants found in Georgia, 380 (9%) are endemic to the country and 600 (14.2%) to the Caucasus. The high level of endemism can be attributed to the physical characteristics of the central and eastern parts of the Great Caucasus, and to the ecological and geographical isolation of certain ecosystems. About 2,000 species of Georgian flora are of economic importance. Through natural selection and with the age of human selection, Georgia has a variety of indigenous vegetables that adapt to specific ecological conditions in different zones of the country.
Crisis in the Agricultural Sector

Agriculture has always played an important role in the Georgian economy. Nevertheless, Georgia has undergone drastic changes in the past 10 to 20 years. In the wake of independence, three separate internal conflicts tore the republic apart just as it was struggling to establish itself as a sovereign nation. Civil strife continues to wreck the lives of countless Georgians and the ensuing state of unresolved conflict is having devastating consequences. Agricultural/agribusiness output is down 30 to 40% from the levels of the late 1980s. Many crops such as fruits, vegetables, sugar beets, grapes and tea have experienced substantial production declines (60–90%), due in large part to a loss of the former Soviet Union markets, scarcity of rural credit, and a breakdown of the processing industry (partly due to the high cost of fuel). This has driven the farmers to rely on a near-subsistence economy, and led consumers to increase their consumption of inexpensive food commodities such as fruits, bakery products, and vegetables, and decrease consumption of meat and dairy products. The nutritional security of the Georgian population is being jeopardized because of this.

There are a number of constraints impeding agricultural sector growth and supporting a drift toward subsistence level production. Some major ones include 1) lack of financing as it affects input suppliers, producers, and value-adding processors; 2) limited input supplies for fertilizers, pesticides, quality seeds and new technologies; 3) little investment from both public and private sectors for modernization and re-capitalization of the agricultural infrastructure; 4) marketing problems such as identification of potential markets, trading relationships with distributors, market information, and quality control; and 5) illegal imports and poor law enforcement.

Water is an important resource for agricultural production in Georgia. There are 34 reservoirs for irrigation in the republic. The reservoir/irrigation system that was first established in the 12th century (for about 60,000 ha of land) and later articulated for an extensive land area during the Soviet period has seriously deteriorated, both from neglect and uncertainty over operational responsibility. The regional water enterprises lack the resources to carry out the operation of the system and the area under irrigation declined in the recent years. Only a few local water user associations have emerged. In those irrigation systems that are functioning, water use is relatively inefficient and fee collection is often a problem. Further declines are anticipated unless investments in repair and maintenance are made along with efforts to decentralize control.

Land Privatization

Georgia’s land privatization program, as part of the economic reform, started in 1992 with the government’s Resolution 48. According to the Agricultural Census of Georgia (2004), 886,766 ha (i.e., about one-third of agricultural land) had been transferred to 1,040,000 households. Because land tenure law and security of land ownership are not well defined, however, many farmers lack the necessary documentation for their plots. Typical sizes of these farms are small, about 1.25 ha. About 84% of the rural population
is dependent on these subsistence farms, where about 80% of the produce is self-con-
sumed.

Ownership of the remaining two-thirds of agricultural land is held by the republic. Just
over one-half of this state-held land is leased (meaning that a little over one-third of
agricultural land is leased) to 16% of the rural population. The leased land is a mixture of
arable land and land in perennial crops, pasture and hay. In general, the large farms in the
leased land tend to be underutilized due to lack of credit. The remaining one-third of
agricultural land, primarily pasture land, is still held by the state and not leased out.

The current pattern of private land holdings is highly fragmented and mixed. To pro-
mote the development of commercially viable farms and further improve land utilization,
however, the consolidation of land holdings among rural residents, the privatization of
state-held leased land, and the development of a land market may be necessary. The
agricultural sector development in Georgia will hinge on how well these land issues are
integrated into a broader development agenda.

**Current Vegetable Production and Marketing**

Vegetables have been an integral part of Georgian diets since ancient times. There were
artifacts and historical records that indicate various types of vegetables and growing
methods used over the past two millennia in the country. The organized vegetable sector
in Georgia was developed in the 19th century when the irrigation system in the country
was fully articulated and the railway constructed in the Caucasus. In the 1860s, *Tsiskari*
(1861, No. 8 and 9) and *Gutnis deda* (1867, No. 1), two of major magazines at that time,
even suggested the construction of greenhouses to produce tomato and cucumber seed-
lings.

Georgia’s vegetable sector was well developed in the 1950s with the establishment of
specialized vegetable farms according to the national plan of the agricultural develop-
ment. Before independence, more than 90% of vegetables in Georgia were produced on
state farms. However, at present, almost all vegetables are produced using manual meth-
ods in open fields of private farms located in all regions of the republic. Currently, Georgia’s
annual vegetable production in 2004 was around 475,000 t from about 50,000 ha of irri-
gated land (State Department of Statistics 2004). The major ones were tomato (23%),
watermelon (23%), cabbage (20%), cucumber (16%), onion (5%) and carrot (1%). The
main months of vegetable production are from April to November. For the rest of the
year, there is a short supply of fresh vegetables. The yearly supply of vegetables in 2003
was 83.2 kg/capita, which is the second lowest amount in the Central Asia and Caucasus
(CAC) region (Tajikistan is the lowest at 81.5 kg/capita, and Armenia the highest at
185.4 kg/capita). Georgia’s average yield of vegetables of 9.6 t/ha in 2005 was the low-
est among the CAC republics. During the past five years, vegetable production and
yields have declined in Georgia. One reason for this is the lack of inputs used on veg-
etable farms due to lack of cash.
To offset the seasonality of vegetable supplies in Georgia, vegetable growers operate storing and/or processing operations of some vegetables. The prevailing processing methods include pickling or salting of cabbage, cucumber and tomato. On the other hand, due to the short supply of vegetable products and financial resources in recent years, the once-thriving packaging and canning industries of vegetable products have waned. In 2004, Georgia produced 3.1 million cans of vegetable products, mainly tomato paste, vegetable sources and pickled vegetables. This amount is a mere 1% of what had been produced before independence. Most processed vegetable products today are for domestic consumption; only 2.1% are exported.

Georgian processors have not been very successful in developing new markets to replace those lost as the Soviet Union broke apart. Sanitation, packaging and quality standards in the West make it difficult for Georgia to enter these potentially lucrative markets in the near term. The problems of outdated, inefficient and oversized facilities and the costs associated with transportation, customs and corruption also make Georgian products expensive, when quality is considered. As a result, it is often difficult for Georgian goods to compete with goods from the West. A general lack of marketing expertise has added to the marketing difficulties.

Before its independence, Georgia exported a significant volume of early potato, early vegetables, and fruits, and their processed products to the other republics of the Soviet Union. However, exports to Russia and other countries of the former Soviet Union have plummeted in recent years. Instead, during the past decade, a huge volume and wide assortment of food commodities have been imported to Georgia, through either legal channels or smuggling. The total value of imported vegetable products in 2003 was about US$4 million; it exceeded by a factor of 4.3 the total value of exported vegetable products. Unfortunately, at present, there are no effective mechanisms to ensure the quality and safety of imported vegetable products.

Currently, the availability of information about vegetable markets remains limited. Only a few Georgians are aggressively seeking marketing information, and information about marketing opportunities is not reaching growers. During the period between the 1960s and 1980s, Georgian National Alliance of the Consumers (Tsekavshiri) had made a significant contribution to the vegetable sector. Around 35% of vegetables produced then in the republic were marketed through this alliance. It had engaged in contracting, scheduling, financing, purchasing, product treatments, processing, quality control, price control, and distribution of vegetables to ensure the supply of quality vegetable products in a timely order. It had received acclaim from its clients located in the cities, industrial centers, and resorts in Georgia and neighboring republics. Tsekavshiri’s entrepreneurship was the first of its kind in Georgia. Unfortunately, it is less active now. Its mode of operation needs to be reactivated in the country.
Vegetable Seed Sector

Before its independence, Georgia had certain levels of vegetable breeding research, seed production, and regulatory activities. Vegetable seeds, along with other crops, were produced on the 50 selected collective farms and vegetable breeding activities were assigned to a couple of breeding stations.

From independence to the civil war period (1991–1999), the government-operated seed supply system was largely stifled. Breeding activities were also at a standstill. The quality of the seed in the breeding pipeline, from much-recycled breeder seed to elite seed, was quite variable. Seed farms had no access to reasonably priced credit for working capital. In other words, seed farms became privatized by default, because they could not obtain resources from the state as they used to do, and because there had been no maintenance and replacement of equipment. Regulatory services of the Variety Testing and Seed Quality Inspection Commissions had also practically ceased to function, with the result that much seed was sold with either incorrect or no certificates.

Much of the seed used by farmers today is of poor quality and highly variable, contaminated with seed-borne diseases and weeds, and generally poor in vigor. Furthermore, because farmers lack financial resources to buy seed, there are no perceivable markets for the seed producers to sell their seed. Some vegetable seed is being imported through legal channels but demand for vegetable seed is also being met by illegal imports, though quantities are unknown. Unfortunately, these vegetable seed prices are quite high when compared with international norms.

To reverse the declining trend in the entire seed sector, the government, with assistance from various international organizations, strives for a series of approaches, including breeding, testing, production, inspection and certification, training and technical assistance. The government is promoting the seed industry, and acting as a regulator and facilitator without taking the risk of seed production. At present, Research Institute of Farming is the main center of vegetable breeding in Georgia. The Institute’s breeding efforts focus on bean, tomato, cucumber and pepper, and are producing a limited quantity of seed. In addition, Georgian State Agrarian University and a couple of breeding stations also carry out some vegetable breeding activities. Only the local germplasm banks are major sources for the vegetable breeding programs. Much of vegetable breeding programs do not receive germplasm from international cooperators.

Future Perspectives

Georgia joined the World Trade Organization (WTO) in 2000. Theoretically, this membership will provide opportunities for investors to develop export markets. Despite these positive initiatives, economic activity in Georgia is still below its potential. The poor fiscal situation has inhibited investment in the agricultural sector. Problems with fiscal policy have affected macroeconomic conditions in general and the agricultural sector in particular. The situation is aggravated by some countries unilaterally banning imported prod-
ucts from Georgia at the same time that exporting countries are shipping vegetables to Georgia at very low prices. All of these disrupt the development of the vegetable sector in Georgia. Looking to the future, a 20% increase of vegetable production by 2010 is feasible using the following measures:

- Develop national vegetable sector policies and strategies, including research and development programs on production and consumption.
- Reactivate national vegetable variety testing and registration programs, starting with niche commodities.
- Strengthen the vegetable seed sector, including national seed quality inspection and seed supply programs for both public and private sectors based on market needs.
- Develop credit and contractual mechanisms that facilitate flows of vegetable products between producers and consumers through a sound value-chain system.
- Develop producer associations and value-adding enterprise associations to promote year-round supplies and increased exports of vegetables.
- Provide training on quality/safety standards, including information on brand development and product design, equipment needs, production techniques/efficiency and packaging.
- Manage a loan fund that will facilitate value-adding enterprise development or producer/processor linkages.
- Develop a prototype for a market information system that includes price information and situation outlooks.

**Literature Cited**

Research and Development of the Vegetable System in Georgia

Alexander Saralidze, Nato Kakabadze, Len Nozadze, Zurab Dzhindzhihadze, and Tinatin Kuprashvilli
Georgian Research Institute of Crop Husbandry, 126, Abanidze St., Tbilisi, 380000, Georgia

Introduction

Georgia (41°07’–43°35’ N, 40°51’–61°44’ E) is ruggedly mountainous. The Greater Caucasus Mountains stretch across the northern third, while the Lesser Caucasus Mountains dominate the central and southern landscape. The land area of the country is 69,700 km², 54% of which is mountains, 33% foothills and only 13% plains. Georgia’s climate is affected by subtropical influences from the west and Mediterranean influences from the east. The Greater Caucasus Mountain range moderates local climate by serving as a barrier against cold air from the north. Warm, moist air from the Black Sea flows into the coastal lowlands from the west. Climatic zones are determined by distance from the Black Sea and by altitude.

There are three distinct agroclimatic zones (Ketskhovelli 1957) (Table 1). Along the Black Sea coast, the dominant subtropical climate features high humidity and heavy precipitation. The plains of eastern Georgia provide a more continental climate with moderate rainfall. Alpine and highland regions in the east and west are cold (Table 1).

Table 1. Agro-climatic characteristics of vegetable crop cultivation zones

<table>
<thead>
<tr>
<th>Crop cultivation zones</th>
<th>Elevation (m)</th>
<th>Avg annual day air temp. (°C)</th>
<th>Cumulative air temps. above 10°C</th>
<th>Vegetation period (days)</th>
<th>Precipitation (m)</th>
<th>Vegetation period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Annual</td>
<td></td>
</tr>
<tr>
<td>Western Georgia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone I (humid sub-tropical)</td>
<td>0–250</td>
<td>13.3–14.7</td>
<td>4,001–4,526</td>
<td>231–247</td>
<td>1,345–2,427</td>
<td>716–1,755</td>
</tr>
<tr>
<td>Zone II (moderate warm)</td>
<td>250–1,000</td>
<td>11.2–13.9</td>
<td>3,607–4,330</td>
<td>201–230</td>
<td>830–1,366</td>
<td>664–757</td>
</tr>
<tr>
<td>Zone III (alpine cold)</td>
<td>1,000–2,100</td>
<td>5.7–10.0</td>
<td>2,039–3,146</td>
<td>151–206</td>
<td>992–1,244</td>
<td>634–720</td>
</tr>
<tr>
<td>Eastern Georgia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zone I (humid sub-tropical)</td>
<td>up to 500</td>
<td>11.8–12.9</td>
<td>3,234–4,088</td>
<td>184–265</td>
<td>378–1,004</td>
<td>331–812</td>
</tr>
<tr>
<td>Zone II (moderate warm)</td>
<td>500–1,200</td>
<td>9.0–11.4</td>
<td>2,885–3,697</td>
<td>174–201</td>
<td>489–644</td>
<td>294–403</td>
</tr>
<tr>
<td>Zone III (alpine cold)</td>
<td>1,200–2,200</td>
<td>4.9–9.7</td>
<td>1,753–3,120</td>
<td>130–182</td>
<td>553–1,585</td>
<td>406–651</td>
</tr>
</tbody>
</table>

Vegetable Production

Vegetables are widely grown throughout the country, but production is most highly developed in Zones I and II, where large cities are located. In Zone I, many kinds of veg-
etables are grown in the open field. This zone used to be an area for export production of early maturing potato and other vegetables in the 1980s. There is a total area of 200 ha for year-round vegetable production in greenhouses.

Cabbage, tomato, bulb onion, and table beet are grown mainly in Zone II. About 43,430 people are engaged in the vegetable sector in the country. Yearly vegetable production is about 490,000 t, including 4,000 t used for seed production, 25,000 t for animal husbandry, 360,000 t for food provision, and 8,000 t for export. The vegetable harvested area in 2004 was 48,000 ha with an average yield of 10 t/ha (FAOstat data 2006). For the past 10 years, vegetable production decreased significantly but not growing area. This yield reduction is caused by the fact that mostly small farms are engaged in vegetable production. Small farms usually have difficulty accessing equipment, fertilizers, pesticides, new varieties, and quality seeds.

Vegetables are one of the major foodstuffs in Georgia. The annual vegetable supply per capita is about 93 kg. Their production has centuries-old history and there are unique vegetables from the country. Djavakhishvili (1934) and Ketskhovelli (1957) have identified 65 species of vegetables, many of them in wild forms, grown in Georgia. Many vegetables such as watermelon, melon, pumpkin, cucumber, radish, cabbage, onion, garlic, eggplant, parsley, basil, and chervil were introduced and now are widely cultivated. New varieties of these crops are also being developed (Jukovsky 1964). For several vegetables, both cultivated and wild forms are grown. For examples, some landraces of carrot, celery and turnip are grown at elevations of 1,500 m or higher. Wild relatives or indigenous species of sorrel, colewort (*Crambe* sp.), asparagus, sukhovey (*Hippomarathrum crispum*), mint, and purslane are grown and consumed. Unfortunately, some of these indigenous vegetables are less studied.

The Georgian Research Institute of Crop Husbandry (GRICH) and its three experimental stations at Gardaban, Gori and Tskhaltubo are engaged in vegetable variety improvement. Breeding efforts, involving hybridization and selection have resulted in a significant number of released varieties for many vegetable crops, including cabbage, tomato, eggplant, pepper, cucumber, bulb onion, carrot, and parsley that suit specific cultivation zones (Table 2). However, much more research is needed to cope with the increasing demand of vegetables. To further advance variety development, it is imperative to collect, conserve and fully utilize diverse indigenous vegetables, and to collaborate with advanced institutions in the management of genetic resources.

GRICH also engages in the development of cultivation technologies for all cultivation zones. Specific crop species and varieties as well as appropriate technologies are selected to meet climatic conditions of specific cultivation zones. A crop rotation system is being developed for improving soil fertility and reducing soil erosion. The system consists of two fields; one is planted with vegetables and other with a mixture of alfalfa and ryegrass. The fields are rotated every two years. Furthermore, minimal-tillage technology enables using lands unsuitable for plowing. Nowadays the proper use of herbicides, pesticides, and mineral and organic fertilizers for irrigated and rainfed conditions are under study, taking product safety and environment sustainability into consideration. Cur-
rently, the greenhouse vegetable production system is not fully extended due to high input costs.

Well before the 1990s, the socialist movement in the country led to the amalgamation of various agricultural organizations. Under this system, seed amalgamation “Gruzovoshsortsem” had stored and distributed crop seeds for the whole country. Within this system, GRICH and its experimental stations were involved in the primary and elite seed production. This amalgamation was dissolved in the 1990s and its lands were transferred to private farmers. Currently GRICH and its stations are involved in the primary seed production for their own needs and sale to the farmers.

To meet the increasing demand of enhanced vegetable production and improved product quality, future directions of vegetable research and development should focus on the following:

- Collect, conserve and characterize vegetable genetic resources.
- Access genetic resources from within and outside the country and employ modern breeding methods to develop both open-pollinated and hybrid varieties.
- Rehabilitate the vegetable seed production system.
- Collaborate with foreign research centers for enhancing vegetable system research capacity.

### Table 2. Released vegetable and melon crop varieties in Georgia

<table>
<thead>
<tr>
<th>Crop</th>
<th>Varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bean, French</td>
<td>Berbook</td>
</tr>
<tr>
<td>Cabbage, head</td>
<td>Borjomian ideal, Gori brownshweig, Harisgula, Likani, Verbukula</td>
</tr>
<tr>
<td>Carrot</td>
<td>Gori-nanti</td>
</tr>
<tr>
<td>Celery</td>
<td>Gruzinskiy</td>
</tr>
<tr>
<td>Coriander</td>
<td>Kutai</td>
</tr>
<tr>
<td>Cucumber</td>
<td>Ahaltsih, Muhranula, Shoo-sha</td>
</tr>
<tr>
<td>Dill</td>
<td>Suhumskiy</td>
</tr>
<tr>
<td>Eggplant</td>
<td>Gardaban, Oni, Shashlyk</td>
</tr>
<tr>
<td>Garlic</td>
<td>Giri</td>
</tr>
<tr>
<td>Eggplant</td>
<td>Gardaban, Oni, Shashlyk</td>
</tr>
<tr>
<td>Onion</td>
<td>Kahetitnian ploskiy, Lizzi, Marneuli, Mestnaya kartinskaya, Shvilissi, Wan</td>
</tr>
<tr>
<td>Parsley</td>
<td>Tkachirska</td>
</tr>
<tr>
<td>Pea</td>
<td>Oboladze 85</td>
</tr>
<tr>
<td>Pepper, hot</td>
<td>Kutai, Swenet</td>
</tr>
<tr>
<td>Pepper, semi-hot</td>
<td>Slonoviy hobot (Elephant’s trunk)</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>Gruzinskiy 54</td>
</tr>
<tr>
<td>Tomato</td>
<td>Aragvi, Pshavi</td>
</tr>
<tr>
<td>Watermelon</td>
<td>Kahetinskaya kruglaya (round), Muhianskiy</td>
</tr>
</tbody>
</table>

**Literature Cited**


Economic and Social Context of the Vegetable System in Kazakhstan

Serik B. Kenenbaev
Scientific-Production Center for Crop Husbandry and Plant-Growing RPG, 1 Erlipesov St., Almalyvakan settlement, Karasay district, Almata Province, 483133 Kazakhstan

Introduction

Kazakhstan’s 15.2 million people occupy a land area of 2.7 million km², stretching between 45° and 87° E longitude, and 40° and 55° N latitude. The republic is rich in land resources. More than 74% of the country’s territory is suitable for agriculture and forestry. Kazakhstan has 32.8 million ha arable land, which is about 8% of its total land area. About 14.0 million ha of this arable land is occupied by grain fields (43%); this makes Kazakhstan one of the world’s largest grain producers and exporters. Agriculture contributes about 10% of the republic’s gross domestic product (GDP) and employs over 20% of the labor force, primarily in rural areas. Forty-three percent of the population lives in rural areas, where poverty still prevails.

Natural Resource Base

Half of Kazakhstan’s land is in desert, one-quarter is in steppes, and the remaining quarter consists of mountains and foothills. There are three major inland seas (Caspian, Aral and Balkhash) fed by rivers in the south. Apart from the Tian Shan Mountain range along the southeast border with China and Kyrgyzstan, and forests and mountains to the east, there are no major physical barriers along the country’s borders.

The climate is continental and is characterized by cold winters, hot summers, and arid to semiarid conditions. Soils can be classified by zones and altitudes. The chernozem zone is in the north, and chestnut soils are located to the south. Annual rainfall varies from 100 mm in the northern steppes and central and southern arid areas to over 600 mm in the east and southern mountains. Most rainfall occurs in early summer. The average annual temperature ranges from 0.5°C in the north to 12.0°C in the south. The variation in the sum of active temperatures for crop cultivation is wide.

The vast territory of Kazakhstan has conditioned the diversity of natural conditions for an enormous biological diversity. From the diverse flora (about 5,700 species), there are more than 210 species of wild relatives of cultivated plants, including 14 vegetable species.

Kazakhstan has four major hydrological regions. The north/northeast region receives water from China and drains it across Kazakhstan to Russia. In the west region, water
flows in from Russia and drains toward the Caspian Sea. In the south/southeast region, water flows in from Kyrgyzstan and Uzbekistan, and together with flow generated in Kazakhstan, drains to the tributaries of the Aral Sea. Lastly about 25% of Kazakhstan’s area drains to internal depressions.

Kazakhstan’s climate makes irrigation a necessity in its fertile fields. Accordingly, irrigated agriculture was greatly expanded in Kazakhstan during the past century. About 70% of water in the republic is used for irrigated agriculture. There are 96,400 km of irrigation canals and 14,900 km of drainage canals. By the beginning of the 1990s, 2.3 million ha of land were irrigated, plus 1 million ha of irrigated pastures. The change from a centrally planned to a market-oriented economy, however, has had a negative impact on irrigated agriculture, resulting in a reduction of irrigated land by about 1 million ha, and a decline in water quality.

Recent Development in the Agricultural Sector

Although Kazakhstan’s territory is diverse, the natural and climatic conditions are favorable to growing a wide variety of crops as raw materials and foodstuffs. This has significant potential for financial rehabilitation, solvency of farmers and domestic manufacturers, and sustainable rural development. However, to unleash this potential, the sector must tackle a number of issues, among which are increased diversification of production, appropriate access to markets, greater know-how, improved technology, and the right scale of credit. At present, the primary agricultural regions are the north-central and southern parts of the republic.

The agro-industrial complex is a major economy in Kazakhstan, and one of the main forces for the country’s economic, social and political stability. However, the agricultural reforms of the early 1990s unfolded under rather unfavorable conditions. Price liberalization forced the lifting of food subsidies. This amounted to a 60–80% increase of retail prices for the major foodstuffs and to one-third of the national budget’s expenditure. As the liberalization proceeded, the prices for raw materials grew faster than the purchase prices in agriculture. Although the barter conditions in the sector became normal in length of time, shortage of credits, suspension of macroeconomic stabilization programs, and an ongoing recession in manufacturing have exacerbated the financial problem, which remains acute up to now. Besides, there is a lack of appropriate infrastructure in the value chain of agricultural products.

The agricultural sector saw its first big gains in 1999, which correlates somewhat with the pace of privatization and land law reform. A recorded rise in agricultural production occurred at this time. Crop production, which rose in real terms by an annual average of 19.5%, is responsible for most of this growth; one-fifth of this came from vegetables and melons. Over the past three years, a steady rise in the population’s living standards and an increase in the consumption of foodstuffs, including vegetables and melons, are on an upward trend. In 2002, the Kazakh people spent 3,641 tenge (US$1 = Kazak tenge 130) on potato, vegetables and fruits (12% of the total amount of consumer
expenses). This indicator exceeded the level of expenditure on dairy produce, eggs, fat and vegetable oil, sugar, tea, coffee, confectionery and spices (Rakhimbekov 2004).

Kazakhstan has embarked upon the restructuring of its agricultural sector through the establishment of new corporate entities and privatization. Private ownership is now the dominant type of organization for agricultural production. Currently, there are 70,000 farms, most of them in the private sector. About 61,000 farms have been transferred on the basis of long-term tenure, involving 27.2 million ha of land, 4,300 farming cooperatives and over 4,000 partnerships. Large farms account for 74% of land, small farms 19%, state-owned farms 6% and individuals 1%. In the last few years, the number of small holding farms swelled dramatically, most of them for vegetable crops (Turekeldiev 2001). Private farms are an essential source of direct farm employment for the rural population, employing about 2.6 million people (Baykatov 2003). They are also a main source of income for 6.5 million of rural population, and provide opportunities for off-farm employment.

Agricultural Development Programs and Farm Credits

Kazakhstan signed into effect an important land law in 2000. This law frees land from collective farming, provides freedom of choice concerning farming activities and product choice, and creates access to markets, materials, information, and finance. The overall effect of this law will be to drive up demand for capital goods, technology and fuel in this sector, particularly as farmers learn to take more risks with capital.

Recently, the Kazak government has also initiated two programs, the Agro-Food Program and Rural Development Program, with total budgets of 49 billion and 58 billion tenge in 2004 and 2005, respectively, to promote agricultural growth and rural development. These two programs have integrated agricultural policy with research, streamlined research institutions, and facilitated enacting laws for credit and privatization of farm-land. It is expected that the programs will increase production of potato by 12%, vegetables by 8% and melons by 11%.

Furthermore, the Agro-Industrial Complex has been set up to provide state assistance to farmers and manufacturers to ensure year-round security in food and nutrition for the republic’s population. Under this scheme, a number of financing institutions and leasing companies have been established (Baetova 2003). The Agrarian Credit Corporation has facilitated the establishment of 90 rural credit unions in 12 provinces. These credit unions strictly impose on the membership, loan, payment, security, etc., and their budgets amount to 1.6 billion tenge. Currently, about 3,000 farms with some 6 million ha of arable land are associated with the rural credit unions. On the other hand, KazAgroFinance, as a state leasing company with a charter capital of 6 billion tenge, is implementing leasing projects on agricultural machinery, special machinery, and agricultural products processing equipment; and financing projects of agricultural producers to upgrade the food-processing sector in terms of increasing supply and processing capacity. At present, the food processing industry is outdated with limited supplies of raw materials. It is for this reason
that the aforementioned two crediting systems were set up within the State Agro-Industrial Program.

In 2003–2004, 970.8 million tenge was also appropriated to subsidize the interest rate on credits allotted by the ten second-level banks toward the replenishment of circulating assets. This was to reduce the average interest rate of 14–15% for 138 domestic processing enterprises. The total sum of reduced credits reached 14.5 billion tenge. Among the banks, BankCenterCredit provided 4.7 billion tenge to 33 borrowers; Bank Turan-Alem 3 billion tenge to 31 borrowers; and KazCommerceBank 1.6 billion tenge to 20 borrowers.

In the period 2003–2004, 993 million tenge was earmarked to credit the leasing of farm equipment. The credits were given at an average interest rate of 3.5% to be repaid within seven years, benefiting 11 domestic enterprises specializing in the processing of agricultural products. However, the portion of leasing operations transacted in Kazakhstan still remains small, only 1% of the total volume of investment in capital assets.

Up to now, the agricultural sector cannot compete with other industries and therefore stands in need of a well-balanced state regulation policy. The food market’s dependency on imported foodstuffs is still high. To offset this trend and boost agricultural productivity, the government has appropriated 11 billion tenge in 2003, a 74% increase from the previous year, to reduce the costs of elite seeds, mineral fertilizers, herbicides and irrigation services.

**Current Situation of the Vegetable Sector**

**Vegetable production**

Kazakhstan produced 2.6 million t of vegetables in 2005 on 160,950 ha of cropping area, which is a 73% increase from the time of independence. The average vegetable yield in the republic was 17 t/ha in 2005. Major vegetables included tomato (18%), cabbage (13%), onion (12%), cucumber (10%) and melons (2%). Tomato occupied 18,000 ha with 360,000 t of production from 2.5–3.5 months of growing period. Tomato production concentrated in the south and southeast of the republic. As for the north, west, east and central parts of Kazakhstan, there is a constant shortage of fresh tomato.

Cabbage occupied about 25,000 ha with total production of 500,000 t, which almost meets the domestic demand. A small amount of early-ripening cabbage was imported. Processing and storage facilities for cabbage are well developed. An annual 478,900 t of onion production was harvested from 23,000 ha.

Protected production of off-season vegetables is facing the challenges of saving fuel costs and maximizing production efficiency. Kazakhstan imports vegetable marrow, eggplant, pepper, and some other vegetables.

Most vegetables are grown in the irrigated land in the southern and southeastern regions. About 70% of vegetable production is in Almaty, South Kazakhstan, Zhambyl
and East Kazakhstan oblasts (provinces). A small amount of vegetables is produced in Atyrau, West Kazakhstan and other provinces. Mangistau practically has no vegetable cultivation. Where the bulk of vegetable production is concentrated, consumption of vegetables exceeds the average national level. Starting in 1998, processing of vegetables tended to grow.

As of January 2004, there are 3,306 registered enterprises in food processing. Currently the volume of their products meets the domestic demand. The per capita supply of vegetables, including imported vegetables, in the republic is about 131 kg/year. Today, domestic production of vegetables meets about 70% of the requirement in the country.

Vegetable enterprises are mostly established in the piedmont zone in the south and southeast of the republic. Most of them are grown under multiple cropping systems. By factoring in stature, environmental requirements and maturities of the crops, often different types of vegetables are grown concurrently in small-scale farms. In contrast, on large-scale farms, vegetables are usually rotated with forage crops, legumes or potato, or intercropped with perennial crops. The legume-vegetable rotation has an edge over monocropping of vegetables. The former enriches soil fertility and provides organic matter for subsequent vegetables. An average vegetable yield in the rotation system could reach 21 t/ha.

Vegetable production, which generally runs from May to October, has dramatically shifted from state-run enterprises to private farms and household plots in recent years (Table 1). To reduce production costs and maximize profits, however, it is necessary to establish large-scale enterprises in the districts most favorable for growing specific vegetables. This will also facilitate establishing profitable value chains and restoring the vegetable canning industry. Socio-economic analysis indicates that vegetables from large-scale enterprises are at a competitive price with imported vegetables.

<table>
<thead>
<tr>
<th>Item</th>
<th>All farms</th>
<th>Agricultural enterprises</th>
<th>Private farms</th>
<th>Household plots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (000 ha)</td>
<td>108.7</td>
<td>102.6</td>
<td>6.3</td>
<td>22.8</td>
</tr>
<tr>
<td>Production (000 t)</td>
<td>1,856.0</td>
<td>1,544.0</td>
<td>70.0</td>
<td>344.0</td>
</tr>
<tr>
<td>Yield (t/ha)</td>
<td>15.6</td>
<td>13.5</td>
<td>11.8</td>
<td>15.4</td>
</tr>
</tbody>
</table>

**Pricing of vegetables**

The price of vegetables from November to May in Kazakhstan is high. And many neighboring republics are taking advantages of this with their vegetables imported to the republic. Recently there is a trend of reducing wholesale prices for vegetables. This is attributed to an increased supply from increasing yields and imports. Raising living standards of Kazakh people also have created demands for more fruits and vegetables.
Despite Kazakhstan’s increasing self-sufficiency in vegetables, there is an increasing trend of their retail prices. At present, the retail price of vegetables in the republic is about 2.4 times higher than the wholesale price (Table 2). The bulk of profits generated from the vegetable sector are in the hands of trading enterprises. An integration of the value chain of vegetables involving production, storage, processing, retailing and wholesaling will stimulate investment not only in the production but also in the development of value-chain infrastructure.

**Table 2. Comparative prices for 2003 (in tenge per kilogram)**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Price fixed by farmers</th>
<th>Import price</th>
<th>Retail price</th>
<th>Export price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>18.54</td>
<td>13.5</td>
<td>39.2</td>
<td>24.2</td>
</tr>
<tr>
<td>Carrot</td>
<td>19.78</td>
<td>12.8</td>
<td>41.4</td>
<td>22.3</td>
</tr>
<tr>
<td>Onion</td>
<td>11.25</td>
<td>31.2</td>
<td>41.3</td>
<td>13.8</td>
</tr>
<tr>
<td>Tomato</td>
<td>23.76</td>
<td>112.6</td>
<td>138.4</td>
<td>74.4</td>
</tr>
</tbody>
</table>

US$1 = Kazak tenge 130

**Trade of vegetables**

Thanks in part to national economic stabilization and measures taken by the government, as well as owing to a growing inflow of investments, positive changes have taken place in the food processing industry in recent years. Agricultural enterprises have stimulated and diversified vegetable production. The share of imports in the food market, including vegetables, stood at 33–35% in 1997, but was reduced to 25% in 2000. The export-import balance showed prevalence of exports over imports (2.3 times higher in 2003). Nevertheless, the share of imported vegetable on sale is significant. Kyrgyzstan, with a large and cheap workforce, offers less expensive vegetables. Besides, Uzbekistan is increasingly supplying a wide range of vegetables, especially in spring and early summer. Moreover, these countries plus other Central Asian countries trade with Kazakhstan on a duty-free basis, which is conducive to maintaining low prices of imported vegetables.

According to the customs statistics data, the turnover of foreign trade in the agricultural sector in 2003 ran into US$1,625.4 million, up 45.9% from the 2002 figure. Such an increase in foreign trade turnover was largely due to a 61.2% rise in the number of export operations. The export value of agricultural products was US$621.9 million, a 54.9% increase from the previous year. Exports of vegetables reached US$14 million, among which tomato accounted for 16%. Values of exported vegetable exceeded imported vegetables by 3.5-fold in 2003.

**Vegetable seed production**

Kazakhstan’s seed sector follows the principle of centrally planned management. The Ministry of Agriculture, through research institutes and affiliated experimental stations and seed laboratories, in principle, is in full control of crop breeding, and all aspects of
seed production and distribution. In practice, however, because of severe financial constraints, the real situation is different.

To meet its needs in vegetable production, Kazakhstan requires at least 1,000 t of seeds. Although the republic’s climatic conditions are favorable for seed production, currently more than 50% of vegetable seeds are imported. Of over 230 vegetable varieties registered for local use, foreign varieties account for 85%. Among 40 vegetables grown, most of their seeds are imported. Breeding efforts focus only on less than 10 crops, e.g., cabbage, tomato, cucumber, pepper, eggplant and onion. Although Kazakhstan produces certified seeds of these major vegetables, the outputs are inadequate. Even their original seeds (super elite and elite) are rather limited, less than 200 kg per annum. Moreover, as a result of limited resources and credits, farmers are unable to purchase certified seed from state entities, hence they are forced to produce and use their own seed from the poor seed stock. If the situation continues to persist, the informal seed supply system will spread.

**Crop protection**

Under the currently effective legislation governing the agricultural sector, the Ministry of Agriculture is commissioned to perform all control and surveillance functions as well as research and development in crop protection. Works such as measures to ensure the proper phytosanitary and epizootic conditions are carried out at the government’s expense. Strict regulations on food quality and safety have limited the use of pesticides in vegetable production in both open-field and greenhouse operations. Hence integrated pest management practices based on aggregate use of proper pesticides, varietal selection, and biological measures are becoming of primary importance in the republic.

**Literature Cited**


Research and Development of the Vegetable System in Kazakhstan

Temirjan E. Aytbaev and Bakhytbek U. Amirov
Research Institute of the Potato and Vegetable Farming, 1 Institutskyaya Street, Kaynar, Karasarayski District, Almatinskaya Region, 040917, Kazakhstan

Introduction

The Kazakh Research Institute of Potato and Vegetable Farming (KazRIPVF) is the lead institute for vegetable research and development in the republic. It coordinates activities with 15 other research institutions. KazRIPVF has 138 employees, 60 of whom are researchers (five with DS and 27 with PhD degrees). Among the 10 departments and labs, there are research departments on genetic resources, breeding, seed production, and production technology.

Besides KazRIPVF, Shalkar Experimental Station carries out research on genetic resources, while other agrarian research institutions and universities focus on the improvement of production technologies.

Genetic Resources

Genetic resources represent the basis for breeding. They provide the diverse material which, when used in the right way, produce new and better varieties that meet the needs of producers and consumers. For this reason, the Kazak scientists have the task to collect, conserve, evaluate and utilize germplasm of vegetables and melons to develop improved varieties and facilitate seed production.

Since 1995, KazRIPVF has made independent efforts to collect and conserve vegetable and melon genetic resources. So far 6,400 accessions have been collected. Among them, 5,776 accessions are of 115 vegetable and melon varieties from 72 countries (Table 1). Among them, 1,465 accessions are kept in the base collection, 963 in the working collection, and 184 in the field, and 3,164 stored as hybrids and selection lines. A total of 4,170 accessions have been documented, and 12 catalogues have been prepared for 2,659 accessions.

Besides what KazRIPVF has conserved, Shalkar Experimental Station is keeping 1,500 accessions of 45 vegetable varieties. And Priaralskiy Research Institute of Agricultural Ecology and Agriculture has a collection of over 200 indigenous melon accessions from the Kyzyl-Orda region.

Kazakhstan is one of the centers of origin for the Allium genus. Beside bulb onion (A. cepa) and garlic (A. sativum), the farmers in the country also grow A. ascolonicum, A. dorum, A. fistulosum, A. f. var. viviparum, A. nutans, A. porrum, and A.
These species are conserved at the Principal Botanical Garden in Almaty. Unfortunately, landraces of onion, mainly of Dungan origin, have been lost. Although they were used as initial materials for developing modern onion varieties, they are no longer available.

The All-Union Institute of Plant Industry of the former Soviet Union (now the N.I. Vavilov All-Russian Research Institute of Plant Industry [VIR]) in Russia arranged a collection expedition for the *Allium* genus in 1972 with KazRIPVF researchers. Part of this collection is being kept at VIR and its experimental stations. A portion of the collected garlic genetic resources, including *A. longispum*, is conserved at KazRIPVF. At present, KazRIPVF is maintaining 10 onion and garlic species in a total of 420 accessions, including 282 of Kazakh origin. This collection is comprised of landraces, clones, mutants, polyploids, hybrids and breeding lines. They are kept in either seed or vegetative form in the field. Their morphologic traits and economic potentials are being studied. Those with valuable traits are used in onion breeding. During the past 15 years, KazRIPVF has released several onion varieties, including ‘Aray’, ‘Igilik’, ‘Mereke’, ‘Tabys’ and ‘Avgustin’, as well as shallot varieties ‘Kaynar’ and ‘Vodorey’, and winter garlic ‘Arman’. They are currently being cultivated, and their seeds or propagules are in great demand.

Kazakhstan is secondary center of origin for melons, and the Priaralskiy Research Institute of Agricultural Ecology and Agriculture research is implementing collection, assessment and restoration of local varieties of melon (*Cucumis melo*) in Kyzyl-Orda. Over 200 accessions have been collected and assessed. The promising materials have been selected and transferred to the State Variety Testing program. KAzRIPVF re-

### Table 1. Conservation of vegetable genetic resources at KazRIPVF (as of October 2004)

<table>
<thead>
<tr>
<th>Crop</th>
<th>No. of acc.</th>
<th>Basic collection</th>
<th>Working collection</th>
<th>Hybrids, selections</th>
<th>Field collection</th>
<th>New acc.</th>
<th>Documented</th>
<th>In catalogue</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>967</td>
<td>588</td>
<td>124</td>
<td>255</td>
<td>-</td>
<td>341</td>
<td>677</td>
<td>555</td>
</tr>
<tr>
<td>Other Solanaceous</td>
<td>195</td>
<td>105</td>
<td>74</td>
<td>16</td>
<td>-</td>
<td>68</td>
<td>95</td>
<td>66</td>
</tr>
<tr>
<td>Bulb onion</td>
<td>220</td>
<td>15</td>
<td>27</td>
<td>178</td>
<td>-</td>
<td>15</td>
<td>33</td>
<td>32</td>
</tr>
<tr>
<td>Garlic</td>
<td>138</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>138</td>
<td>5</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>Cabbage</td>
<td>189</td>
<td>22</td>
<td>60</td>
<td>107</td>
<td>-</td>
<td>39</td>
<td>140</td>
<td>128</td>
</tr>
<tr>
<td>Cucumber</td>
<td>110</td>
<td>27</td>
<td>26</td>
<td>57</td>
<td>-</td>
<td>24</td>
<td>83</td>
<td>74</td>
</tr>
<tr>
<td>Melon</td>
<td>2,238</td>
<td>44</td>
<td>8</td>
<td>2,186</td>
<td>-</td>
<td>1</td>
<td>1,726</td>
<td>791</td>
</tr>
<tr>
<td>Watermelon</td>
<td>449</td>
<td>44</td>
<td>79</td>
<td>326</td>
<td>-</td>
<td>2</td>
<td>370</td>
<td>132</td>
</tr>
<tr>
<td>Others melons</td>
<td>85</td>
<td>38</td>
<td>42</td>
<td>5</td>
<td>-</td>
<td>36</td>
<td>48</td>
<td>38</td>
</tr>
<tr>
<td>Root vegetables</td>
<td>244</td>
<td>122</td>
<td>92</td>
<td>30</td>
<td>-</td>
<td>67</td>
<td>184</td>
<td>163</td>
</tr>
<tr>
<td>Legumes</td>
<td>231</td>
<td>201</td>
<td>30</td>
<td>-</td>
<td>-</td>
<td>38</td>
<td>226</td>
<td>182</td>
</tr>
<tr>
<td>Dill</td>
<td>308</td>
<td>48</td>
<td>260</td>
<td>-</td>
<td>-</td>
<td>174</td>
<td>137</td>
<td>103</td>
</tr>
<tr>
<td>Greens</td>
<td>123</td>
<td>57</td>
<td>61</td>
<td>2</td>
<td>3</td>
<td>36</td>
<td>81</td>
<td>72</td>
</tr>
<tr>
<td>Spices</td>
<td>213</td>
<td>129</td>
<td>68</td>
<td>1</td>
<td>15</td>
<td>36</td>
<td>178</td>
<td>154</td>
</tr>
<tr>
<td>Others</td>
<td>66</td>
<td>25</td>
<td>12</td>
<td>1</td>
<td>28</td>
<td>12</td>
<td>62</td>
<td>39</td>
</tr>
<tr>
<td>Total</td>
<td>5,776</td>
<td>1,465</td>
<td>963</td>
<td>3,164</td>
<td>184</td>
<td>894</td>
<td>4,170</td>
<td>2,659</td>
</tr>
</tbody>
</table>
searchers are collecting watermelon (*Citrullus vulgaris*) genetic resources in Semipalatinsk. In the near future, KAZRIPVF’s collection of vegetables and melons likely will reach over 10,000 accessions.

**Production and Post-harvest Technologies**

All major technologies for vegetable growing and post-harvest handling have been developed for major production areas of the republic. KazRIPVF scientists have ascertained that vegetables with soil allopelagic treatment and application of organic and mineral fertilizers improved yields by 20–25% in the open field. Research priorities include 1) extending the vegetable growing period; 2) crop rotations to increase unit land productivity; 3) mechanized cultivation and harvesting of tomato; 4) proper applications of inorganic and organic fertilizers to increase yields and conserve soil fertility; and 5) chemical and biological means of controlling diseases, insect pests, and weeds for safe vegetable production.

For the protected production, the following technologies have been developed: 1) polymeric materials for nurseries and early yields; 2) straw substratum to hasten growth; and 3) scheduling of tomato and cucumber in rotation for winter production.

For post-harvest handling, natural losses have been estimated, and methods and terms of storage defined. Methodic and biological assessments of spoilage and food preparation were developed. KazRIPVF has elaborated 30 republic and 4 industrial standards for vegetable production, and 5 specifications for foods.

**Breeding Targets and Variety Release**

Kazakhstan has active breeding activities on onion, shallot, garlic and tomato for the open field, as well as cucumber, watermelon, melon, pumpkin, dill and spring radish for protected cultivation.

Breeding targets often change due to agricultural and economic development of the republic. For example, from 1971–1980 the onion development program aimed for high yielding crops with resistance to peronosporosis, from 1981–1990 it was oriented toward mechanized cultivation and harvesting, and from 2001–2005 it focused on developing varieties that resisted the most harmful storage pathogen, *Botrytis allii*.

Variety requirements for tomato depend on soil and climatic conditions, cultivation technology, and utilization (fresh or processing). This leads to versatile breeding directions; however, stable and high yields, high adaptability, and resistance to major diseases are common traits for all types. For processing types, early maturity with high yield, smooth rounded fruits, and resistance to transportation are important. For fresh-market types, fruits should be large, pulpy, multi-loculed, transportable, and have long shelf-life.

Cucumber breeding in Kazakhstan was initiated in 1970s. Genetic resources, open-pollinated varieties and F₁ hybrids were introduced from VIR, Russia, Moldova, Ukraine,
Uzbekistan, and other parts of the world. Over 200 accessions of them were evaluated in KazRIPVF’s breeding nursery from 1980–2000. Selections were based on resistance to major diseases, tolerance to extreme climatic factors of southeast Kazakhstan, and ideal parents for developing commercial varieties.

Previously melon breeding was oriented toward early maturity, but now breeding targets of both melon and watermelon are focusing on protected production with different maturing types, disease resistance, high fruit quality, and transportability.

At present, 261 varieties and hybrids of 38 vegetable and melon species are released for cultivation in the republic. These include 39 cucumber (15 for open-field and 24 for protected production); 39 watermelon; 11 each of melon and onion; 10 carrot; 9 each of spring radish and sweet pepper; 8 table beet; 6 each of garlic, pumpkin and radish; 5 each of cauliflower, shelling pea and vegetable marrow; 4 each of lettuce, dill and vegetable bean; 3 parsley; 2 each of red cabbage, Chinese cabbage, squash, sorrel, rhubarb, shallot, parsnip, celery, sweet corn and eggplant; and 1 each of mustard, spinach, Welsh onion, leek onion, honey pea, turnip, sweet and hot pepper.

Due to its efforts, KazRIPVF has developed a total of about 100 open-pollinated and hybrid varieties of vegetable and melon crops. Many of them are outstanding in domestic and global markets. The onion variety ‘Oktyabrskiy’ was awarded with the gold medal of the USSR Exhibition of Economic Achievements and released in 7 regions in Kazakhstan and in 22 regions of the other republics. Onion variety ‘Dungan 56’ was awarded with the silver medal at the International Exhibition in Erfurt (Germany). Melon variety ‘Iliyskaya’ received the bronze medal at the USSR Exhibition of Economic Achievements, and the shallot variety ‘Kainarskiy’ was a prizewinner of Kazakhstan Exhibition of Economic Achievements.

At present, 34 varieties developed by KazRIPVF were released for cultivation in Kazakhstan. Six onion varieties cultivated in Oktyabr, Mereke, Tabys, Aray, Igilik and Avgustin account for 50% of the total production in the republic. The production shares of other released varieties are as follows: ‘Kaynar’ and ‘Vodoley’ (100% of shallot); ‘Zailiyskiy’ and ‘Arman’ (33% of garlic); 3) ‘Plamya’, ‘Narttay’, ‘Meruert’, ‘Samaladay’ and ‘Luchezarniy’ (25% of open-field tomato); ‘Jalyn’ and ‘Dias’ (10% of protected tomato); ‘Kreypsh’, ‘Medeu’, ‘Shilde’ and ‘Azat’ (27% of cucumber); ‘Mozoleevskaya’, ‘Carina’ and ‘Aphrodite’ (60% of pumpkin); ‘Dungan 12/8’ (11% of early radish); ‘Kaskelenskiy’ (25% of dill); ‘Mejdurechenskiy’, ‘Krasnosemyannik’, ‘Medok Semipalatinskiy’ and ‘Stoksik Semipalatinskiy’ (26% of watermelon); and ‘Alyona’, ‘Altynochka’, ‘Tasiya’ and ‘Iliyskaya’ (36% of melon).

Eleven varieties including ‘Shyryn’, ‘Sheker’, ‘Mayskaya’, ‘Chempionka’ and ‘Shugyla’ melon; ‘Sokol’ onion; ‘Zarya Vostoka’ and ‘Rassvet’ open-field tomato; ‘Kargalinets’ and ‘Asar’ watermelon; and ‘Orken’ cucumber are currently under evaluation through the State Variety Testing program.
KAzRIPVF produces 1.0–1.5 t per year of foundation seed of bulb onion, tomato, cucumber, pumpkin, marrow, watermelon, melon, carrot, beet, dill, early radish, lettuce, etc. This meets the republic’s needs for elite seeds.

Seed Production and System

According to 2004 statistics, total areas of vegetable and melon production in Kazakhstan are 110,000 ha and 42,000 ha, respectively; average yields are 17.7 t/ha and 14.5 t/ha, respectively; and annual seed demands are 630–650 t and 150–160 t, respectively. And for these amounts of seeds, about 600 ha are required to produce stock seeds and 3,500 ha to produce standard seeds for the growers (Table 2).

Table 2. Annual production of vegetable and melon seeds in Kazakhstan

<table>
<thead>
<tr>
<th>Crop</th>
<th>Prod. area (000 ha)</th>
<th>Super elite</th>
<th>Elite</th>
<th>I Reproduction</th>
<th>II Reproduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Stock (ha)</td>
<td>Seed (ha)</td>
<td>Seeds (kg)</td>
<td>Stock (ha)</td>
<td>Seed (ha)</td>
</tr>
<tr>
<td>Beet, table</td>
<td>5.0</td>
<td>0.10</td>
<td>0.01</td>
<td>3.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Cabbage</td>
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<td>0.20</td>
<td>0.02</td>
<td>5.0</td>
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<tr>
<td>Carrot</td>
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<td>0.20</td>
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<td>5.0</td>
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</tr>
<tr>
<td>Cucumber</td>
<td>13.0</td>
<td>-</td>
<td>0.60</td>
<td>15.0</td>
<td>-</td>
</tr>
<tr>
<td>Melons</td>
<td>45.0</td>
<td>-</td>
<td>0.45</td>
<td>16.0</td>
<td>-</td>
</tr>
<tr>
<td>Onion</td>
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<td>0.05</td>
<td>10.0</td>
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<tr>
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<td>25.0</td>
<td>-</td>
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<td>3.0</td>
<td>-</td>
</tr>
<tr>
<td>Others</td>
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<td>0.15</td>
<td>0.15</td>
<td>3.0</td>
<td>0.1</td>
</tr>
<tr>
<td>Total</td>
<td>155.0</td>
<td>1.15</td>
<td>1.45</td>
<td>60.0</td>
<td>3.4</td>
</tr>
</tbody>
</table>

1 Mother plants

The released open-pollinated varieties and F₁ hybrids that have been shown to possess significant agronomic values such as high yielding, disease resistance and tolerance to environmental stresses are usually accepted into the seed production scheme in the republic. These varieties usually have the potential of increasing yield by 20% or more compared to traditional varieties.

Due to the collapse of the large-scale seed production operations on former state farms of the former Soviet Union, the republic has been left without a supply of quality vegetable and melon seeds. This becomes a major hindrance to the availability of vegetables. The republic needs to catch up with evolving vegetable production and marketing scenarios outside the region. At present, state farms, cooperatives, peasants and private sector account for about 70% of the total area that produces varieties from foreign sources, mainly from Holland and the Russian Federation. Various trade companies are dealing with seed importation and distribution. These vegetable and melon seeds are mainly produced by small-scale farmers, who usually sell the seeds independently or through the seed trade associations (Sortsemovosh) established in different regions such as Almaty Tukym, Almaty Semena, Shymkent Tukym, Jambyl Tukym, and Invent Plus.
Immediate actions should be taken for the rapid establishment of a sound national seed production system for principal vegetable and melon crops. The success of this system shall rely on detailed information of released varieties, agronomic requirements to be observed in planning and production, quality standards, designated authority for implementing the rules of the systems on behalf of the government, and sources of financial assistance.

The environment of Kazakhstan is favorable to produce a wide array of vegetable and melon seeds to meet its domestic and export demands. The following components should be parts of the actions to revive the vegetable and melon seed production system in the republic:

• Define the specific targets for reviving the seed production system.
• Enact legal acts and rules on production, treatment, storage, marketing, transportation and use, and establish the inspectorate of the different parts of the system for tests and observations.
• Identify seed production farms based on specific environmental requirements of the crops. The first choice will be the farms which have been previously involved in the seed production in the former Soviet Union.
• Assign specific institutions to produce foundation seeds of specific varieties.
• Form coalitions of seed producers by specifying services on preparation and marketing.
• Establish an incentive system for elite seed growers, for example, increased financial payments.
• Establish the assured national order and quota for original and elite seeds.
• Create conducive conditions for the farmers to produce the seed with provisions of credits and lease of machinery, equipment, etc.
Economic and Social Context of the Vegetable System in Kyrgyzstan

Akbaraly Abdivasiev
Ministry of Agriculture, Water Management and Processing Manufacture, 96a. Kievskaya St., Bishkek, Kyrgyzstan

Introduction

Kyrgyzstan is located in the eastern Central Asia between 39° and 43° N and 69° and 80° E. The republic is bounded to the north by Kazakhstan, to the south by China and Tajikistan and to the west by Uzbekistan, and has an area of 19.8 million ha, of which about 4% is water. Kyrgyzstan is dominated by the Tien Shan Mountains that lie in a series of dramatic parallel ranges running west to east and which divide the country into three main zones. The elevation of about 94% of the terrain is 1,000 m or more above sea level. The only relatively flat regions are the Kyrgyzstani part of the Fergana Valley in the southwest, and in the Chui and Talas Valleys along the northern border. The population of the republic is about 5.4 million; 60% of them live in the rural areas. Being a mountainous and poor country, the Kyrgyz people face illnesses related to deficiencies of iodine, iron and copper in their diets.

Natural Resource Base

Kyrgyzstan’s climate is continental, with cold winters and hot summers, but with great local variations depending on altitude, aspect and the lie of the mountain ranges. In July, average temperatures at lower elevations are generally near 27°C but can exceed 40°C in the Fergana Valley. In winter, frost occurs in all regions. Summers are generally dry but storms of heavy rain, hail and even snow occur, even in mid-summer and even at lower altitudes. Mean sums of active temperatures over 10°C in the valleys range from 2400 to 4500° with frostless period of 150–212 days a year. In the mountainous areas from 2000 to 3000 m, annual precipitation ranges from 250 to 800 mm and the frostless period ranges from 85 to 150 days. The republic’s soils are mainly sierozem, chestnut-colored chernozem, and brown soils.

The annual precipitation varies from 300 mm to 500 mm, which is not adequate for the production of most crops without artificial irrigation. Water resources are the most valuable natural assets of the republic. The Tien Shan Mountains are the source of the most significant river systems watering the surrounding steppes and deserts of Central Asia. These river systems were extensively developed in Soviet times both for hydroelectricity and irrigation, and the head waters of Syr Darya have supported irrigated agriculture in the Fergana Valley.

Due to the variable terrain in the mountains and valleys, the flora of Kyrgyzstan is diverse and accounts for more than 4,500 species of higher plants. About 1,600 species
have economic and useful value including 50 species for food. The Tien Shan region is a significant geographical center of origin for many deciduous, temperate fruit trees. Kyrgyzstan is home to wild relatives of carrot, onion, garlic, sorrel and rhubarb, which would be valuable sources for the improvement of cultivated varieties of these vegetables to combat various biotic and abiotic stresses.

Only about 7% of Kyrgyzstan’s land area is arable. This land is mainly in the northern Chui Valley, the Talas Valley, around Lake Issyk-Kul, and the Fergana Valley in the south. Less than half of the arable land is under irrigation. Soviet-era irrigation works are critical for crop production. Due to the limited cultivable area, the amount of arable land available per worker is low (averaging 1.1 ha), and irrigated land is even more limited. Evaporation in key irrigated areas can vary between 1,200 mm and 1,600 mm, far exceeding average precipitation.

**Sectoral Context of Agricultural Production**

Since independence in 1991, Kyrgyzstan has carried out a series of measures aimed at transforming its farm sector from a state-managed to a private, market-oriented one. This has resulted in the formation of enterprising “peasant private farms” (krestianshyie khozyaistva), which includes individuals owning land, family farms and group farms of different kinds. By 2000, the share of peasant private farms in the total cultivable land area was 48%. Average size of peasant private farms is slightly over 10 ha, with much smaller farms in the densely populated south and larger ones in the northern oblasts (provinces). The number of members ranges widely, from one to over a hundred members. On the other hand, some of the former state and collective farms have been restructured as joint stock companies, collective peasant farms and agricultural cooperatives. The average size of these farms is over 100 ha with membership from a few hundred to over two thousand individuals.

Kyrgyzstan’s gross national product (GDP) in 2005 amounted to 93.5 billion soms (about US$ 2.2 billion). Agriculture outputs accounted for 37% of GDP. The share of crop outputs amounted to 56% of the total agricultural outputs. Among the republic’s 2.7 million total labor force, 55% are engaged in agriculture.

The total area of crops is estimated at about 1.2 million ha of which 59% are irrigated and 41% are rainfed. The main crops are wheat, barley, maize, potato, melon, oilseed crops, vegetables and fodder. Sugar beet is an important cash crop in Chui oblast; cotton and tobacco in the southern Fergana oblasts. Since independence, the need for food security has given wheat production an importance it never had in Soviet times when the republic was, to a great extent, fed from elsewhere.

Basic estimates of farm performance, calculated as profit per hectare, showed that smaller-scale farmers are substantially more profitable than larger ones. In spite of this, Kyrgyz farmers face various difficulties at all stages of production. Fertilizer is rarely available due to the removal of subsidies and the cost of transport, machinery often belongs to a few people and is unsuitable for small-scale agriculture, and transporting
crops is difficult as fuel is expensive. Many independent farmers must sell their crops at a low price to middlemen who transport the crops to the markets or processing plants. Additionally, there are few opportunities for farmers to obtain credit, and due to the high population to land ratio, many families can only afford a plot too small to reap a significant profit.

Kyrgyz agriculture, despite a relatively egalitarian privatization, is not prospering. In order for the situation to improve, the input and output markets must be strengthened and transportation must become more affordable. Agriculture is not without prospects, on the contrary, but until these problems can be solved, it will be difficult for farmers to prosper. It is imperative for Kyrgyzstan to develop its agricultural base so that the profits can develop other industries. If land is fairly equally distributed, agriculture can provide one of the best bases for growing prosperity without huge social differentiation, and rising incomes in agriculture will lead to broad-based demand that will stimulate other industries. For a landlocked country for which it is difficult or expensive to export, these arguments are particularly important. Toward this direction, the government has adopted “Concept of Agricultural Policy of the Kyrgyz Republic till 2010” as its guideline and agenda for action in agricultural development.

**Status of Vegetable Production**

Almost all of vegetables are produced on the peasant private farms. There are no collective enterprises involve in vegetable production. Depending on the size and ownership, some of the peasant private farms are specialized in certain crops. According to the National Statistics Committee, Kyrgyzstan produced 985,000 t of vegetables and melons on 53,800 ha (about 3.5% arable land) in 2004. Among vegetables, tomato accounts for 21%, of production, followed by carrot (15%), onion (14%), cabbage (12%), watermelon (10%) and cucumber (7%). Among various oblasts for vegetable production, Chui accounts for 47%, followed by Dzhalal-Abad (15%), Osh (13%) and Talas (12%).

Average yields of major vegetables in 2004 are 18.9 t/ha for tomato, 20.0 t/ha for onion, 20.0 t/ha for cabbage, 17.8 t/ha for watermelon and 15.0 t/ha for cucumber. The average yield of vegetables overall is 19.5 t/ha. The oblasts with higher average vegetable yields are Talas, Chui and Dzhal-Abad. The average vegetable yield is relatively low when comparing with the level obtained in other temperate countries. This is due to inadequate application of fertilizers, lack of modern crop production technologies, and poor quality seed, among other factors.

With the collapse of the socialist economy and shortage of cash in the republic, few if any of the old state seed farms that produced vegetable seed do so any more on a commercial basis, except in reduced quantities for their own use, or for barter between neighbors. Quality of these seeds is usually low, so farmers use high seeding rates to compensate for low germination rates. Production of basic and certified seed of promising varieties (of both open-pollinated and hybrids) that were developed in the republic does not exist. Currently, seed markets are full of seed of non-released varieties pro-
duced through private farmers’ own selections. On the other hand, although many foreign varieties have been officially tested and released in the republic, private farmers lack the funds required to purchase them.

Vegetable availability per capita in Kyrgyzstan is 149 kg per annum, which is above the recommended level of 105 kg per annum for a healthy diet. The excessive vegetable output enabled the republic to export part of its vegetable products in either fresh or processed form. In 2004, Kyrgyzstan exported 2,497 t of tomato, 5,636 t of onion, 60,427 t of carrot and table beet, and 19,182 t of other fresh vegetables. The exported volume can be further increased if the transportation cost could be reduced.

Vegetable production accounted for 14.3% of the entire crop production sector in the monetary term in 2004. To achieve this, mean vegetable production costs per hectare were about 59,500 som (US$1,451). The farmer’s gain was about 14,830 som per hectare, or 3,330 som (US$81.2) per ton of product.

Kyrgyzstan’s vegetable sector has limited financial resources and farmers are not able to charge a premium for their products, and consequently earn modest profits. As a result, they are not able to generate enough revenue to self-finance further development and growth. Although some private farms received financing from the Bai-Tushum Financial Fund, Kyrgyz Agricultural Financial Corporation, and 60 plus other credit unions in the republic, the majority of farms have limited access to these financial institutions due to high interest rates, and lack of common assets and property to be pledged as collateral.

New marketing channels have emerged and price liberalization taken place since independence. Because of this, there are wholesale markets, small-sized markets, storage facilities, and individual vendors. Farmers either sell their products directly or through middlemen. However, these new marketing channels are far from being competitive. Small vegetable farms often face difficulties with marketing their products at reasonable prices.

As pointed out earlier, vegetables are a significant export product for the Kyrgyz economy. However, this sector is currently suffering from low profitability. This is because of the break-up of established trade relations with other republics of the former Soviet Union; the limited supply of quality products at competitive prices due to high unit costs; the use of obsolete seed and technology; shortage of raw materials; overproduction of certain vegetables due to poor planning; and high transport costs and tolls. In addition, loss of competitiveness because of poor product quality and collapse of the processing industry also contributed to a declined export of vegetables.

The fruit and vegetable processing sector is represented by 35 private enterprises of which about 20 are working. They have processed 250,000 t of vegetables (mainly tomato), and generated 245 million som in 2004. However, processing plants generally operate at a low capacity (25–30%) due to lack of financial assets, weak management of the enterprises, old equipment, lack of raw material and spare parts, low quality of products, and reduced market demand. Low capacity utilization increases overhead costs
and reduces profits. Enterprises operating at low capacity frequently sell their products at a price that covers only variable costs, not fixed costs. Eventually, these firms will use up their fixed capital and no longer be able to operate.

**Challenges Ahead**

Beside the small size of the domestic market, a major constraint to improving vegetable production in Kyrgyzstan is the lack of improved high yielding varieties for changing production scenarios. With the break-up of the former Soviet Union, Kyrgyzstan has been left without a supply of new varieties, or in some cases without seed of existing varieties. Yields are far below those achieved in agroecologically similar regions of the world. While the immediate aim is to evaluate available germplasm and identify suitably adapted cultivars that can be multiplied for immediate release, thereby having a rapid impact on productivity, a longer-term goal is to support the development of sustainable national breeding programs. Emphasis will be on the development of germplasm with resistance/tolerance to both biotic and abiotic stresses.

The lack of resistant varieties, pesticides and other chemical controls has left the republic prone to huge yield losses from disease and pest epidemics. Inexpensive integrated pest management strategies that can be readily accommodated by smallholders are needed.

Kyrgyzstan faces problems in seed supply due to the collapse of the former large-scale seed production on state farms. Assistance in strengthening national seed production systems will ensure the diffusion and uptake of new varieties that result from research in germplasm enhancement, while improvements in quality control and seed health testing will ensure that the full yield potential of improved varieties is maintained in farmers’ fields.

Kyrgyzstan used to supply raw materials to other parts of the Soviet Union for food processing. Now there is a need to process for the local market. The republic produces high-value vegetable crops but due to poor organization of post-harvest processing and agribusinesses, the quality of storage facilities and processing is low, resulting in losses in production value. The economic efficiency and incomes of small-scale farmers could be significantly improved if post-harvest management, packing, storage, processing of vegetable products and quality standards and certifications were improved and better oriented toward market opportunities.

In April 2004, the government issued the decree “On new priorities and measures of land and agricultural reforms” as part of a long-term plan. The decree promotes land ownership and agriculture. It also sets the development of cooperatives as a priority. Under this premise, collaboration among collective enterprises, rural commodity producers, and various input corporations will be important for the vegetable sector.

Toward this direction, it is also needed to inform policymakers of the benefits of appropriate investment in production, processing and post-harvest technologies directed
to niche markets. The expected outcomes and impacts of this investment include increased income for producers (value added), increased employment, and increased national income from exports. Moreover, it shall attract foreign investors to bring in capital, technology, management skills, and knowledge of potential export markets.

Taking the above into planning and action, the future of the vegetable industry of the Kyrgyzstan would be positive. Kyrgyz vegetable suppliers already have a foothold in major export markets such as Russia and Kazakhstan. Those markets, as well as the rest of Central Asia and China, provide tremendous opportunities for the future growth of the Kyrgyz vegetable industry.
Research and Development of the Vegetable System in Kyrgyzstan

Asanbek Ajibekov¹, Sharshenbek Ismoilov¹, and Yuriy Levchenko²
¹Center of Agrarian Science and Extension Services, 354a, Lenin pr., s. Lebedinovka, Alamedin district, 722160, Kyrgyzstan; ²Research Institute of Crop Husbandry, 73/1 Timur Frunze St., Bishkek 720027, Kyrgyzstan

Introduction

Vegetables are an important diet of the Kyrgyz people. Vegetable consumption per capita per annum in 2004 is 142 kg. This amount includes tomato (28 kg), carrot and radish (24 kg each), cabbage (21 kg), onion (20 kg) and cucumber (10 kg). However, the supply of vegetables is extremely seasonal. Moreover, diversity of vegetables is rather limited.

The vegetable sector in Kyrgyzstan is very risky and highly dependent upon the weather. Besides that, the sector still suffers from lack of modern equipment, poor financing, and low-quality infrastructure.

Overview of Vegetable Production

Because of the low and unreliable rainfall, rainfed agriculture is possible only in limited areas near the mountains. Vegetable production in Kyrgyzstan is mainly in unprotected, open fields. It relies on surface-applied furrow irrigation. Overhead sprinklers and hose irrigation are only used in greenhouse production.

To extend the cropping season and supply of vegetables, vegetable growers use three types of protected production methods: heated ground, hotbed and greenhouse. The heated ground method (with film covering) occupies the largest area. Hotbed facilities are mainly for raising seedlings. Greenhouses cover a total of 20 ha. Owing to energy costs, a considerable number of heated greenhouses are used for growing mushrooms and flowers. Over the past few years, simplified, polyvinyl film-covered hothouses without heating have been widely used for growing vegetables.


Vegetable growers also extensively use both open-pollinated and hybrid varieties that originated from Russia, the Netherlands, China and Uzbekistan for their unique horticul-
tural and quality traits. For example, powdery mildew-resistant cucumber hybrids imported from the Netherlands are gaining popularity in the republic.

The current variety registration legislation in Kyrgyzstan mandates that all new varieties be tested for two years under the auspice of the State Variety Testing Commission and registered under the State Register of Protected Plant Varieties before legal seed production and sales can take place. Furthermore, only licensed seed farmers are permitted to produce elite or certified seed that are under the patent protection. This regulation, however, does not apply to those varieties whose patents have already expired. Furthermore, the cereal seed producers are compensated with extra payments, whereas none for vegetable seed producers. These stipulations tend to halt private farmers’ interest in producing seeds of new, patented vegetable varieties. Instead, vegetable seed producers continue to produce older, non-patented varieties. Moreover, it has become much easier to import foreign seed. In this case, the seeds are not subject to the state variety testing measures.

During the frost-free cropping season, vegetable production is often constrained by climatic variability. Anomalous frosts in late spring and early fall can damage seedlings, delay planting, retard growth and development, or injure harvested parts. Hot, dry spells in the rainy months of April and May, when most crops are thriving in the field, may destroy the crop. Cold weather in spring delays the thawing of snow and ice in the mountains, thereby limiting the availability of irrigation water. Occasional hail storms and heavy rain showers in May to July, and sometimes in August, destroy crops in the field and cause soil erosion.

Currently all mineral fertilizers are imported from Russia, Kazakhstan and Uzbekistan, as Kyrgyzstan has no facilities for fertilizer production. Due to the increase in vegetable prices and a decrease of interest fees on loans, some of vegetable growers have started to use imported mineral fertilizers as well as locally-produced organic fertilizers, which in return generate higher yields and profits. On the other hand, there is a growing concern of an overuse of nitrogen-based fertilizers in other crops, which leads to environmental contamination and nitrate/nitrite accumulation in food products.

For the major vegetable crops, the most prevalent insect pests include: cabbage (flea beetle, cabbage aphid, diamondback moth, cabbageworm, cabbage looper and cutworm); cucumber (melon aphid); onion (thrips, big bud mite, wireworm and maggot); and tomato (cutworm, Colorado potato beetle and russet mite).

Among the most prevalent vegetable diseases are: cabbage (black rot); cucumber (bacterial fruit rot, blossom end rot, phomopsis black stem); gourd (phomopsis black stem, powdery mildew); onion (onion mosaic virus, bacterial streak and rot, neck rot); and tomato (Phytophthora blight, early blight, bacterial leaf spot, Septoria leaf spot).

The crop protection system in Kyrgyzstan is comprised of three major components: quarantine, preventive measures, and control measures. Plant quarantine centers are placed in strategic locations with appropriate quarantine services. Preventive measures encompass crop or variety rotations, and proper cultivation methods to reduce disease
and insect incidences. Control measures use both chemical and biological methods to control diseases and insect pests, and ensure the safety of their use. At present, all agricultural chemicals have to be registered with the State Register and labeled with instruction on the proper preparation and application before sales can take place. Unfortunately, there are incidents of illegal importations of pesticides without proper registration and labeling. On the contrary, biological control is gaining popularity and several factories are rearing insect predators and parasitoids in great quantity to meet the demand.

**Vegetable Research and Development**

Vegetable research and development (R&D) in Kyrgyzstan is mainly conducted at the Kyrgyz Research Institute of Crop Husbandry (KyRICH) under the authority of the Ministry of Agricultural and Water Management. KyRICH’s vegetable R&D efforts focus on improvements of varieties, production technologies and seed production of tomato, onion, cabbage, radish and carrot. To some extent, KyRICH’s experimental stations, KI Skryabin Kyrgyz Agrarian University, and Kyrgyz Experimental Station on Cotton also partake in vegetable R&D. Below are some recent achievements on the republic’s vegetable R&D:

**New varieties.** Two cabbage varieties, ‘Kirgizskaya’ and ‘Chuiskaya’, are distinguished for their high yielding potential, drought resistance, transportability, good keeping quality, and excellent market qualities. The yield potential of ‘Bishkek’ tomato reaches 60 t/ha.

**Seedling production and transplanting technologies.** These improved technologies allow early harvest of tomato and ensure stable supply of tomato products in the market; and have been widely adapted in Oshskaya oblast (province).

**Basic research on aphids.** In the Chuisk Valley, eight types of aphids, six on shoot and two on root, are identified on cabbage. Cabbage aphid, mustard aphid and peach aphid prevail on cabbage shoots. Cabbage aphid is most harmful. These aphids also attack radish, horseradish and other cruciferous crops.

**Control measures for diseases and insects.** An improved integrated pest management for cabbage aphid reduces the use of pesticides without compromising yield. Protective measures for diseases and insect pests of other vegetables have also been developed.

**Seed treatments.** Seed treatment methods have been developed to stimulate rapid and uniform emergence, leading to higher yields. Laser irradiation of the seed has been shown to promote early maturity and increase the yield of radish, beet, onion and corn.

**Highland vegetable production.** Vegetable cultivation methods have been devised for the alpine zones in Narynskaya oblast.
Appropriate fertilizer application. Carrot yield reached over 45 t/ha when a complete set of mineral fertilizers (120N–90P–80K) is applied. Improved methods of sidedressing with nitrogen have also been developed. About 4,000 t of nitrogen sidedressing have been applied to 20,000 ha of vegetables in 2004.

Conclusions

Long-term sustainable growth of the vegetable sector in the Kyrgyz Republic depends on improved productivity, which in turn, depends on proper economic incentives, efficient use of agricultural inputs, and appropriate technology and support services. Achieving this will not be an easy task. Because of privatization, farm restructuring, breakdown of Soviet distribution channels, and severe capital constraints on farmers, there is a demand in the republic for research into the development of low-cost technologies that meet local needs as well as export potential. Unfortunately, the Kyrgyz national agricultural research system (NARS) still largely reflects the model instituted during the Soviet period. In many cases, their research efforts have limited relevance to the immediate needs of private vegetable farmers.

Kyrgyz NARS has a great potential to serve as a mediator, striving to find common ground among meeting national goals for agricultural and rural development, serving the new class of private farmers that has emerged since privatization, and capturing the domestic and international markets that structure opportunities for these farmers. This potential will only be fully realized if the Kyrgyzstan government makes institutional development a high priority and commits a significant amount of resources in agricultural R&D. Moreover, Kyrgyz NARS should shed their inherited institutional approaches to setting priorities and rewarding researchers, and adapt their basic research and diffusion activities to new demands from the private vegetable farmers.

Under the current situation of the vegetable sector, the above could only be achieved if Kyrgyz NARS could cooperate with the international agricultural research community and receive certain international support. The government should actively secure and coordinate donor assistance. Since the availability and use of appropriate inputs, technology and support services are essential to improve productivity, profitability, and sustainability of the vegetable sector, the following R&D topics will be important for collaborative activities:

- Formulate sound policies for the vegetable sector based on statistical data, economic information, and analytical studies.
- Exchange vegetable germplasm to facilitate variety improvement and diversify vegetable production and supply.
- Organize vegetable seed production and supply systems.
- Exchange information on research methodologies, advanced cultivation technologies and cropping systems through exchange visits, workshops, and the Internet.
• Establish information management systems for the market-oriented vegetable sector.
• Invest in improving research facilities and supplies.
• Train young scientists of KyRICH and other agricultural research institutions.
Economic and Social Context of the Vegetable System in Tajikistan

Tursun Akhmedov
Scientific-Production Association “Bogparvar”, Tajik Academy of Agricultural Science, 17 Giprozemgorodok, Dushanbe, 734000, Tajikistan

Introduction

Tajikistan is a landlocked mountainous country of 143,600 km², stretching between 67°31’ and 75°41’ E longitude, and 36°40’ and 41°05’ N latitude. It borders with China in the east, Afghanistan in the south, Kyrgyzstan in the north, and Uzbekistan in the west. Only 960,000 ha (7%) of the total land area is under crops and orchards. Approximately 570,000 ha of this land are irrigated. About 3.86 million ha (27%) of the total land area is pasture, meadow or in fallow. Half of the total land area is mountainous with an average elevation of 3,000 m, and the remaining 16% is in desert. The central part encompasses the southern spurs of the Tien Shan and Pamir Alay Mountain ranges while the southeast comprises the Pamir Plateau.

Tajikistan’s population is 6.7 million, with 70% living in rural areas. In 2002, the agriculture sector accounted for 26.4% of the republic’s gross domestic product (GDP). The total employed population of the country was 1.9 million, of which 67% was in agriculture. The agricultural sector contributes about 10–20% of the republic’s total export earnings.

Natural Resource Base

The absolute heights of Tajikistan vary from 300 to 7,495 m. Low mountain ranges and wide valleys occupy the southwest part of Tajikistan. The plains of Tajikistan lie at various heights above sea level—from 300 to 1,000 m. Tajikistan has about 60% of all glaciers in Central Asia, which serve as major water reserves for the republic’s more than 900 rivers (each with a length of more than 10 km), and more than 680 km² of lakes. These rivers and lakes bring life to the neighboring areas downstream; they are important for irrigation, power generation and household water supply.

Tajikistan’s climate is continental, subtropical, and semi-arid. It changes drastically according to elevation and region—from hot dry plains to frigid glacial mountains. The annual mean temperatures vary from 17°C in the south to −6°C in the Pamirs. Maximum temperatures are observed in July and the minimum in January. In the south, maximum temperatures can exceed 45°C. The Fergana Valley and other lowlands are shielded by mountains from Arctic air masses, but temperatures in that region still drop below freezing for more than 100 days a year. In the subtropical southwestern lowlands, which have the highest average temperatures, the climate is arid, although some sections now are
irrigated for farming. At Tajikistan’s lower elevations, the average temperature range is 23 to 30°C in July and -1 to 3°C in January.

The average annual precipitation for most of the republic ranges between 700 and 1,600 mm. The annual precipitation in the valleys ranges from 155–450 mm, in hilly areas 500–700 mm, and in mountains over 700 mm. In central Tajikistan, precipitation can exceed 1,800 mm a year. Most precipitation occurs during winter and spring.

The longest duration of sunshine is observed in the lowlands of northern Tajikistan, Gissar and Zeravshan Valleys, southwest Tajikistan and in the Pamirs. Cloud cover reduces solar radiation by 32–35% in the lowlands during the year. Total solar radiation reaches its peak from May to July.

Flora of Tajikistan is rich and diverse and includes more than 5,000 species of higher plants. The combination of latitude, longitude, and altitude create a great variety of ecological niches, which have been significant factors in the evolution of Tajikistan’s flora. The republic has 800 species of native plants and over 100 species of food and vitamin-bearing plants. Tajikistan is a center of origin for many species of plants now used in agriculture, including wild species of some vegetables and melons. These wild relatives of cultivated plants are valuable and unique genetic resources.

Agricultural Sector

Official sources indicate that 50% of the total cropped area and 50% of the irrigated land area have been privatized and converted into lease farms, joint stock companies, and private (dehkan) farms. Overall, some 60% of the farming units have been privatized to date. The most common type of dehkan farm is a family farm with an average of 4.0 ha of arable land. At present, there are about 2,670 dehkan farms. Household plots have increasingly become subsistence-oriented given the declining economic conditions of the republic. Household plots account for over 50% of rural families’ in-kind and cash income. The average size of household plots is 0.13 ha or about one-fifth of the total arable land available per active farm employee. These plots are being used for intensive fruit, oilseed and vegetable cultivation, as well as for double cropping in the plain areas. It is expected that all state and collective farms will be converted to dehkan farms and production cooperatives by 2007.

Tajikistan’s agriculture is characterized by mixed cropping and livestock production. The major crops are cotton (280,000 ha), cereals (220,000 ha), and vegetables (e.g., onion, garlic, pumpkin, cabbage, lettuce, cucumber, and tomato in a total land area of 45,000 ha) in the valleys; and fruit and nut trees (105,000 ha), and tuber/root crops such as potato and carrot (32,000 ha) in the sub-alpine to alpine regions. Most of them are grown under small-scale irrigation systems.

Currently, Tajikistan’s agricultural sector faces many challenges. Agriculture has borne the brunt of the structural adjustments of the economy. The bulk of the republic’s fertilizer requirements in agriculture are covered by imports, mainly from Uzbekistan. Pro-
ductivity of the agricultural sector has declined due to the collapse of input supplies and the deterioration of the irrigation system and of farm equipment. Economic and market difficulties have led to increasing reliance on subsistence rather than commercial commodity production. Inadequate rainfall during the past years has exacerbated the much deeper problems faced by the country’s agricultural sector.

A number of constraints hamper the development of national markets for agricultural products. In particular, the transaction cost of moving bulky products around the country is quite high. Traders and farmers incur many unforeseen costs across the marketing chain, from the farm gate to retail markets. The transaction costs that the traders and farmers incur are then passed on to consumers in the form of high prices for food products. Falling purchasing power of the rural households combined with distorted local consumer prices force many individuals to substantially alter or reduce their diets, despite the fact that food commodities are generally available in the markets.

**Status and Challenges of the Vegetable Sector**

Traditionally, Tajikistan was one of the largest producers of vegetables for the former Soviet Union with a reputation for high quality. Since 1990, production has dropped for many reasons, including the loss of previous markets after the collapse of the Soviet Union and a five-year civil conflict that ended in 1997.

Tajikistan has advantages in climate and production, including ready availability of water for irrigation, which offers the potential for growing a wide range of vegetables for an extended production season. The climatic conditions offer a competitive edge compared with other Central Asian countries, giving the country the ability to supply fresh produce earlier than its competitors. A few years ago, Tajik vegetable products were losing market share in Russia, but that share has been regained, reportedly due to Tajikistan’s “ecologically clean product.” Soil in the growing areas is medium loam in texture with good drainage, thus salinity is easily avoidable.

Currently, the share of vegetable production in Tajikistan’s economy is considerable, amounting to 15–17% of the national income (Akhmedov 2005). Vegetable production is the mainstay of income and job opportunities for dehkan farms in peri-urban and rural areas. These dehkan and other farms produced about 863,000 t of vegetables and melons in 2005 from 43,400 ha of land area, most of them irrigated. The government is currently encouraging further expansion of dehkan-based vegetable production. Among vegetables produced today, tomato accounts for 24% of production, followed by onion (22%), watermelon (17%) and carrot (14%). Most vegetables and melons are sold and consumed fresh in the republic and serve as major micronutrient sources for the population. Minimal amounts of vegetable are exported or processed. At present, per capita consumption of vegetables and melons in Tajikistan is around 125 kg per year.

Given the situation of population growth, improved income and increased export potential in Tajikistan, the volume of vegetable production has to increase. The current average vegetable yield is about 19.9 t/ha. Drought, early frost and diseases are major
limiting factors for increasing the yield above this level. However, the potential for higher yield still exists under favorable climatic and soil conditions. With improved varieties and production technologies, early onion yield (May and June) could reach 35–45 t/ha, late onion 80–90 t/ha, early tomato 25–30 t/ha, late tomato 50–70 t/ha, early cabbage 30–35 t/ha, and late cabbage 55–65 t/ha. Moreover, rainfed production of vegetables in the areas with plentiful rainfall, and off-season greenhouse production could contribute to the year-round vegetable production. In spite of the aforementioned potential, the following factors, at present, hinder the development of the vegetable sector in Tajikistan:

- **Shortage of specialized machinery and equipment.** Antiquated farm machinery and equipment that were used in collective farms (former sovhozes and kolkhozes) are not applicable for small-scale dehkan farms to grow vegetables.

- **Inefficient supplies of fuel, spare parts, fertilizers and chemicals.** High prices of agricultural inputs reduce both profits for farmers and demand from consumers.

- **A poor vegetable seed system.** There is a lack of quality vegetable seeds in irrigated areas and the continued use of degenerated genotypes in both irrigated and rainfed systems are considered major contributing factors to low yields. The availability of quality seeds is structurally constrained by the lack of seed multiplication capacity, as well as economic constraints to implement regulations for seed production/certification and to import appropriate quality seeds from abroad.

- **Reduced production potential in small-scale dehkan farms.** Small dehkan farms limit crop rotations, which increase soil fertility, decrease pest incidence, and extend the period of production.

- **Price fluctuations.** Vegetable price fluctuates greatly in Tajikistan. For example, the price of spring onion and winter cucumber and tomato in the republic is extremely high. Off-season production technologies and marketing strategies need to be developed.

- **Poor state of the economy.** Vegetable production requires skillful producers, but low salaries have reduced the number of vegetable growers and seed producers. Researchers have also left the vegetable sector for similar reasons.

- **Lack of credits and subsidies.** Personal incentives for the vegetable farmers are directly associated with their outputs. Currently, the government does not provide any subsidies to vegetable growers. Short-term credits are needed for the operation of established dehkan farms, and long-term credits are needed for restoration or acquisition of fixed assets.

- **Post-harvest losses.** Lack of storage space and transport facilities at the retail level have increased post-harvest losses of vegetable products and created a negative effect on the vegetable value chain.
• _A poor marketing system._ Markets in Tajikistan generally suffer from a severe lack of information on domestic and international market prices.

• _Limited export opportunities._ Export operations remain in the hands of those few operators who are able to obtain licenses. Farmers experience severe delays in receiving payments and the actual returns paid are very low. Furthermore, the interest of the state in promoting cotton to maintain foreign exchange earnings limits the diversification of crops. Decreased vegetable processing industries and increased transportation costs and tariffs further deter the development of the export sector for vegetables.

• _Inadequate research backup._ Previous agricultural research and development was oriented to large specialized collective farms, whose results are usually not applicable to vegetable-growing dehkan farms. Applied research on improved varieties and modern farm management practices, as well as improved marketing systems are needed.

Facing the above challenges in the vegetable sector, the Tajikistan government, with the support of external donors, is setting programs to support farmers by developing and making available modern production and storage technologies, mineral fertilizers, and crop protection technologies.

**Literature Cited**

Research and Development of the Vegetable System in Tajikistan

Tolib Nabiev and Tursun Akhmedov

1Tajik Academy of Sciences, 33, Rudaki Avenue, 734025 Dushambe, Tajikistan; 2Scientific Production Association “Bogparvar,” 17, Giprozemgorodok, Dushambe, Tajikistan

Introduction

Tajikistan is a landlocked mountainous country of 143,000 km². Only 960,000 ha (7%) of the total land area is arable while the remaining is either mountainous or in desert. The climatic conditions vary widely by region and altitude—from hot dry plains to extremely cold glacial mountains. The agricultural sector employs about 67% of the republic’s seven million people, contributes approximately 25% of its gross domestic product and accounts for about 15–20% of export revenues. In the coming decade, the agricultural sector will remain a key component of the economy in terms of employment, exports, and economic development. The agricultural crops grown in Tajikistan reflect the great diversity of its flora: over 1,000 species of wild relatives of cereals, 1,550 varieties of fruits and berries, and 463 varieties of vegetables and melons. Tajikistan is the center of origin for onion, garlic and carrot.

Vegetable Production

Traditionally, Tajikistan was one of the largest producers of vegetables for the former Soviet Union with a reputation for high quality. Since 1990, production has dropped for many reasons, including the loss of previous markets after the collapse of the Soviet Union and a 5-year civil conflict that ended in 1997. This is further complicated by a lack of modern farm management practices and machinery. However, the potential for high quality production still exists.

Tajikistan has a favorable climate and other advantages for growing vegetables. Rich water resources are readily available for irrigation, and its soil in the vegetable growing areas is loam with good drainage. Thus, salinity is easily curtailed. Climatic conditions allow for the production of a wide range of vegetables in an extended season with 2–3 harvests, thus offering a competitive edge compared with other republics in Central Asia and the Caucasus. Farmers in Tajikistan have the ability to supply a large number of vegetable products over a year-round period and earlier than its competitors.

After gaining independence, many of the large state farms (sovkhозes) were re-organized into over 240 associations, 35 collective farms (kolхозes), and about 22,300 private farms (dehкans). Many of these farms are intensifying in vegetable production. The State Statistical Committee estimates that private farms account for 67% of Tajikistan’s commercial vegetable production. Most of these vegetable private farms use truck farm-
ing techniques in peri-urban areas (this is where food processing industries are based). Vegetable production in mountainous regions consists of mainly gardens for subsistence. It is only recently that direct links between producers and consumers of vegetables have become established through cash transactions at the market.

Land under vegetable production has varied in recent years due to political turmoil and drought, but it reached 41,600 ha with 795,000 t of outputs in 2005. Among the total output, about 13–15% of production (mainly tomato) is processed for export markets. The current vegetable output is still well below the levels grown before independence. The supply of most vegetables is seasonal, the exceptions being onion, carrot and cabbage. Poor cold storage facilities and transportation infrastructure, as well as poor development of protected production facilities have contributed to the short supply of vegetables.

Tajikistan is importing significant volumes of fresh and processed products of vegetables, including fresh cucumber and tomato, canned cucumber, tomato paste and ketchup, vegetable seasoning, green pea, and corn. These are mainly imported by Commonwealth of Independent States (CIS), Iran, Pakistan and Turkey. Although the importation entails some extra costs, the cost for domestic production, transportation and sale of a number of vegetables within the republic still exceed the export prices.

Aiming for an adequate, stable supply of vegetables for local consumption and export markets, the government’s policy is to increase vegetable cultivation area to 44,000 ha with 1 million t of outputs for 2010, and to elevate average yield to 23 t/ha from the current level of 17 t/ha. Moreover, cold storage facilities and transportation infrastructure are to be rehabilitated and equipped.

The major vegetables grown in Tajikistan include tomato, bulb onion, watermelon, melon, carrot and cabbage. Onion, tomato and watermelon occupy about 70% of the entire cultivated area and output volume of vegetables. Currently, cauliflower, cucumber, pumpkin, hot pepper, sweet pepper, eggplant, beet, garlic, herbs, turnip, radish and green bean are also widely cultivated.

Tomato is the most important vegetable in the republic. Production is concentrated on private farms in Sogdiana, Gissar and Hatlon. The current level of production area in the republic is about 9,200 ha with 200,000 t of outputs. By 2010, the production area is expected to increase to 11,500 ha in all types of farms, and the average yield is expected to increase from the current level of 20 t/ha to 29 t/ha.

Onion is grown for fresh and dry products, as well as for seeds. Varietal types include May onions (sown in September and harvested from late May to early August), early red onions (sown in March and harvested from May to early August) and Spanish onions (sown in June and harvested from September to November). Yields are around 20–30 t/ha. Farmers, using recommended quantities of inputs, could obtain up to 50–60 t/ha. Onion drying is a significant agribusiness opportunity, especially considering the price of dried onion in Russia is 5 to 8 times higher than in Tajikistan. It is expected the growing area and gross production of onion will increase in the near future.
Melons and watermelons are grown in summer and autumn in both rural and peri-
urban areas under either irrigated or rainfed conditions. The annual production of melons
and watermelons in 2004 amounted to 115,000 t, which is still slightly lower than before
independence, but likely will reach 200,000 t by 2010. Average yields are 25–35 t/ha and
12–25 t/ha for irrigated and rainfed lands, respectively. Both melons and watermelons
have the potential to become a specialty export product, as the extraordinary summer
heat makes them sweeter than those produced elsewhere.

Tajikistan exports vegetable seeds in minor quantities to such countries as Uzbekistan,
Turkmenistan and Kyrgyzstan.

**Constraints of Vegetable Production**

Tajikistan’s agricultural sector faces many challenges. Agriculture has borne the brunt of
the structural adjustments of the economy. As a result, productivity of the vegetable
sector has declined due to the collapse of input supplies as well as the deterioration of the
irrigation system and of farm equipment. Economic and market difficulties have led to
increasing reliance on subsistence rather than commercial production of vegetables. Below
are some of specific constraints attributed to the vegetable sector development.

**Seeds**

Lack of quality vegetable seeds in irrigated areas and the continued use of degenerated
genotypes in both irrigated and rainfed systems are considered major contributing factors
to declining vegetable yields in the recent past. The availability of quality seeds is struc-
turally constrained by lack of seed multiplication capacity as well as shortage of funds to
import appropriate varieties and quality seeds from abroad.

**Fertilizers and pesticides**

The bulk of the country’s fertilizer requirements are covered by imports. On the other
hand, prices of domestic fertilizers are usually well above the import parity prices. Actual
availability of pesticides is also limited and prices are high. Increasing oil prices certainly
will aggravate the situation. In fact, vegetable farmers in Tajikistan use very little pesti-
cides and chemical fertilizers, and sub-optimal quantities of manure. Under these condi-
tions, if the process can be internationally certified as organic farming, it will draw huge
exports and foreign currency to further upgrade technical facilities. Organic production
in Tajikistan presents a huge potential for investors.

**Irrigation**

The irrigated area accounts for about 75% of total arable land. More than 46% of the
irrigation systems rely on gravity flood irrigation fed through extensive irrigation struc-
tures. Lift pump irrigation accounts for about 42% of the total irrigated area and func-
tions between April and September. Recently, some private vegetable farmers have utilized ground water on a limited basis by digging small-scale wells. Recent low precipitation coupled with decaying irrigation structures has seriously compromised the efficacy and efficiency of irrigation for vegetable production.

**Marketing**

Markets in Tajikistan are, by and large, disintegrated and suffer from severe lack of information on national and international market prices. Despite formal deregulation, the district governments assign crop area quotas and planned output targets to collective farms as well as private farms. Export operations remain in the hands of those few operators able to obtain licenses. However, farmers experience severe delays in receiving payments and the actual returns paid are very low. Furthermore, the interest of the state in promoting cotton to maintain foreign exchange earnings induces it to maintain large farms, thus limiting any restructuring in the cotton growing regions and the diversification of crops. A number of constraints hamper the development of a national market for vegetable products. In particular, the transaction cost of moving usually bulky vegetable products around the country is quite high. Traders and farmers incur many unforeseen costs across the marketing chain, from the farmgate to retailing. The transaction costs that the traders and farmers incur are then passed on to consumers in high prices for vegetable products. Falling purchasing power of the rural households combined with distorted local consumer prices force many individuals to substantially alter or reduce their diets, despite the fact that food commodities are generally available in the markets.

**Credits**

Provisions of internal credit resources are only available for large farms for producing onion, cabbage and tomato. Unfortunately, short-term credits are not available for producing minor vegetables. Thus, together with lack of quality seeds, diversity of vegetable production in the republic is limited. A financing system need to be devised for the vegetable sector, where profitability mainly depends upon economies of scale and risks.

**Vegetable Research and Development**

The Scientific Production Association (Bogparvar) under the authority of the Tajik Academy of Agricultural Sciences is dealing with the issues of the vegetable sector. Bogparvar’s vegetable research and development (R&D) efforts are mainly carried out in the Tajik Research Institute of Horticulture, Viticulture and Vegetable Growing (Tajik RIHVVG), and IV Michurin Institute of Horticulture in Sogdiana. The former was established in 1932 under the name of Research Institute of Fruit and Vine and Vegetable Economy. Currently, there are 12 scientists engage in the introduction of new vegetables and varieties; development of onion, carrot and tomato varieties with high yielding potential, good quality and disease resistance; crop management improvement; safe vegetable production technologies; and seed production.
Below are a few examples of recent vegetable R&D achievements in Tajikistan that have been practiced at the farm level:


- Regional zoning of onion production in the republic was developed. Harvesting for early maturing varieties in April/May in Vahsh, and middle and late maturing from June to September in Gissar and Sogdiana allows for a year-round supply of onion in the republic.

- Appropriate machinery, spacing and seeding rate of major vegetables were designed for large-scale farms. Using this equipment, seed requirements of onion, carrot, radish and horseradish were reduced 40–60% yet yields increased 25–30%. Mechanized transplanting methods were also established for tomato, cabbage, pepper and eggplant seedlings.

- Optimal rates of both inorganic and organic fertilizers for crop and seed production of onion, carrot, cabbage, tomato and melon were specified for the various areas of the republic. Appropriate rates and application methods were also extended for pesticides such as Stomt, Zenkor, Fuzilad, and Targa.

- Sprinkling methods for cabbage, tomato, carrot, cucumber and onion were established, saving two times more water compared to traditional furrow irrigation.

- Habrobracon spp. (Hymenoptera: Braconidae), which are larval parasites of lepidopteran pests, as well as Trichogramma evanescens (Hymenoptera: Trichogrammatidae), a facultative gregarious egg parasitoid that attack a wide range of lepidopterous eggs, were used alone or in combination for insect pests of tomato and sweet pepper in both open-field and protected production. Both yellow traps impregnated with pheromone and Encarsia (Trichoporus) partenopea (Hymenoptera: Aphelinidae), a parasitic miniwasp, were also used to control whitefly (Bemisia tabaci) in greenhouse tomato production.

- The IV Michurin Institute of Horticulture in Sogdiana and Bogparvar Test Station Sumbuli in Gissar are now specialized in production of elite seed and stock seed of onion, tomato, carrot, watermelon and pumpkin.
At present, given the pressing need to meet domestic food demands, national policies tend toward promoting food security, both through increased production and diversification of the crops produced. Toward this end, future priorities for vegetable R&D include:

- **Germplasm collection and management.** Currently, Tajik RIHVVG is maintaining 60 tomato varieties, 72 cucumber varieties, 16 garlic varieties, and a good number of melons and watermelons. Unfortunately, its storage facility is antiquated and germplasm collection stored therein is deteriorating. More importantly, an estimated 500 landraces of vegetable and melon are disappearing. Concerted efforts should be taken to inventory the existing vegetable genetic resources in the republic, and to collect and conserve them before they are extinct.

- **Variety introduction and improvement.** For the short-term outlook, introduction and selection of best varieties would be the desirable direction. This could be started with exchange of promising varieties with the neighboring republics in the region. Major constraints to improving vegetable production are the lack of high yielding varieties, thus research activities on germplasm enhancement should breed for different crop varieties with resistance to both biotic and abiotic stresses. Efforts in variety improvement should partner with the State Variety Testing and Protection Committee under the authority of the Ministry of Agriculture.

- **Capacity building in primary production and business development.** These investments include improved crop management, crop diversity and cropping system, integrated pest management, farm business and management skills, improved product storage and handling, improved post-harvest technologies and marketing chain management.

- **International cooperation for vegetable R&D.** Currently, it is mainly limited to the All-Russia Scientific Research Institute of Vegetable Growing, KA Timiryazev Moscow Agricultural Academy, and All-Russia Research Institute of Breeding and Seed-Growing of Vegetable Crops. The linkages with the research institutions in CIS and beyond need to be established.
Economic and Social Context of the Vegetable System in Turkmenistan

Yuri Arestov
Ministry for Agriculture, 63 Azadi Street, Ashgabat, 744000, Turkmenistan

Introduction

Turkmenistan is located in Central Asia between 35°08’ and 42°48’ N and 52°27’ and 66°41’ E. It occupies 48.8 million ha of land area, of which about 75% is Karakum (Garagumy, Black Sand) Desert. A narrow strip of the Kopetdag Mountain chain stretches across the south and southeast. Almost 80% of its territory is in the limits of vast Turan Basin, with an average elevation of 100–200 m above sea level. The population of the republic is over 6 million people, 51% of whom live in rural areas. Agriculture accounts for about 40% of total employment.

Natural Resource Base

The climate of the republic is sharply continental, with the exception of the inshore zone of the Caspian Sea and the mountains. The average annual air temperature ranges from 12–17°C in the northern plains to 15°–18°C in the southeastern plains. The coolest month is January with the average temperature from –6°C in the northeast to 4°N in the southeast and 5°N in the far west. The average temperature of July (the hottest month) ranges from 27–30°N. The absolute maximum temperature reaches 48–50°N in central and southeast Karakum.

The other feature of Turkmenistan is the abundance of sunny days (more than 70% of the days each year). Excessive heat and low levels of precipitation are common and drought is a major limiting factor in agricultural development.

Water resources are irregularly placed within the republic and have historically been located away from most agricultural land. Ninety percent of resources are within the Amu Darya River system in the east; the remaining 10% consists of rivers, springs and discovered aquifers in the south and southwest. The waters of the Murgab, Tedzhen and Sumbar Rivers and the streams along the Kopetdag foothills have been fully utilized for irrigation for many years in the south, where 80% of the land suitable for agriculture is located. The Karakum canal was constructed to meet demands of water for agricultural production in the fertile fields of the west and south.

More than 2,900 species of vascular plants that belong to 105 families are found in the diverse landscapes of Turkmenistan. Of these, about 400 species are considered economically useful. These species vary in the amount of their resources, variety of useful properties, and prospects of their use. The flora of Kopetdag is especially rich in plant diversity, consisting of 332 native species.
The utilized area of irrigated lands in Turkmenistan is about 1.5 million ha. This is mostly located along the Karakum canal and accounts for more than 70% of the republic’s agricultural production. Soils in this area are primarily meadow and takyr soils or light sierozem. The existing application of high irrigation rates, mineral fertilizers, and heavy agricultural machinery is causing salinization and degradation of the irrigated fields.

**Sectoral Context of Agricultural Production**

After its independence, Turkmenistan’s traditional collective landholdings were divided into plots that were leased to families while retaining the overall collective structure and state ownership. There are three groups of family-based producers: household plots, newly created independent private farmers, and family leaseholders operating in large farm associations that no longer function as production cooperatives. Some of the high-performing leased plots eventually were privatized. This unique farm restructuring has resulted in more than three-quarters of the arable land leased to individual households or small groups. At present, most crop production is still circumscribed by central planning. However, there is a trend emerging that the fewest institutional constraints on production and marketing choices lead to the highest levels of productivity.

Turkmenistan has liberalized prices for consumer goods and the republic has experienced an economic rebound from its early transition years. This rebound was supported through a greater investment in the agricultural sector, a tripling of grain production, and a decline in the number of malnourished persons.

Agricultural production amounted to 18.32 trillion manat (US$3.5 billion) in 2004, or 20% up from the previous year, according to the annual report from the Turkmen National Institute of Statistics and Information. The sector accounted for 25% of gross domestic product (GDP), in which the private sector had an 82% share.

To further enhance the contribution of agriculture to food security and economic growth for the years ahead, the republic’s agricultural policy and program have been established and implemented in accordance to the “Strategy of economic, political and cultural development of Turkmenistan for the period through 2020.” The central tenets of the strategy are as follows:

- State control over land and water management for all types of farms.
- User cost sharing for the maintenance of irrigation system.
- Centralized provision of agricultural equipment, including its repair and maintenance.
- Centralized provision of mineral fertilizers and agricultural pesticides.
- Public and private partnership on the development of environmental-friendly, sustainable agricultural production practices.
- Promotion of entrepreneurship on agricultural production that is not under state control.
• Support to all aspects of the agri-food industry through an improved national agricultural research system.

At present, cotton is Turkmenistan’s most valuable crop, taking up one-half of its irrigated land and earning foreign exchange for the economy. However, the amount of land devoted to cotton production may be reduced in the future due to the government’s attempt to diversify its agricultural industry for wheat and horticultural crops, including vegetables.

Status of Vegetable Production

Turkmenistan’s favorable climate and long growing season (230–280 frost-free days) makes it suitable for the production of a variety of vegetables in the open field during much of the year. However, high summer temperatures associated with low humidity (relative humidity ranges from 20 to 35%) may limit production of some vegetables.

Vegetable production occupies about 2% of Turkmenistan’s entire irrigated land, and is concentrated in peri-urban areas. All vegetables are being cultivated with furrow irrigation. Mean irrigation rates during the vegetation period are about 10,000 m³/ha for short-duration vegetables, and 12,000–14,000 m³/ha for long-duration vegetables. Vegetable yields show high variability despite the prevalence of irrigation.

In 2004, vegetable production in Turkmenistan reached 540,000 t and melon production 210,000 t; this represented a 40% increase from the transition period. The major vegetables are watermelon (35%), tomato (30%), onion (12%), carrot (8%), and cabbage (8%). Other vegetables occupy only 7% of the vegetable production area. Almost 90% of vegetables and melons are produced in crop-specialized private farms. At present, vegetable availability per capita is 120 kg; this is anticipated to double by 2010.

Ahal velayat (province) is the major province for the commercial vegetable production, about 33% of the republic’s total production area. Within this province, Ruhabat etrap (district) accounts for 1,200 ha, of which 800 ha is for tomato production. Most tomato products are processed at the Serdar food processing plant for exportation; these products were valued at US$1.3 million in 2004.

Vegetable production is mostly based on the use of antiquated Russian and Uzbek varieties. However, some locally bred varieties with unique horticulture and consumption qualities are also grown. The Ministry of Agriculture issue licenses for vegetable seed production. In 2004, Turkmenistan imported more than 2 t of 21 hybrid varieties of seven vegetables (e.g., tomato, cucumber, sweet pepper and cabbage) for open-field and protected production from the Netherlands at the cost of 505,500 Euro. During the period from October to April, some private vegetable farms use protected facilities; in 2004, these facilities produced 4,100 t of vegetables and 129 t of mushrooms.

The Ruhubelent Joint-Stock Association of the Food Industry of Turkmenistan is the leading enterprise for vegetable production and processing in the republic. The association has the necessary fleet and advanced technology for land preparation and crop
management, and can provide high-quality seeds and seedlings as well as technical assistance to farmers. Tomato paste, ketchup and various juices produced by the association have been in popular demand in both domestic and world market for several years. Taking into account the growing demand for the high-quality goods produced at Ruhubalent, the fields allotted for tomato likely will increase to 4,000 ha in 2006. All the farmers who made contracts with the Ruhubalent will be paid for their tomato in cash at market prices.

Most vegetable production is a consumer-tailored approach; however, because of poor planning, improper crop rotation and insufficient seed production, the distribution and marketing of products are not functioning well. Many modern marketing methods do not work well. This leads to highly seasonal fluctuations of vegetable prices.

**Future Priorities**

The outlook for the vegetable sector in Turkmenistan depends largely on the extent of reforms in land tenure and free entrepreneurship, as well as related agricultural policies on food security, crop allotment, marketing networks and farm community development.

Although there is an upward trend of vegetable production in recent, this trend is masking the fact that average yields appear to be low if not declining. Technically, the vegetable sector in the republic faces numerous challenges that need immediate attention. Some of priorities include:

- Introduction and evaluation of new vegetables so as to diversify diet habits and cropping systems.
- Collection and enhancement of vegetable germplasm resistant to diseases, insect pests, drought, heat and salinity.
- Improvement of technologies for production (both open-field and protected), crop protection, post-harvest storage and distribution, and food processing.

Problems specific to the vegetable seed sector include antiquated processing and testing equipment, weak variety maintenance, dysfunctional seed certification system, absence of new varieties, lack of marketing, and the need to better understand the complexity of a seed program in which the essential components are strongly interrelated. The government has yet to fully appreciate the leading role that the private sector in both domestic and international arenas could play in the vegetable sector for both open-field and protected production of vegetables in future.

Given the complexity of problems that Turkmenistan has to face in the vegetable system, the government and its national agricultural research system have to further strengthen international and regional cooperation. Areas of collaboration may include:

- Structural adjustments and policy amendments to attract foreign investment and strengthen national research strategies and program plans.
- Exchange of germplasm and breeding materials.
• Strengthening of vegetable seed programs, including regional coordination and variety testing systems.

• Identification and testing of modern technologies for diversifying the agricultural system and improving stable supply of vegetables.

• Strengthening human capacity on vegetable research and extension, including business management and marketing principles, through training and information sharing.
Research and Development of the Vegetable System in Turkmenistan

Geldy Goshaev, Akhammet Aklyev, and Orazmirad Palvanmuradov
Research Institute of Crop Husbandry, 63, Azadi St., Ashgabad 744000, Turkmenistan

Introduction

Commencing from 2003, Turkmenistan is executing the national program of “Strategy of economic, political and cultural development of Turkmenistan for the period through 2020.” The stepwise implementation of objectives defined in the strategy is being taken to increase the volumes of agricultural production, including vegetable crops.

Vegetable Production

In 2004, Turkmenistan produced 538,000 t of vegetables, 214,200 t of melons, and 209,900 t of potato from about 53,000 ha of irrigated land areas. Among the republic’s five velayats (provinces), Akhal velayat produced 172,000 t, Mary velayat 98,300 t, Lebap velayat 67,900 t, and Dashoguz velayat 91,200 t.

The republic is targeting to produce 1136,800 t of vegetables and 583,000 t of melons, reaching per capita availability of vegetables and melons at 199.3 kg by 2010. To meet this target, production area will likely need to be significantly expanded; furthermore, from 2010 to 2020, the current yield level of 12.5 t/ha will need to be doubled. At present, each velayat has about 6 ha of hothouses for protected production of tomato and cucumber varieties imported from the Netherlands. This protected production method also has to be extended using locally improved varieties.

The major vegetables produced in Turkmenistan are watermelon, tomato, onion, cabbage, melon, carrot and table beet. Minor vegetables include garlic, cucumber, sweet and hot pepper, winter radish, and eggplant. Some leafy greens and herbs, such as dill, lettuce, parsley, coriander, sorrel, spinach, garden peppergrass and lettuce are also grown.

Vegetable Research and Its Achievements

In compliance with the aforementioned national program, vegetable research activities are mainly carried out by Research Institute of Crop Husbandry, Scientific Research Institute of Farming, Research Institute of Agriculture and Water Management, Turkmen Academy of Agricultural Sciences, and various regional scientific production experimental centers. The main objectives of the research efforts under these institutions are to:
• Collect germplasm and elite varieties of tomato, pepper, eggplant, garlic, melon, watermelon, cucumber and pumpkin from abroad, and select promising materials for extension or further improvement.

• Develop high yielding vegetable varieties with resistance to diseases and harsh environmental conditions, and suitable for mechanical harvest, fresh marketing and processing.

• Develop suitable cropping systems, irrigation schemes, environmentally safe technologies and protective production methods for stable year-round supply of vegetables.

• Produce seeds of selected vegetable and melon varieties, with emphasis on elite and certified seed production.

Below are some recent research achievements in variety improvement. Toward the objectives defined in the aforementioned strategy, however, capacity building in all aspects of vegetable research and development has to be further improved through training, information exchange, and international partnership.

**Tomato**

Turkmen scientists have obtained 75 tomato accessions with various horticultural traits. Through various trials, several promising ones were selected. They include ‘Uzbekistan’, ‘Progressivniy’, ‘Vostok-36’ and ‘Uzmach’ from Uzbek Research Institute of Vegetables, Melon Crops and Potato; ‘Volgogradskiy 5/95’ from Volgograd Experiment Station; ‘Alpatyev 905’ from All-Russia Research and Development Institute of Selection and Vegetable Crop Seed-Growing; ‘Tyomnokrasniy’ from Belarus Research Institute of Vegetable Crops; and ‘Podarok’ from Crimean Experimental Station.

Through their long-term research efforts, Turkmen scientists have also developed their own tomato varieties for public release. Below are a few outstanding ones:

‘Kopetdag’ (‘Tyomnokrasniy’ × ‘Alpatjev 905’) is early-midseason maturing. It is a determinate-vine type that grows 50–55 cm high. The first inflorescence appears above the 6th to 7th leaf. Fruit is flat-round, smooth, red, and of medium weight (70–90 g). Pulp contains 6.0–6.5% dry matter, 3.0–3.4% sugars, and 19–21 mg ascorbic acid/100 g. Average yield is 45.0–60.0 t/ha. One ton of fruit produces about 3.5 kg of seed.

‘Gok-Yaila’ (‘Homestat’ × ‘Podarok 105’) matures in the midseason. It is a determinate-vine type that grows 60–65 cm high. The first inflorescence appears above the 7th to 8th leaves. Fruit is round, smooth, red, and of medium weight (70–89 g). Pulp contains 7.0–7.4% dry matter, 3.5–3.8% sugars, and 20–22 mg ascorbic acid/100 g. Average yield is 60.0–80.0 t/ha. One ton of fruit produces about 3.5 kg of seed. ‘Gok-Yaila’ has the largest production area in the republic. In Akhal velayat alone, the variety grows on 1,500 ha. A cannery factory within Akhal velayat (Rukhabat Etrap) processes 60 t of tomato daily from its farm of 740 ha.
In addition to the above, Balkan (‘Volgogradskiy 5/95’ × ‘Crimsonwee’) and Sedar (‘Volgogradskiy 5/95’ × ‘Uzbekistan’) are also promising and currently undergoing state variety testing.

For the development of early maturing hybrids, an accelerated breeding method has been devised. This method grows two generations in one season, using the 210–225 frost-free day season. For the first generation, seeds are sown in the hothouse and seedlings transplanted to the pot in the second week of January. For the second generation, newly harvested seeds are sown in the open field in the second or third week of June. With this method, six promising lines have been selected: ‘L5’ (‘Fakel’ × ‘Gok-Yaila’), ‘L6’ (‘Lukuchich’ × ‘Nevskiy rannyi’), ‘L7’ (‘Volgogradskiy 5/95’ × ‘Koral’), ‘L8’ (‘Ermak’ × ‘Uzmash’), ‘L9’ (‘Chemenly’ × ‘Slivka’) and ‘L10’ (‘Serdar’ × ‘Oktyabr 60’). Among these, ‘L8’ is especially promising. This line is a midseason maturing and determinate-vine type that grows 35–40 cm high. Fruit is cylindrical, smooth, red, and of medium weight (65 g). It is suitable for processing.

**Melons**


‘Zaami 672’ is a fast growing variety. Its fruit is globe-shaped at 2.8–3.1 kg with brownish orange rind. The netting is thin. Flesh is medium-thick, white, sweet, juicy, and of pleasant flavor. Average yields range from 22.0–24.0 t/ha.

‘Vakharman 499’ is a midseason maturing type. Plants are vigorous for long-season areas. Fruit is elongated in shape and weighs 3.6 kg on average. The rind is smooth and yellow with greenish ribs. Flesh is medium-thick, white, crisp, very sweet (with 17.5% sugar content), and has a faint vanilla flavor. Average yields range from 25.0–30.0 t/ha.

‘Karrygyz’ is a late maturing type. Plants are vigorous for long-season areas. Its fruit is egg shaped and ranges from 3.5–4.5 kg in weight. Its lightly corrugated rind is dark-green and the netting is firm. Flesh is white, dense, and very sweet (with 16–23% sugar content). Average yields range from 25.0–30.0 t/ha. It is adapted for long-term storage.

**Watermelon**

Currently the most widely grown watermelon variety in the republic is ‘Astrakhanskii’; however, local scientists have recently released a few new varieties.
‘Zimniy 344’ is a midseason maturing type. The pear-shaped, small fruit weighs 3.0 kg and has a light-green rind with irregular stripes. Its flesh is light red, sweet and juicy. Average yields range from 20.0–30.0 t/ha.

‘Djeikhun’ (‘Amerikanskiy beliy’ × ‘Klondaik’) is a late maturing type with moderate resistance to powdery mildew. Fruit is oblong, moderate in weight (7.8 kg), and has a smooth green rind. Flesh is reddish-crimson, medium thick, granular, soft, sweet and juicy. Average yields range from 31.5–34.3 t/ha. It is adapted for shipping.

‘Aikhan’ is newly developed and is currently undergoing state variety testing. It is an early maturing type with moderate resistance to powdery mildew. Elongated fruit is 34–36 cm long with 8.6–8.9% sugars, 9.4–9.7% dry matter, and 6.5–7.0% ascorbic acid/100 g. The rind is between 1.0–1.2 cm thick. Flesh is juicy, red and sweet. Average yields range from 23.1–29.3 t/ha.

Cucumber

Three high yielding and heat tolerant varieties were developed: ‘Gyaurs-3’, ‘TOCO-1’ and ‘Akhal’. Among these, ‘Gyaurs-3’ and ‘TOCO-1’ have been released and ‘Akhal’ is currently undergoing state variety testing.

‘Gyaurs-3’ is a midseason maturing type. The fruit is smooth-skinned with lengths that range from 12–15 cm and weights that range from 100–120 g. Average yields range from 20.0–24.0 t/ha.

‘TOCO-1’ is an early maturing type. Fruit is cylinder-shaped with smooth skin. Fruit weight ranges from 100–110 g, and yields from 20.0–25.0 t/ha. It is suitable for both fresh market and pickling.

‘Akhal’ (‘TOCO-1’ × ‘Uzbekistan-740’ is early maturing and resistant to powdery mildew. Its large-leaved vines are vigorous and stout, reaching 120–130 cm. Fruit is 11–12 cm long, 4.6–6.5 cm wide, and 130–140 g in weight, with dark-green, smooth skin. Average yields range from 20.6–23.4 t/ha. Fruits contain 5.1% total sugars, 9.0% dry matter, and 7.1% ascorbic acid/100 g. It is suitable for fresh marketing and pickling.

In addition to the above, Turkmen scientists are working on collecting germplasm, developing improved breeding methods, increasing seed production and developing 30 promising lines of both hybrid and open-pollinated types to further advance cucumber breeding and seed production efforts.

Gourds

Turkmen scientists have created two new gourd varieties, ‘Plov Kadi Mestniy’ and ‘Dash Kadi Mestniy’, which are widely used in production all over the republic.

‘Plov Kadi Mestniy’ is a late maturing type. Fruit is elongated, tapered at ends, and weighs 4–6 kg. Rind is brown and firm. Flesh is dense, orange and sweet (11.3% sugar
content). Average yields range from 25.0–30.0 t/ha.

‘Dash Kady Mestniy’ is a midseason maturing type. Plants are vigorous. Fruit is cylindrical and of medium weight. Rind is thin, woody and very firm. Flesh is medium thick, orange and very firm. Sugar content is low (7–8%). Average yields range from 20.0–25.0 t/ha.

**Garlic**

‘Uzbek Violet’ is an overwintering, late maturing type with a hard flower stalk (scape). Bulb weights range from 40–60 g with 7–14 cloves. Bulbils at the top of scape are small. Average yields range from 6.5–7.0 t/ha. Bulbs contain 37.9% dry matter, 22% sugars, and 5.9 mg ascorbic acid/100 g. It is most suitable for the republic’s climatic and soil conditions.

‘Mestny Bely’ is an early maturing type. Bulb weights range from 30–50 g with 8–12 cloves. Average yields range from 7.0–8.0 t/ha. Bulbs contain 36.2–37.0% dry matter, 19–20% sugars, and 5.9–6.5 mg ascorbic acid/100 g.
Economic and Social Context of the Vegetable System in Uzbekistan

Odil Olimjanov and Khasan Mamarasulov
Ministry of Agriculture and Water Management, 4 Navoi St., Tashkent 700000, Uzbekistan

Introduction

Uzbekistan is located between 37–45° N latitude and 56–73° E longitude within the subtropics. The republic is bordered by Kazakhstan to the north, Kyrgyzstan to the east, Tajikistan to the southeast, Afghanistan to the south, Turkmenistan to the south and west, and the Aral Sea to the northwest. Among the Commonwealth of Independent States (CIS), Uzbekistan is the third largest in terms of its population (26 million, the largest in Central Asia) and fourth largest in land area (44.7 million ha). The republic is divided into 13 administrative areas (oblasts). More than 60% of its population lives in densely populated rural communities. Agriculture plays a pivotal role in the Uzbekistan economy, accounting for 25–30% of its gross domestic product, 40% of employment of the adult labor force, and 55% of export earnings. Agriculture, on the whole, is highly specialized, intensive and mechanized, and accounts for about 90% of foodstuffs and 70% of commodity circulation. Every industrial sphere in the republic is related to agriculture. However, agriculture in the recent years has suffered from inadequate water supply, depleted soils, salinization and a deteriorating irrigation network. Moreover, the problem of food security, with 25% of its population malnourished, is real and complex (FAO 2005). The government’s mid-term goal is to achieve food self-sufficiency through gradual farm privatization and a variety of agricultural reforms, including research and development, resources management, and financial investment.

Natural Resource Base

The climate of Uzbekistan is arid continental and is characterized by considerable seasonal and daily fluctuations of temperature. Solar radiation is particularly high, reaching up to 800 to 1,000 Mj/m² in summer months. The average July temperature on the plains’ territory varies from 26°C in the north to 30°C in the south, and the maximum temperature in the republic reaches 45–47°C. The average January temperature falls to as low as −8°C in the north and 0°C in the south. Precipitation primarily occurs during the winter-spring period. Annual precipitation amounts to 80–200 mm on the plains, 300–400 mm in the foothills area and 600–800 mm on the eastern and southeastern slopes of the mountain ridges. The maximum precipitation occurs in March and April, the minimum in August and September. Winter is fairly short, about two months in the south. Spring is usually short and early, with the growing season beginning in late March/April in the north and early March in the south. Summers in the deserts and the piedmont regions are...
long, hot and dry. Uzbekistan’s climatic conditions favor open-field production of warm-season crops, typically one crop per year.

The territory of Uzbekistan contains five natural ecosystem types: the plain desert ecosystem; the piedmont semideserts and steppes; the rivers and coastal ecosystems; the ecosystems of wetlands and deltas; and the Tien Shan Mountain ecosystem in the east and southeast. The arid plain, about 75% of the territory, extends from Turan Basin in the west to Tien Shan Lowlands in the east. The main rivers are Syr Darya and Amu Darya, which deliver their waters into the Aral Sea, and Zaravshan Darya and their tributaries. These rivers are flanked by broad, flat valleys, which are intensely used for irrigated agriculture.

Flora of Uzbekistan is represented by at least 4,500 species of vascular plants from 650 genera and 146 families. The rate of endemism is rather low among the total number of species.

Uzbekistan is able to support its large population in considerable measure because many of its lands are naturally fertile, especially given the developed irrigation and drainage systems. More than 90% of the value of agricultural production comes from irrigated land, a large part between the major rivers. Unfortunately, however, irrigated waters are unevenly distributed over the country’s territory, with densely populated areas corresponding closely with the availability of surface water. Furthermore, the majority of Uzbekistan’s river waters originate in Kyrgyzstan and Tajikistan. As the rivers flow through the country’s plains, they are depleted through irrigated crop use, infiltration and evaporation—gradually drying up and very often slowing to a trickle in the lower reaches of the two river basins. Unfortunately, Uzbekistan’s ability to maintain the economic potential of its land and water management systems is increasingly threatened by severe land degradation—due primarily to mismanagement of irrigated agriculture for cotton, wheat and rice production—coupled with intensifying national and regional competition over shared and scarce surface waters. Given the abundance of solar radiation and heat, the major factor limiting the use of agroclimatic and land resources is a deficit of water.

**Farming Infrastructure**

As one of the strategies to accelerate economic reforms, a number of laws and decrees have been issued in order to establish a legal framework for the establishment of mixed economy enterprises and agri-businesses. One of the changes in agriculture is the structure of farming, which includes agricultural cooperatives (shirkats), dehkan farms and private farms. Shirkats deal mainly with the production of the strategic crops cotton and wheat. This is the biggest production unit—the average size of farms range from 900 to 1,600 ha. Land is owned by the state, and the cooperative receives land for unlimited use for agricultural purposes. There are two types of contract agreements shirkats have with families. One is a production contract with families for one year. The contract usually includes the production amount of main crops such as cotton and wheat. Shirkats are obliged to guarantee the supply of all necessary material and technical resources. The
other is a land rental agreement, which is usually made for a longer term. At the beginning of each year, the shirkat administration receives a state order plan from a government organization, which identifies the amount of production and area to be sown. It is prohibited to grow crops different from the state order. The average size of family contracts is around 15 ha. The labor intensity per unit of arable area ranges from 0.23 to 0.41 worker per ha.

Private farms are considered a new market-oriented production unit. Private farms (averaging about 20 ha nationally) increased in number quickly in the late 1990s (reaching about 63,000 in 2002), accounting for almost 1.2 million ha in 2004. Private farms received land from the state through long-term leases of up to 50 years. Private farmers are fully independent from local authorities and shirkats in organizing agricultural production. However, in some cases, private farmers also have to produce state-ordered crops, limited not only to cotton and wheat, but also including fruits, vegetables and melons.

Shirkat employees and private farmers can generate an additional source of income from personal household plots of less than 0.35 ha, called tomorkas, as limited by law. Since independence, the total area under these smallholdings has increased significantly and has reached 750,000 ha. The tomorkas are usually located on former shirkat lands that are unprofitable for cotton or wheat production. Since 2000, the state has encouraged farmers to register their tomorka as dehkan farms (or household plots) on the basis of long-term leasing. The registration helps farmers to receive credit, however at the same time it increases state control on income through taxation of land and use of irrigated waters. This type of production could be considered as a purely private type and much more productive because farmers make independent decisions on production and marketing.

Most dehkan farmers are part-time farmers, and they grow a wide variety of crops. Some cultivate for subsistence while others produce cash crops for income. They are an extremely important sector and account for a substantial proportion of agricultural output—reportedly 75% of food other than wheat that is produced in the country. Dehkan farms are an important source of income for households with scanty means, thus play a vital role in poverty reduction in rural areas. Limiting factors of dehkans are the size, location of farm and availability of irrigation.

**Crop Areas and Production Levels**

Of the total land area of Uzbekistan, 4.3 million ha (about 10% of the total land area) are irrigated at 0.13 ha per capita, 3.3 million ha being irrigated arable land and 1.0 ha being irrigated pasture. Covering 15% of the total territory, irrigated lands account for 95% of crops produced in the republic. Unfortunately, there is little possibility for further expansion of the arable area. The unimproved natural pasture area amounts to 23 million ha accounting for over 80% of all agricultural land, or 50% of the total land area.

Crop production in Uzbekistan is largely state controlled. Targets for wheat, rice and cotton, which account for the bulk of the area sown, are set centrally. The state also
directly controls production and prices of inputs and processing as well as exports of cotton and imports of wheat. Products other than cotton, wheat and rice are not subject to explicit production quotas or procurement orders. Official data indicate that the aggregate area sown to crops has been almost stable since 1991. However, the area sown to cereals has increased substantially, mainly at the expense of fodder crops and to a lesser extent cotton. The aggregate area sown to grains has increased steadily from 1.1 million ha in 1991 to a targeted 1.8 million ha in 2005. The area sown to cotton has declined from 1.7 to 1.4 million ha, with irrigated land being diverted to cereals in line with the government’s food security policy. Productions of cereals and cotton have reached 6.2 million t and 1.3 million t, respectively, in 2005 (FAO 2005). Uzbekistan’s yields of crops other than cotton are consistently below that for other countries with similar growing conditions, thus experts believe that productivity in the republic can be improved significantly.

**Vegetable Production**

Wheat and rice are the most important food crops, but vegetables are also important in the Uzbek diet. However, the harsh climate limits year-round production of most vegetables. Institutional transformations in agriculture in the past decade have promoted significant growth of cereal production, but not for vegetable production. Today’s vegetable production area and production are only 76% of what they were in 1991. At present, vegetables are mainly produced on dehkan farms, contributing about 75% of total production in the republic.

The overall area under vegetables in 2004 covered 138,000 ha, which generated 3.3 million t of total production (Uzbek State Statistics Committee 2005). This is a significant decline from the time of independence. Furthermore, average yields during this period have been stagnant at around 24.1 t/ha. Taking into account exports and post-harvest losses, the average Uzbek has access to 95–100 kg of vegetables per annum for consumption, less than the 166 kg that is recommended.

From a socio-economic perspective, the decline of vegetable production in the past one and half decades could be attributed to the weakening of agri-business that supported commercial operations, absence of specialization and regionalization of farming operations, rising costs of fertilizers and other inputs, and ineffective marketing structures. Moreover, technically, vegetable production per se has been limited by many factors: limited irrigation water, use of obsolete technologies, inefficient pest management technologies, and inadequate mechanization (Buriev et al. 2005). At present, the primary task facing the nation’s agrarian sector is to overcome these constraints in order to further increase the production volume of vegetables.

Since independence, the development of vegetable markets was given immediate attention. The efforts made in this direction resulted in the formation of a new type of marketplace based on fundamental market principles. Playing an increasingly prevalent role in the production of vegetable output, the private sector fuels positive changes in the national economy as a whole.
Commercial banks also offer a whole spectrum of credit and financial services to farms specializing in vegetable production. Dehkan and private farms are given credits on favorable terms at the low interest rate of 3%. Compared with other sectors of the nation’s agrarian and industrial complex, the vegetable sector enjoys the best prospects for attracting investments, both domestic and foreign, which can be attributed, first of all, to a high degree of its capital turnover and low resource-intensity.

Opportunities for Export Markets

While partially meeting domestic demand for vegetables, through the creation of an appropriate legal environment, the vegetable sector is steadily raising its share of exports as part of the market reform efforts. In 2003, the export volume of fruits and vegetables amounted to US$42.6 million or 1.3% share of total exports. In the first nine months of 2004, it reached to US$31.7 million, or 1.4% share of total exports. The bulk of exported products were sent to the CIS. For example, Uzbek melon varieties, which are characterized with high fruit sugar content, shelf life and shipping quality, are widely popular in CIS and non-CIS countries as well.

The current level of vegetable exports is much lower than in previous years (Figure 1). Moreover, despite the ongoing trade of vegetables, the export potential of the vegetable sector is far from realized. Many factors limit this development, including the disintegration of the unified transportation network (this causes significant crop losses), international tariffs, lack of marketing information, absence of settled mechanisms for export products, lack of representatives in trading countries, and significant transporta-

![Figure 1. Composition of fruit and vegetable exports from Uzbekistan during 1999–2004](image-url)
tion expenses (Buriev et al. 2005). Recently, the government is paying a great deal of attention to promote the exportation of agricultural products. In 1997, Uzbekistan lifted customs payable by manufacturing enterprises with participation of foreign investors, and simplified registration procedures of contracts with the Agency for Foreign Economic Relations. Measures were also introduced to ensure an increased inflow of foreign capital for the creation of joint ventures. Socio-economic researches of domestic and external markets, expansion of the national export potential, and policy reformation were also conducted.

On the other hand, Uzbekistan had increased existing excise taxes on the importation of a number of food products in 2004. The tax increased to 70% on several kinds of vegetable and fruit juices. The changes concern luxury items above all and do not concern basic products. The changes are to support local producers and stimulate the output of new products.

**Opportunities for Processing Industry**

Given its size and enormous growth potential, Uzbekistan’s food processing and packaging industry represents one of the best prospects for exports. According to the State Statistics Committee, about 11% of the total production of fruits and vegetables is processed. However, the share of canned fruits and vegetables has increased only by 1% in the past five years, accounting for 3% of this produce’s retail turnover. Currently, only 40–50% of the nation’s processing capacities are utilized. This is attributed to a shortage of raw materials, absence of a well-organized marketing system, and a lack of stable market linkages between producers and processing enterprises. In many cases, producers prefer not to sell their harvested crops to processing enterprises because of low prices. Nonetheless, Uzbekistan ranks among the five leading producers of tomato paste. The republic also produces vegetable juices. Uzbekistan has the potential to develop into one of the major food exporters in Central Asia. Therefore, demand for sophisticated, high-tech packaging and processing equipment will greatly expand. Currently, food processing and packaging equipment and technology is antiquated. Packaging in Uzbekistan was not developed previously. After the break-up of the Soviet Union, Uzbekistan was left with only a small packaging industry. The government is taking measures to speed up domestic production of packaging materials, as well as importing advanced processing technologies.

The Uzplodoovoschvinprom Holding Company is the national company responsible for the processing sector. At present, this company produces 140 types of canned and dried food products, reaching 50,000 t per annum. The company runs 17 enterprises in canning-related industries, 2 factories in dried fruits, 3 baby-food enterprises of the Bolalar Taomlary Group and 7 canneries. In addition, the sector encompasses 51 agricultural enterprises, which provide domestic canneries with raw materials. Tomato paste production accounts for almost 70% of processed food products. The sector’s enterprises also turn out concentrated juices and canned fruits and vegetables. However, one must admit that the share of domestically processed fruits and vegetables remains insufficient.
Even though a considerable amount of food is processed in Uzbekistan, it is still below Western standards in terms of packaging, shelf life, hygiene, and nutritional value. The marketing strategies are frequently ineffective. Nonetheless, economic reforms and the process of integration into the world economy require local food processors to raise the quality standards of their products to world levels. The government is putting greater emphasis on the development and implementation of certification for the agricultural products that are in line with international standards. In 1994, a certification system of commodity exports was introduced. In addition, the State Customs Committee established quotas on different product groups, which promoted foreign trade activity. In 1995, domestic export tariffs were aligned with international levels.

Prospects for Vegetable Systems Development

Uzbekistan has a vast potential for increasing cultivation of early and late maturing vegetable crops. And the export of vegetable products is one of crucial driving forces. To elevate the vegetable production level, appropriate conditions have been put in place for active participation of different public and private sectors in the selection of themes for research works. Much of applied research aims to address the following problems: adaptation of the vegetable system to a market-oriented economy; increase in both the volume and quality of vegetable products; improvement of breeding and seed-production systems; introduction of advanced technologies; and reduction of production costs.

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Research and Development of the Vegetable System in Uzbekistan

Batir Azimov
Uzbek Scientific Production Center for Agriculture, 1 Usman Yusupov St., Tashkent 700000, Uzbekistan

Introduction

The history of vegetable cultivation in Uzbekistan goes back several centuries. Archaeologists have found evidence of vegetable cultivation in ancient monuments and writings. It is estimated that onion, cabbage and cucumber cultivation have been grown over 4,000 years, and carrot, beet, radish and garlic over 2,000 years (Balashev and Zeman 1972). With urbanization at the end of 19th century, other vegetables were introduced to the republic. At the beginning of 20th century, new immigrants from Bulgaria, Russia and Ukraine have brought with them tomato, pepper, eggplant and other vegetables to the republic for cultivation.

Trend of Vegetable Production

Before 1925, the republic did not fully utilize its favorable climate for the development of the vegetable sector. In 1913, the area under vegetables on the territory of present Uzbekistan was only 40,800 ha, therein 6,400 ha for potato and 19,000 ha for melons. The intensive development of the vegetable sector did not start until after 1930. In 1934, the area under vegetables accounted for 55,400 ha. In 1940, it expanded to 87,000 ha, among them 38,000 ha for melons and 23,800 ha for potato. By then, principal vegetables included tomato, onion, carrot, cabbage, garlic, table beet, cucumber, melon, watermelon and pumpkin. Other vegetables that emerged at that time included eggplant, sweet pepper, hot pepper, spring radish, winter radish, turnip, leek, Chinese cabbage, cauliflower and other leafy greens.

Table 1 shows the trend of vegetable (including melon) production over the past six decades in the republic. Before independence in 1991, Uzbekistan was one of the major exporters of vegetables to the other parts of the Soviet Union. After independence, there was a significant reduction in the total area and production of vegetables in the republic. The limited export market opportunity was one of the important factors for this cutback. It was almost after a decade when the declining trend of vegetable production started to reverse.

Agricultural production in Uzbekistan is specialized according to the economy of the area, farming infrastructure, agro-eco systems, and market needs. Most of vegetable production concentrates in peri-urban areas near Kibray, Tashkent, Zangiata, Yangiyul, and Bostanlyk of Tashkent oblast (province), Tashkent City, Samarkand and Tailak of
RESEARCH AND DEVELOPMENT OF THE VEGETABLE SYSTEM IN UZBEKISTAN

Samarkand oblast, as well as other large city centers of other oblasts. The large inter-farm and interregional storage facilities for vegetables are being constructed for various farms in these locations. Likely, these locations will remain as the mainstays of vegetable production for the republic in the near future.

The Ministry of Public Health has established a guideline of vegetable consumption for the republic’s population at 142 kg (32 kg of them melons) per capita per annum. In 2003, the republic produced about 3.3 million t of vegetables, among them 587,300 t for melons and 69,200 t for pumpkin. This accounts for per capita availability of vegetables at 152 kg (25 kg of them melons) per annum. This relatively high level of per capita vegetable availability allows the population to acquire an adequate amount of micronutrients from vegetables. Regardless of the increase in overall vegetable production, however, Uzbekistan still does not meet the demand of certain vegetables. This could be due to rapid growth of population, concentration on cotton and grain production, and limited expansion of irrigated land.

Table 1. Trend of vegetable production in Uzbekistan

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<th>Yield (t/ha)</th>
<th>Production (000 t)</th>
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<td>7.9</td>
<td>376</td>
</tr>
<tr>
<td>1999</td>
<td>139</td>
<td>19.3</td>
<td>2,680</td>
<td>47</td>
<td>12.5</td>
<td>588</td>
</tr>
<tr>
<td>2000</td>
<td>130</td>
<td>20.3</td>
<td>2,645</td>
<td>42</td>
<td>12.2</td>
<td>507</td>
</tr>
<tr>
<td>2001</td>
<td>131</td>
<td>21.0</td>
<td>2,749</td>
<td>38</td>
<td>13.5</td>
<td>510</td>
</tr>
<tr>
<td>2002</td>
<td>128</td>
<td>22.8</td>
<td>2,901</td>
<td>41</td>
<td>13.2</td>
<td>540</td>
</tr>
<tr>
<td>2003</td>
<td>142</td>
<td>23.2</td>
<td>3,301</td>
<td>43</td>
<td>15.3</td>
<td>656</td>
</tr>
</tbody>
</table>

Source: State Statistics Committee of the Republic of Uzbekistan

Average vegetable yields in the past decade were in the range of 18.2–20.3 t/ha. Specialized farms usually have higher average yields than non-specialized farms, by 1.3–2.7 times. However, in fact, the yield potential of certain released varieties is expected to be even higher than this level. This relatively low yield at the farm level could be attributed to increased soil salinity, low soil fertility, absence of improved varieties and crop rotations, high temperatures in the summer season, and lack of irrigated water.
In line with the republic’s economic reforms, the attention is now directed to increasing vegetable production. By 2010, it is expected to reach annual production of 4.2 million t, including tomato at 1.7 million t and melons at 1.0 million t, from all types of farms. This is to be achieved through the introduction of multiple cropping systems, modern production technologies and high-yielding varieties.

**Vegetable Seed Production**

Actions were taken in the republic to improve vegetable seed production capacity in the republic. Well back in 1939, systematic approaches of seed production were initiated with the establishment of “Uzsortsemovosh,” a specialized association for seed production and marketing. At present, there are 29 seed production farms, including 8 dehkan farms, 17 shirkats and 3 specialized seed farms of “Soh,” “Bozsu,” and “Bagizagan.” They produce about 1,000 t of seeds per year, with an adequate amount for domestic production of melon crops.

During 2000–2005, 110 t of purebred elite and first grade vegetable seeds (including 41 t of melon seeds) were transferred for production in the total area of 167,000 ha.

**Vegetable Research and Development System**

Scientific research on vegetables in Uzbekistan did not start until 1924 when the All-Union Institute of Plant Industry of the former Soviet Union (now N.I. Vavilov All-Russian Research Institute of Plant Industry [VIR]) set up a branch experimental station in Uzbekistan for the Central Asian region, which later was transformed into the Uzbek Research Institute of Plant Industry (UzRIPI), to collect and study plant genetic resources for variety improvement. By then, a vegetable seed-growing farm was also established for both indigenous and introduced varieties, and the state universities established vegetable sections in their agriculture departments.

In 1933, the Vegetable and Potato Growing Experimental Station was established. During the initial stage, the station engaged in collection and evaluation of genetic resources, variety improvement, production technologies, and seed production. Later the station was transformed as the Uzbek Research Institute of Vegetable, Melon Crops and Potato (UzRIVMCP).

Augmented with the above two institutes, significant improvements of vegetable production took place because of extended adoption of mechanization and new production technologies, as well as the increased availability of fertilizers and other agricultural chemicals, appropriate information, improved varieties, and quality seeds.

At present, the Uzbek Scientific Production Center for Agriculture (UzSPCA) of the Ministry for Agriculture and Water Management provide directions and manage all facets of agricultural research and development of the republic. UzSPCA has 18 institutes, including UzRIPI and UzRIVMCP. In addition, the Uzbek Academy of Sciences has
institutes of botany, genetics and plant experimental biology, microbiology, and soil science that deal with agricultural issues. This applies also to four universities and seven institutes that engage entirely in agricultural education and research or have faculties or departments for that purpose.

UzSPCA has 109,000 ha of experimental fields, including 43,000 ha of irrigated land and 3,200 ha of gardens and vineyards. It has 23 experimental farms with land areas exceeding 2,000 ha each, and 70 experimental farms with land areas less than 300 ha each. The state provides budget to UzSPCA for its research operations, whereas UzSPCA experimental farms have to be self-supported. UzSPCA has 1,200 scientists including 12 academicians. UzSPCA also collaborates with various international agricultural centers, and companies from the USA and Greece.

UzRIPI and UzRIVMCP are the two major institutes responsible for the conservation of vegetable genetic resources in the republic. UzRIPI maintains a collection of 4,628 accessions, including 2,739 of cucurbit crops, and 35 registered vegetable varieties (Table 2). UzRIVMCP’s collection consists of melon (340 accessions), tomato (18), cucumber (11), watermelon (7), onion (6), cabbage (6), carrot (5), sweet pepper (5), turnip (3), 2 accessions each for eggplant, winter radish and pumpkin, and 1 each for table beet, radish, dill, coriander, lettuce and squash.

Table 2. Collection of vegetable resources at Uzbek Research Institute of Plant Industry

<table>
<thead>
<tr>
<th>Crop</th>
<th>Accessions</th>
<th>Crop</th>
<th>Accessions</th>
<th>Crop</th>
<th>Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amaranth</td>
<td>25</td>
<td>Eggplant</td>
<td>44</td>
<td>Pepper</td>
<td>49</td>
</tr>
<tr>
<td>Anise</td>
<td>1</td>
<td>Fennel</td>
<td>4</td>
<td>Potato</td>
<td>105</td>
</tr>
<tr>
<td>Artichoke</td>
<td>2</td>
<td>Garlic</td>
<td>205</td>
<td>Potato, sweet</td>
<td>2</td>
</tr>
<tr>
<td>Basil</td>
<td>8</td>
<td>Gourd, luffa</td>
<td>18</td>
<td>Pumpkin</td>
<td>926</td>
</tr>
<tr>
<td>Beet, table</td>
<td>38</td>
<td>Gourd, smooth</td>
<td>22</td>
<td>Radish</td>
<td>154</td>
</tr>
<tr>
<td>Cabbage</td>
<td>104</td>
<td>Jerusalem artichoke</td>
<td>2</td>
<td>Radish, winter</td>
<td>83</td>
</tr>
<tr>
<td>Caraway</td>
<td>6</td>
<td>Lettuce</td>
<td>121</td>
<td>Spinach</td>
<td>2</td>
</tr>
<tr>
<td>Carrot</td>
<td>125</td>
<td>Love-in-a-mist</td>
<td>4</td>
<td>Swede</td>
<td>1</td>
</tr>
<tr>
<td>Celery</td>
<td>46</td>
<td>Melon</td>
<td>957</td>
<td>Turnip</td>
<td>19</td>
</tr>
<tr>
<td>Coriander</td>
<td>9</td>
<td>Onion</td>
<td>106</td>
<td>Tomato</td>
<td>546</td>
</tr>
<tr>
<td>Cucumber</td>
<td>11</td>
<td>Parsnip</td>
<td>4</td>
<td>Watermelon</td>
<td>805</td>
</tr>
<tr>
<td>Dill</td>
<td>61</td>
<td>Parsley</td>
<td>12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Before any variety is registered and released for production, the promising varieties have to be submitted to the State Commission for Variety Testing of Agriculture for the examination of claimed selection achievements. The Uzbek State Register of Varieties of Plants currently has 251 vegetable varieties registered under its auspice (Table 3). The breeders from UzRIPI, UzRIVMCP and Tashkent State Agrarian University have contributed 100 entries that are disease resistant and high yielding. And UzRIVMCP’s breeders have a biggest share of this contribution.
Table 3. Vegetable varieties registered under the Uzbek State Register of Varieties of Plants

<table>
<thead>
<tr>
<th>Crop</th>
<th>Total</th>
<th>Indigenous</th>
<th>Introduced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bean</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Beet, table</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Cabbage, white</td>
<td>21</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>Cabbage, Chinese</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Carrot</td>
<td>12</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>5</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Coriander</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Corn</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Cucumber (open-field)</td>
<td>20</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>Cucumber (protected production)</td>
<td>17</td>
<td>3</td>
<td>14</td>
</tr>
<tr>
<td>Dill</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Eggplant</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Estragon</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Fennel</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Garlic</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Lettuce</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Melon</td>
<td>36</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>Onion</td>
<td>11</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Parsley</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pea</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pepper, hot</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Pepper, sweet</td>
<td>6</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>5</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Radish, spring</td>
<td>7</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Radish, winter</td>
<td>4</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Sorrel</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Spinach</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Squash</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Tomato (open-field)</td>
<td>34</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Tomato (protected production)</td>
<td>23</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td>Turnip</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Vegetable marrow</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Watermelon</td>
<td>17</td>
<td>11</td>
<td>6</td>
</tr>
</tbody>
</table>

Total: 251 135 116

Source: National Registry of Agricultural Crops Recommended for Sowing at the Territory of the Republic of Uzbekistan

In addition to variety improvement, UzRIVMCP also engages in the following crucial areas of vegetable research and development:

- Integration of mechanization for vegetable production.
- Development of improved soil management methods including both organic and inorganic fertilization as well as crop rotation.
• Application of integrated pest management (IPM) along with the use of resistant varieties.

• Development of protected technologies for off-season production.

• Extension of new technologies and information to the farmers.

In relation to the above, UzRIVMCP’s recent achievements include optimal rate and timing of inorganic fertilizer application, rotations with lucerne crops, new IPM methods, and tomato seed treatment to fight against viral diseases. UzRIVMCP is providing over 2 t of treated tomato seeds to the farms located in Tashkent, Zangiata, Kibray and Samarkand. Moreover, the plastic film cover technique for early planting has been extended to over 3,000 ha. It is expected that greenhouse production will reach 1,000 ha by 2010. Along with other techniques, the protected production technology will generate 250,000 t of vegetables. Moreover, most of open-field productions will be mechanized.

The Challenges Ahead

Uzbekistan is facing three major challenges: ensuring food security, alleviating poverty, and protecting the environment (Beniwal and Warma 2000). During the period of transition to market economy, crop production and water supply systems as well as economic and social conditions are changing in the republic. The economic independence of agricultural enterprises has been extended. On the other hand, Uzbekistan’s natural resource base is degrading or depleting, which is compounding the threat to food security, human health, and sustainable ecosystems. This results in a need to alter the structure of vegetable production systems. Research is therefore urgently needed which takes these factors into account to design sustainable, productive vegetable systems. Some of research challenges include:

• High population growth, which creates the need to greatly increase food production.

• Subdivision of land into smallholdings for which appropriate production technologies is not always readily available.

• Expansion of agricultural production into marginal rainfall areas for which little or no research works have been carried out.

• Rapidly declining soil fertility in some areas due to soil erosion or continuous cropping.

• Frequent droughts and diminishing water resources due to destruction of vegetation in catchment areas.

• Increasing costs of agricultural inputs such as fertilizers, pesticides, machinery and implements.
The challenges mentioned herein define the future directions for research and development in the vegetable sector. Major priorities include:

- Ensure provisions for basic and applied research for the vegetable sector.
- Ensure more effective use of irrigated water, fertilizers and other inputs for vegetable cultivation.
- Intensify breeding activities for the development of disease-resistant and high yielding varieties.
- Improve elite and primary seed production.
- Expand use of IPM and other biological control measures for plant protection.
- Improve efficiency and reliability of agricultural machinery.
- Develop technologies for both protected and open-field productions.
- Develop safe vegetable production technology.
- Expand research on post-harvest handling, storage and processing.
- Intensify science-based hybrid seed production.
- Improve credit and lease systems and marketing infrastructures.
- Intensify international cooperation.
- Expand human resource development activities in graduate programs and internships abroad.
- Encourage scientific publications in both local and international journals and proceedings.

**Literature Cited**


Setting Research and Development Priorities for Market-oriented Vegetable Production Systems in Central Asia and the Caucasus

Mubarik Ali, Ravza Mavlyanova, Mei-huey Wu, Umar Farooq, Li-ju Lin, and C. George Kuo
AVRDC – The World Vegetable Center, P.O. Box 42, Shanhua, Tainan 74199, Taiwan

1 Introduction

The Central Asia and the Caucasus (CAC) region, encompassing Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan from Central Asia, and Armenia, Azerbaijan and Georgia in the Caucasus, is located at 39–48º N to 43–75º E. It covers more than 4 million km² of land and 33.2 million ha of arable land with a population of more than 74 million people. The area under all crops in one year is 25.1 million ha, out of which about half is irrigated (Table 1).

Kazakhstan is the largest while Armenia is the smallest country in the region. Uzbekistan is the most and Armenia is the least populous country. The population growth in the region stands at 0.72% per annum. Average population density is about 18 persons/km² with a variation ranging from 6 persons/km² in Kazakhstan to 103 persons/km² in Armenia, and per capita availability of arable land in the regions ranges from 0.15 ha in Georgia to 1.39 ha in Kazakhstan with an average of 0.45 ha. During 2003, the per capita gross domestic product (GDP) was US$816, ranging from US$210 in Tajikistan to US$1,780 in Kazakhstan. The contribution of agriculture to GDP ranges between 8% in Kazakhstan to 39% in Kyrgyzstan and the population that depends upon agriculture ranges from 12% in Armenia to 32% in Turkmenistan (Table 1).

In terms of agriculture and food, the region is unique in several characteristics: 1) climatic patterns limit crop cultivation to only the cool-wet spring and hot-dry summer; 2) proportion of the labor force engaged in agriculture is low, implying labor shortage for intensive agriculture in general and vegetable cultivation in particular; 3) per capita arable land is small, exerting a great pressure on land to meet the population’s food requirements; 4) relatively large farm sizes increases reliance on machinery; 5) a large proportion of arable land is allocated to pastures and fruit crops; and 6) the relatively large portion of irrigated crop lands, except in Kazakhstan, favors vegetable cultivation.

Prior to the independence from the former Soviet Union in 1991, the CAC republics were economically interdependent under the centrally managed economy. Each republic was specialized in producing agricultural commodities according to its agro-climatic resources, and the products distributed through the Soviet trade system. The state farms controlled about 95% of farm land, and the state organizations controlled most of input supply market chains.
Table 1. Geographic and socio-economic status of Central Asia and the Caucasus

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>40 00 N, 45 00 E</td>
<td>30</td>
<td>23</td>
<td>35</td>
<td>950</td>
<td>50</td>
<td>3.1</td>
<td>103</td>
<td>12</td>
<td>495</td>
<td>290</td>
<td>280</td>
<td>0.16</td>
<td>-1.25</td>
<td>-1.65</td>
<td>-0.04</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>40 30 N, 47 30 E</td>
<td>87</td>
<td>14</td>
<td>46</td>
<td>820</td>
<td>49</td>
<td>8.4</td>
<td>97</td>
<td>26</td>
<td>1,783</td>
<td>1,248</td>
<td>1,455</td>
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<td>1.02</td>
<td>0.42</td>
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<td>70</td>
<td>21</td>
<td>23</td>
<td>770</td>
<td>54</td>
<td>5.1</td>
<td>74</td>
<td>18</td>
<td>799</td>
<td>585</td>
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<td>-0.95</td>
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<td>2,725</td>
<td>8</td>
<td>38</td>
<td>1,780</td>
<td>19</td>
<td>15.4</td>
<td>6</td>
<td>18</td>
<td>21,535</td>
<td>14,060</td>
<td>2,350</td>
<td>1.39</td>
<td>-0.91</td>
<td>-1.20</td>
<td>-6.12</td>
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<td>200</td>
<td>39</td>
<td>23</td>
<td>340</td>
<td>40</td>
<td>5.1</td>
<td>26</td>
<td>24</td>
<td>1,345</td>
<td>938</td>
<td>1,072</td>
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<td>1.35</td>
<td>0.45</td>
<td>0.54</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>39 00 N, 71 00 E</td>
<td>142</td>
<td>31</td>
<td>29</td>
<td>210</td>
<td>60</td>
<td>6.2</td>
<td>44</td>
<td>32</td>
<td>930</td>
<td>1,154</td>
<td>719</td>
<td>0.15</td>
<td>1.15</td>
<td>-0.89</td>
<td>0.90</td>
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<tr>
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<td>40 00 N, 60 00 E</td>
<td>488</td>
<td>25</td>
<td>46</td>
<td>1,120</td>
<td>58</td>
<td>4.9</td>
<td>10</td>
<td>32</td>
<td>1,850</td>
<td>2,155</td>
<td>1,800</td>
<td>0.39</td>
<td>2.02</td>
<td>2.14</td>
<td>2.82</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>41 00 N, 64 00 E</td>
<td>447</td>
<td>38</td>
<td>26</td>
<td>420</td>
<td>28</td>
<td>26.1</td>
<td>58</td>
<td>26</td>
<td>4,848</td>
<td>4,637</td>
<td>4,281</td>
<td>0.17</td>
<td>1.79</td>
<td>1.14</td>
<td>0.03</td>
</tr>
<tr>
<td>Overall</td>
<td>39-48 N, 43-75 E</td>
<td>4,189</td>
<td>25</td>
<td>33</td>
<td>816</td>
<td>37</td>
<td>74.3</td>
<td>18</td>
<td>24</td>
<td>33,221</td>
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<td>12,426</td>
<td>0.45</td>
<td>0.72</td>
<td>-0.05</td>
<td>-4.10</td>
</tr>
</tbody>
</table>

Sources: 1CIA (2004). The contribution of the services sector is 100 minus the contribution of agriculture and industry; 2World Bank (2004); 3CIA (2005); 4World Bank (2005); and remaining from FAOstat data (2006)

*Weighted average of individual country poverty data where share of population of each country in the total population of the region was used as weights
After independence, the state-controlled trade arrangements collapsed and the large state farms posed problems for the new republics. Previously practiced input intensive production systems were now difficult to operate because of high energy costs. Due to lack of resources, the irrigation system deteriorated. The farm lands were privatized and farm subsidies withdrawn. The seed supply systems especially for fruits and vegetables were on the verge of collapse. The productivity of major crops dropped during the first 5–7 years after independence, which contributed to a significant decline in GDP. With the governments’ efforts, crop productivity in the region started to rise in the late 1990s, and GDP began to rise in the early 2000s. However, much work remains to be done. Currently, about 37% of the population lives below the poverty line (Table 1). Available irrigated land has increased by only 0.4% per annum from 1992–2002. Per capita availability of arable land actually declined at 4.1% per annum over this time, mainly because a large portion of agricultural land was abandoned in Kazakhstan due to lack of labor and capital. Moreover, the research and development system needs to be restored in the region.

The purpose of this study is to identify priority areas of collaborative research and development (R&D) areas to boost market-oriented vegetable systems in the CAC region. Under this background, the study aims to 1) review the past and present status of vegetable production; 2) set priorities for vegetable productions by agro-ecosystems; and 3) recommend strategies for realizing the potential of the vegetable sector in the region. The study conducted an opinion survey of policymakers and vegetable researchers in the CAC region during February and March 2005. The information sought in the questionnaire included area and production of individual vegetables, contribution of various production systems and ecological conditions in total supply, major diseases and pests in major vegetables, and researchable issues and development strategies in their respective countries. The macro data from the Food and Agriculture Organization of the United Nations (FAO), Central Intelligence Agency of the United States (CIA), and other sources were used as references in the analysis.

2 Physical and Socio-economic Environment of the Region

2.1 Climate

A variety of climatic conditions, from arid deserts to polar mountains, occur in CAC (Table 2). Generally, there are three seasons: winter, spring, and summer. Winter temperatures reach below 0°C, and heavy snowfall dominates in this season, especially in the mountains. The summer temperatures in some regions can reach above 40°C. Much of the rainfall, although less than 40 mm per month, occurs during spring.

The length of seasons varies across countries and in different regions within a country. For example, the northern part of Kazakhstan has long winters with short summers, but Uzbekistan and Tajikistan have long summers with short winters. This variation could be exploited for vegetable trade in the region. Temperate vegetables in Uzbekistan and tropical vegetables in Tajikistan could be exported to Kazakhstan during winters and
summers, respectively. However, the allocation of different vegetables in various regions or countries will require a strong transport and storage infrastructure, which is currently lacking in the CAC region.

### Table 2. Climatic conditions in the CAC region

<table>
<thead>
<tr>
<th>Countries</th>
<th>Climatic conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>Highland continental, hot summers, cold winter</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>Dry, semiarid steppe</td>
</tr>
<tr>
<td>Georgia</td>
<td>Warm; Mediterranean-like on Black Sea coast</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>Cold winter and hot summer, arid and semiarid</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>Dry continental to polar in high Tien Shan; subtropical in southwest (Fergana Valley); temperate in northern foothill zone continental,</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>Mild-latitude continental, hot summer, mild winter; semiarid to polar in Pamir Mountains</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>Subtropical desert</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>Mostly mid-latitude desert, long, hot summer, mild winter; semiarid grassland in east</td>
</tr>
</tbody>
</table>

Source: CIA (2004)

### 2.2 Agro-ecological environment

The International Center for Agricultural Research in the Dry Areas (ICARDA) has classified the CAC region into four agro-ecological zones of lowland rainfed, lowland irrigated, lowland semi-arid rangeland, and mountains (ICARDA 2002). Below are some of opportunities and constraints in different zones:

- The rainfed areas are predominantly cereal-based. Input levels are low and maintaining soil fertility is a problem. Considerable potential exists for developing integrated farming.
- The lowland irrigated areas have salinization and waterlogging problems. Potential for intensification exists with improved irrigation practices to maximize water productivity.
- The lowland semi-arid rangelands are basically non-arable common steppe lands more suitable for livestock production.
- The mountain areas, foothills and upland valleys support dryland farming. Productivity is low and rural communities are among the poorest in the region. The improved soil and water management system would be an integral part of the system to improve the productivity.

### 2.3 Food production and nutrient deficiency

After independence, most of CAC republics followed the path of food self-sufficiency, which led their agricultural systems toward increased wheat production (Baydildina et al. 2000). All the input supplies, research, and extension activities focused on wheat produc-
tion. As a result, wheat producing and exporting Kazakhstan suffered due to loss of its traditional markets in previously wheat-deficit countries such as Tajikistan, Turkmenistan, Uzbekistan, and Azerbaijan. This focus on wheat production retarded exploitation of various regions in producing high value crops in those countries where wheat production lacks its comparative advantages.

Despite the recent surge of economic growth, the incidence of poverty remains high in the CAC region, and the extent of poverty differs within each country. For Kyrgyzstan, poverty is highest in rural areas, in female-headed households, in households with large numbers of children, and for those with less education (Pomfret 1998). For Kazakhstan, 50% of women and 60% of pregnant women had some degree of anemia (Bauer et al. 1997), and protein intake of mothers in southern Kazakhstan is only 57% of the recommended level (Babu and Reidhead 2000).

2.4 Investment in agriculture

Publicly funded support for the agriculture sector in the CAC region plummeted in the early 1990s. This trend greatly affected vegetable variety development, production and distribution of vegetable seed, extension services, and input supplies. Uncertainties in land ownership and marketing system discouraged the investment on land and irrigation improvements critically required for vegetable cultivation. Moreover, lack of experience in marketing led to dramatic increases in marketing margins and costs, and a reduction in farmers’ share in the final value of agricultural products. Although much of the transportation infrastructure from the Soviet era is still in operation, reduced investments in maintenance have limited their services. Moreover, much of storage capacity for transporting cereals is in bad shape (Longmire and Moldashev 1999), not to mention shifting their use for the vegetable system.

3 Trends in the Vegetable Sector

3.1 Vegetable production

Vegetables are an integral part of the diet in the region. The contribution of vegetables to the total diet was reported to be about 8% in Kazakhstan and Turkmenistan (Baydildina et al. 2000). During 2004, more than 10 million t of vegetables were produced in the CAC region from 0.64 million ha with the average annual growths in area, production and yield at 2.8, 4.1 and 1.3%, respectively (Figure 1). The largest expansion in production area was in Azerbaijan, but Uzbekistan experienced a negative trend. An overall increase in yield was attributed to its increase in Kazakhstan despite a decline in Azerbaijan, Georgia, Tajikistan and Turkmenistan (Table 3).

Cereal production in the region increased with an annual growth rate of 2.4%. A sharp decline took place from 1993 to 1995; later it experienced a fluctuating slow rise till 2002, but then set on declining trend again till 2004 (Figure 2). The trend was reflected the trend in Kazakhstan, the dominant cereal producing republic of the region. The area
under cereals in CAC region fell from 25.5 million ha in 1993 to 17.4 million ha in 2004 with an annual decline of 2.8%, which again reflected the decline in Kazakhstan. On the other hand, an annual growth rate of 5.1% in cereal yields reflected cereal yield improvements in all CAC republics except Georgia (Table 3).

The increase in vegetable production occurred in those countries where cereal production declined or increased only slightly. Vegetable production declined where cereal production increased significantly. Azerbaijan is the only exception where both cereal and vegetable productions increased simultaneously. This negative correlation between vegetable and cereal productions stresses the importance of fundamental reformations in the vegetable systems to spur vegetable production in the region.

<table>
<thead>
<tr>
<th>Crop / country</th>
<th>Area (000 ha)</th>
<th>Production (mil t)</th>
<th>Yield (t/ha)</th>
<th>Annual growth rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetables and melons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Armenia</td>
<td>22</td>
<td>27</td>
<td>0.45</td>
<td>0.67</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>35</td>
<td>106</td>
<td>0.53</td>
<td>1.39</td>
</tr>
<tr>
<td>Georgia</td>
<td>31</td>
<td>47</td>
<td>0.41</td>
<td>0.45</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>97</td>
<td>158</td>
<td>0.99</td>
<td>2.44</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>17</td>
<td>42</td>
<td>0.28</td>
<td>0.71</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>32</td>
<td>38</td>
<td>0.59</td>
<td>0.57</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>46</td>
<td>53</td>
<td>0.53</td>
<td>0.53</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>212</td>
<td>167</td>
<td>3.67</td>
<td>3.30</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>492</td>
<td>638</td>
<td>7.46</td>
<td>10.06</td>
</tr>
<tr>
<td>Cereals</td>
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<td></td>
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<tr>
<td>Armenia</td>
<td>187</td>
<td>193</td>
<td>0.31</td>
<td>0.42</td>
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<tr>
<td>Azerbaijan</td>
<td>702</td>
<td>806</td>
<td>1.14</td>
<td>2.04</td>
</tr>
<tr>
<td>Georgia</td>
<td>228</td>
<td>326</td>
<td>0.40</td>
<td>0.70</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>21,781</td>
<td>12,786</td>
<td>21.53</td>
<td>12.14</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>626</td>
<td>594</td>
<td>1.54</td>
<td>1.70</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>268</td>
<td>387</td>
<td>0.26</td>
<td>0.71</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>432</td>
<td>940</td>
<td>1.01</td>
<td>2.81</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>1,302</td>
<td>1,359</td>
<td>2.16</td>
<td>5.07</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>25,526</td>
<td>17,391</td>
<td>28.36</td>
<td>25.60</td>
</tr>
</tbody>
</table>
**Figure 1.** Trends in area, production and yield of vegetables in CAC region during 1993–2004

Source: FAOstat data, 2006
Figure 2. Trends in area, production and yield of cereals in CAC region during 1993–2004

Source: FAOstat data, 2006
3.2 Per Capita Availability

The per capita availability of vegetables, fruits and cereals changed at annual rates of 3.8%, –1.5%, and –0.5%, respectively (Figure 3). The per capita availability of veg-

![Graph showing trend in per capita availability of vegetables, fruits, and cereals from 1993 to 2003.]

Source: FAOstat data, 2006

**Figure 3.** Trend in per capita availability of vegetables, fruits and cereals in CAC region during 1993–2003
Table 4. Changes in per capita availability of cereals, fruits and vegetables in CAC region by country

<table>
<thead>
<tr>
<th>Country</th>
<th>Cereals (kg/year) 1993</th>
<th>Cereals (kg/year) 2003</th>
<th>Fruits (kg/year) 1993</th>
<th>Fruits (kg/year) 2003</th>
<th>Vegetables (kg/year) 1993</th>
<th>Vegetables (kg/year) 2003</th>
<th>Mean annual growth rate (%) Cereals</th>
<th>Mean annual growth rate (%) Fruits</th>
<th>Mean annual growth rate (%) Vegetables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>231</td>
<td>226</td>
<td>53</td>
<td>61</td>
<td>131</td>
<td>223</td>
<td>1.8</td>
<td>-2.4</td>
<td>3.5</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>265</td>
<td>343</td>
<td>100</td>
<td>67</td>
<td>65</td>
<td>170</td>
<td>5.6</td>
<td>-3.0</td>
<td>11.7</td>
</tr>
<tr>
<td>Georgia</td>
<td>250</td>
<td>309</td>
<td>135</td>
<td>89</td>
<td>76</td>
<td>111</td>
<td>4.2</td>
<td>-8.9</td>
<td>2.6</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>1008</td>
<td>537</td>
<td>11</td>
<td>12</td>
<td>59</td>
<td>158</td>
<td>-1.2</td>
<td>3.3</td>
<td>13.2</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>528</td>
<td>338</td>
<td>12</td>
<td>28</td>
<td>61</td>
<td>145</td>
<td>1.0</td>
<td>8.4</td>
<td>10.9</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>326</td>
<td>186</td>
<td>41</td>
<td>28</td>
<td>106</td>
<td>86</td>
<td>-3.4</td>
<td>-2.1</td>
<td>-2.3</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>520</td>
<td>524</td>
<td>38</td>
<td>36</td>
<td>134</td>
<td>108</td>
<td>2.0</td>
<td>-0.5</td>
<td>-2.4</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>233</td>
<td>215</td>
<td>43</td>
<td>44</td>
<td>162</td>
<td>141</td>
<td>-1.3</td>
<td>1.0</td>
<td>-1.4</td>
</tr>
<tr>
<td>Overall</td>
<td>469</td>
<td>329</td>
<td>47</td>
<td>41</td>
<td>105</td>
<td>143</td>
<td>-0.5</td>
<td>-1.5</td>
<td>3.8</td>
</tr>
</tbody>
</table>

Note: The mean annual growth rate is obtained by accounting for availability of cereals, fruits and vegetables for every year from 1993 to 2003. Since availability fluctuates significantly in many cases, comparing data from 1993 and 2003 alone may be somewhat misleading.
Source: FAOstat data, 2006

3.3 International Trade

During 2003, total trade in vegetables in the CAC region amounted to 515,000 t with a value of over US$126 million (Table 5). Imports constituted about one-sixth of the total trade in 2003. The trade surplus amounted to 0.34 million t and was valued at over US$71 million. The trade surplus remained positive throughout the period of 1993–2003, ranging from US$46 million to US$133 million. Less than 5% of the production in the CAC region was exported, and vegetable trade of the region was quite erratic. For example, vegetable exports were 0.19 million t in 1993, then increased to 0.47 million t the following year, and then fell to 0.29 million t in 1998. Similar fluctuations in imports, total trade, and trade surplus were also observed (Table 5).

During the recent past, vegetable prices for export were lower than import prices. This is due to added transportation costs on the imported vegetables. The difference also reflects that the CAC region imports high value and exports low value vegetables. Targeting production of high value commodities for export markets can reverse this situation, and create competitiveness of the vegetable sector in the region. However, annual fluctuations in international prices of vegetables make it hard for the farmers to plan their production activities for export (Table 5). Part of this fluctuation is attributed to the poor infrastructure and link with international markets. The low international vegetable prices...
during the last four years (1999–2003) may have discouraged farmers to invest on vegetable production.

**Table 5. Vegetable trade in the CAC region during 1993–2003**

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantity (000t)</th>
<th>Value (milUS$)</th>
<th>Price (US$/000t)</th>
<th>Quantity (000t)</th>
<th>Value (milUS$)</th>
<th>Price (US$/000t)</th>
<th>Quantity (000t)</th>
<th>Value (milUS$)</th>
<th>Price (US$/000t)</th>
<th>Quantity (000t)</th>
<th>Value (milUS$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>23.3</td>
<td>11.1</td>
<td>4.78</td>
<td>186.2</td>
<td>78.5</td>
<td>4.22</td>
<td>209.5</td>
<td>89.6</td>
<td>163.0</td>
<td>67.4</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>38.9</td>
<td>18.6</td>
<td>4.77</td>
<td>469.7</td>
<td>151.5</td>
<td>3.23</td>
<td>508.6</td>
<td>170.1</td>
<td>430.7</td>
<td>132.9</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>60.2</td>
<td>35.1</td>
<td>5.83</td>
<td>395.3</td>
<td>100.9</td>
<td>2.55</td>
<td>455.5</td>
<td>136.0</td>
<td>335.2</td>
<td>65.8</td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>122.8</td>
<td>67.4</td>
<td>5.49</td>
<td>388.9</td>
<td>145.0</td>
<td>3.73</td>
<td>511.8</td>
<td>212.5</td>
<td>266.1</td>
<td>77.6</td>
<td></td>
</tr>
<tr>
<td>1997</td>
<td>76.2</td>
<td>56.4</td>
<td>7.40</td>
<td>388.3</td>
<td>147.0</td>
<td>3.79</td>
<td>464.5</td>
<td>203.5</td>
<td>312.0</td>
<td>90.6</td>
<td></td>
</tr>
<tr>
<td>1998</td>
<td>66.9</td>
<td>61.1</td>
<td>9.14</td>
<td>287.4</td>
<td>106.9</td>
<td>3.72</td>
<td>354.3</td>
<td>168.1</td>
<td>220.6</td>
<td>45.8</td>
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</tr>
<tr>
<td>1999</td>
<td>47.9</td>
<td>13.1</td>
<td>2.75</td>
<td>435.7</td>
<td>63.2</td>
<td>1.45</td>
<td>483.6</td>
<td>76.3</td>
<td>387.9</td>
<td>50.1</td>
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<tr>
<td>2000</td>
<td>42.6</td>
<td>12.6</td>
<td>2.96</td>
<td>355.2</td>
<td>60.4</td>
<td>1.70</td>
<td>397.8</td>
<td>73.0</td>
<td>312.6</td>
<td>47.7</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>57.2</td>
<td>16.5</td>
<td>2.89</td>
<td>235.1</td>
<td>66.2</td>
<td>2.81</td>
<td>292.3</td>
<td>82.7</td>
<td>177.9</td>
<td>49.7</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>78.6</td>
<td>24.0</td>
<td>3.05</td>
<td>400.3</td>
<td>76.7</td>
<td>1.92</td>
<td>478.9</td>
<td>100.7</td>
<td>321.7</td>
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<tr>
<td>2003</td>
<td>87.2</td>
<td>27.5</td>
<td>3.15</td>
<td>427.8</td>
<td>98.7</td>
<td>2.31</td>
<td>515.0</td>
<td>126.2</td>
<td>340.6</td>
<td>71.3</td>
<td></td>
</tr>
</tbody>
</table>

Source: FAOstat data, 2006

Fresh and dried vegetable is the major form of exportation, while preserved vegetables and vegetable juices are the major form of importation (Figure 4). During 2003, dry onion was the major vegetable exported from the region contributing about one-fourth of the total exported value, while 11% of imported value was also onion (Figure 4). The major value-added vegetable product exported was tomato paste, but it also occupied a substantial percentage of import value. To become a major player in the international vegetable trade, the CAC region has to broaden their export base and create value-addition activities of vegetable commodities.
4 Role of Vegetables in the Cropping System

4.1 Share in Area

One of the distinguished changes in the cropping system was an increase of vegetable share in the total crop area (Figure 5). The ratio stood at 2.2% in 2004 against 1.0% in 1993, with an annual growth rate of 7.1%. However, annual growth rates varied among the countries. Azerbaijan had the largest growth, Turkmenistan and Uzbekistan experienced negative growth, and Armenia remained stagnant (Table 6). Although Kazakhstan’s contribution to the region’s growth rate was high, its actual percentage of cropland in vegetables remained the lowest (approximately 0.9%).

With regard to the type of vegetables produced, the share of fruit vegetables increased from 47% to 55% and root and bulb vegetables from 22% to 25% while leafy and flower vegetables declined from 31% to 20% (Table 7). The aforementioned variations may reflect different degrees of market-oriented structural changes among the CAC republics.
Table 6. Percentage of vegetable to total crop area in CAC region by countries during 1993-2004

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>Armenia</td>
<td>4.5</td>
<td>5.0</td>
<td>5.5</td>
<td>5.3</td>
<td>5.3</td>
<td>4.8</td>
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<td>5.2</td>
<td>4.8</td>
<td>5.0</td>
<td>5.4</td>
<td>5.1</td>
<td>0.4</td>
</tr>
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<td>Azerbaijan</td>
<td>2.0</td>
<td>2.4</td>
<td>2.3</td>
<td>2.7</td>
<td>3.4</td>
<td>5.9</td>
<td>5.8</td>
<td>6.0</td>
<td>6.1</td>
<td>6.6</td>
<td>6.3</td>
<td>6.3</td>
<td>12.5</td>
</tr>
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<td>5.0</td>
<td>5.2</td>
<td>4.5</td>
<td>4.6</td>
<td>4.5</td>
<td>6.6</td>
<td>6.7</td>
<td>7.4</td>
<td>6.4</td>
<td>6.3</td>
<td>6.6</td>
<td>7.0</td>
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<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
<td>0.6</td>
<td>0.8</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>11.7</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>1.3</td>
<td>1.9</td>
<td>2.9</td>
<td>3.1</td>
<td>3.4</td>
<td>4.3</td>
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<td>3.4</td>
<td>3.7</td>
<td>3.6</td>
<td>6.3</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>3.7</td>
<td>4.3</td>
<td>4.3</td>
<td>3.7</td>
<td>3.9</td>
<td>4.4</td>
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<tr>
<td>Uzbekistan</td>
<td>4.6</td>
<td>4.6</td>
<td>4.2</td>
<td>3.8</td>
<td>3.4</td>
<td>3.7</td>
<td>3.6</td>
<td>3.8</td>
<td>3.7</td>
<td>3.9</td>
<td>3.9</td>
<td>3.9</td>
<td>-1.4</td>
</tr>
<tr>
<td>Overall</td>
<td>1.0</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
<td>2.0</td>
<td>2.3</td>
<td>2.2</td>
<td>2.3</td>
<td>2.1</td>
<td>2.2</td>
<td>2.2</td>
<td>7.1</td>
</tr>
</tbody>
</table>

Source: FAOstat data, 2006

Figure 5. Trends in the vegetable-total crop area ratio in CAC region during 1993–2004

Table 7. Area and production shares (%) of various vegetable types in the CAC region during 1992 and 2003

<table>
<thead>
<tr>
<th>Type of vegetable</th>
<th>Share of area (%)</th>
<th>Share of production (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit</td>
<td>62</td>
<td>66</td>
</tr>
<tr>
<td>Leafy and flower</td>
<td>16</td>
<td>13</td>
</tr>
<tr>
<td>Root and bulb</td>
<td>22</td>
<td>21</td>
</tr>
</tbody>
</table>

Source: Estimated from the survey data provided by country collaborators
4.2 Major vegetables produced

More than 30 types of vegetables are grown in the CAC region. Tomato, watermelon, cabbage, onion, cucumber and carrot occupy more than four-fifths of the total vegetable area (Figure 6).

Tomato is the major vegetable in Armenia, Kyrgyzstan, and Uzbekistan; watermelon in Azerbaijan, Kazakhstan and Turkmenistan; and cabbage in Georgia (Table 8). Shallot is exclusively grown in Armenia and garden radish in Georgia. Leafy greens are mainly grown in Georgia, table beet in Kazakhstan and melon in Uzbekistan. About half of region’s cauliflower is grown in Georgia, carrot in Kazakhstan, garlic and tomato in Uzbekistan (Table 9).

![Figure 6. Major vegetables grown in the CAC region during 2003](image)

**Table 8.** Major vegetables by country in the CAC region during 2003

<table>
<thead>
<tr>
<th>Country</th>
<th>Major vegetables (% share in total vegetable area in a country)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>Tomato (27), cabbage (12), watermelon (9)</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>Watermelon (28), tomato (21), onion (12), cucumber (10)</td>
</tr>
<tr>
<td>Georgia</td>
<td>Cabbage (19), tomato (15), leafy greens (11)</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>Watermelon (22), cabbage (13), carrot (12), onion (11)</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>Tomato (19), cucumber (15), carrot (14), onion (13), cabbage (11), watermelon (11)</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>Watermelon (26), onion (23), tomato (22)</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>Watermelon (25), tomato (24)</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>Tomato (42), watermelon (26), cabbage (13)</td>
</tr>
</tbody>
</table>

Source: Estimated from the survey data provided by country collaborators
Table 9. **Leading countries in the cultivation of different vegetables in the CAC region during 2003**

<table>
<thead>
<tr>
<th>Country</th>
<th>Major vegetables (% share of the country in total area of CAC for that crop)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>Shallot (100), cauliflower (35) sweet pepper (26), eggplant (12), leafy greens (12), garlic (9)</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>Eggplant (48), watermelon (35), chili pepper (34), peas (28), garlic (26), cucumber (25), onion (23), tomato (18), cabbage (10)</td>
</tr>
<tr>
<td>Georgia</td>
<td>Garden radish (100), leafy greens (88), cauliflower (49), sweet pepper (29), eggplant (25), table beet (24), pea (17), chili pepper (15), cabbage (10)</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>Table beet (58), carrot (51), pumpkin (46), chili pepper (41), sweet pepper (40), watermelon (37), cabbage (31), onion (29), cucumber (26), melon (17), eggplant (13), tomato (10)</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>Garlic (20), cauliflower (16), carrot (16), cucumber (13), onion (9)</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>Onion (17), carrot (12), watermelon (12), tomato (7)</td>
</tr>
<tr>
<td>Turkmenistan</td>
<td>Watermelon (7), carrot (6), pumpkin (6), cucumber (5), tomato (5), onion (4)</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>Melon (77), tomato (46), garlic (45), pea (43), pumpkin (34), cabbage (30), cucumber (19), onion (11)</td>
</tr>
</tbody>
</table>

Source: Estimated from the survey data provided by country collaborators

As so many vegetables are grown in the region, no country can do research on every vegetable crop. This implies that while setting regional priorities, the leading role of R&D for different vegetables should be assigned to the countries having the major share of a given crop’s production. The underlying objective is to establish the synergistic interactions among cooperating institutions to maximize the research outputs from the limited resources.

Average yields of major vegetables in the region are higher than those in the tropical and sub-tropical countries, but lower than those in developed countries in the temperate region (Table 10). This shows the potential of improvement in the CAC region.

Table 10. **Per ha yield (t/ha) of major crops in CAC region in comparison with the yield in other developing and developed countries during 2004**

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>CAC</th>
<th>India</th>
<th>Indonesia</th>
<th>Philippines</th>
<th>USA</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabbage</td>
<td>25.8</td>
<td>21.4</td>
<td>19.6</td>
<td>12.0</td>
<td>24.9</td>
<td>21.4</td>
</tr>
<tr>
<td>Carrots</td>
<td>18.7</td>
<td>14.6</td>
<td>15.5</td>
<td>-</td>
<td>39.7</td>
<td>73.9</td>
</tr>
<tr>
<td>Cucumber</td>
<td>12.0</td>
<td>6.7</td>
<td>8.5</td>
<td>6.2</td>
<td>14.1</td>
<td>31.5</td>
</tr>
<tr>
<td>Onion</td>
<td>16.4</td>
<td>10.3</td>
<td>9.4</td>
<td>9.2</td>
<td>54.4</td>
<td>43.7</td>
</tr>
<tr>
<td>Tomato</td>
<td>22.7</td>
<td>14.1</td>
<td>12.7</td>
<td>9.7</td>
<td>73.9</td>
<td>177.8</td>
</tr>
<tr>
<td>Watermelon</td>
<td>13.4</td>
<td>12.8</td>
<td>-</td>
<td>18.9</td>
<td>29.2</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: FAOSTAT data, 2006
5 Vegetable Cultivation by Agro-Ecosystems

To estimate an overall distribution of all vegetables in the region, the distribution of each crop was weighted by its share in the total area of all vegetables. The data suggest that more than half of total vegetable production is concentrated in the peri-urban lowlands. The overall contribution of home gardens in supplying vegetables is about the same from cotton- and wheat-based systems.

The distribution for certain vegetables deviates from the overall distribution. For example, cauliflower and garlic come mainly from home gardens (Table 11). The share of the production system in supplying vegetables varies across countries, too. For example, the peri-urban system in Georgia provides about two-thirds of the overall vegetable supply (data not shown).

Vegetable cultivation in the CAC region is seasonal. About half of the supplies comes from autumn (August–September), and another one-fourth from hot-dry summer (June–July). The concentration of vegetables supply during autumn season is due to the fact the crop sown after rainy season. Very little (about 15%) vegetables are available during winter (November–January) and early spring (February–March) (Table 12).

Onion, cucumber (open field), and radish are concentrated in the summer season, whereas sweet pepper, garlic, and other leafy vegetables are equally distributed between summer and autumn. Oversupplies of these crops happen during summer. Therefore, a market system should be developed to encourage the export of these crops, especially to the tropics where these crops are difficult to grow during the hot season.

On the other hand, a large percentage of tomato and cucumber (both from greenhouse) and table beet are grown from February to May, whereas a reasonable percentage of cabbage, cauliflower, radish, peas and leafy vegetables are grown from November–January (Table 12). In some countries like Uzbekistan, a large share of vegetable supplies is concentrated in the winter and early spring. The trade of certain vegetables should be encouraged by growing those crops in the winter and early spring. The yield improvement of vegetables for cold and drought tolerances will help to overcome the seasonality problem in the vegetable supply. Another possible strategy is to utilize cold protection technologies. However, the economics of the latter should be carefully determined beforehand.
Table 11. *Distribution of vegetables supplies by production system in CAC region by crop*

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Peri-urban lowland</th>
<th>Cotton/wheat-based</th>
<th>Home garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bean</td>
<td>16</td>
<td>4</td>
<td>80</td>
</tr>
<tr>
<td>Beet, table</td>
<td>43</td>
<td>29</td>
<td>28</td>
</tr>
<tr>
<td>Cabbage</td>
<td>59</td>
<td>16</td>
<td>25</td>
</tr>
<tr>
<td>Carrot</td>
<td>44</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>25</td>
<td>11</td>
<td>64</td>
</tr>
<tr>
<td>Cucumber</td>
<td>54</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>Eggplant</td>
<td>65</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>Garlic</td>
<td>34</td>
<td>4</td>
<td>62</td>
</tr>
<tr>
<td>Leafy greens</td>
<td>54</td>
<td>14</td>
<td>32</td>
</tr>
<tr>
<td>Melon</td>
<td>54</td>
<td>25</td>
<td>21</td>
</tr>
<tr>
<td>Onion</td>
<td>55</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Pea</td>
<td>29</td>
<td>17</td>
<td>54</td>
</tr>
<tr>
<td>Pepper, chili</td>
<td>65</td>
<td>4</td>
<td>31</td>
</tr>
<tr>
<td>Pepper, sweet</td>
<td>60</td>
<td>5</td>
<td>35</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>42</td>
<td>31</td>
<td>27</td>
</tr>
<tr>
<td>Pumpkin, bush</td>
<td>50</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>Radish, garden</td>
<td>45</td>
<td>5</td>
<td>50</td>
</tr>
<tr>
<td>Shallot</td>
<td>70</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Tomato</td>
<td>66</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Watermelon</td>
<td>45</td>
<td>36</td>
<td>19</td>
</tr>
<tr>
<td>Total vegetables</td>
<td>54</td>
<td>22</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 12. *Distribution of vegetables supplies by ecology in the CAC region by crop*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet, table</td>
<td>27</td>
<td>38</td>
<td>10</td>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>Cabbage</td>
<td>6</td>
<td>11</td>
<td>14</td>
<td>49</td>
<td>20</td>
</tr>
<tr>
<td>Carrot</td>
<td>3</td>
<td>6</td>
<td>15</td>
<td>69</td>
<td>7</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>3</td>
<td>3</td>
<td>18</td>
<td>47</td>
<td>29</td>
</tr>
<tr>
<td>Cucumber (greenhouse)</td>
<td>24</td>
<td>47</td>
<td>14</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Cucumber (open-field)</td>
<td>0</td>
<td>4</td>
<td>58</td>
<td>37</td>
<td>1</td>
</tr>
<tr>
<td>Eggplant</td>
<td>1</td>
<td>3</td>
<td>32</td>
<td>60</td>
<td>4</td>
</tr>
<tr>
<td>Garlic</td>
<td>0</td>
<td>10</td>
<td>43</td>
<td>43</td>
<td>4</td>
</tr>
<tr>
<td>Leafy greens</td>
<td>4</td>
<td>7</td>
<td>33</td>
<td>35</td>
<td>21</td>
</tr>
<tr>
<td>Melon</td>
<td>0</td>
<td>0</td>
<td>19</td>
<td>79</td>
<td>2</td>
</tr>
<tr>
<td>Onion</td>
<td>3</td>
<td>9</td>
<td>47</td>
<td>35</td>
<td>6</td>
</tr>
<tr>
<td>Pea</td>
<td>1</td>
<td>6</td>
<td>19</td>
<td>46</td>
<td>28</td>
</tr>
<tr>
<td>Pepper, chili</td>
<td>1</td>
<td>2</td>
<td>19</td>
<td>74</td>
<td>4</td>
</tr>
<tr>
<td>Pepper, sweet</td>
<td>1</td>
<td>4</td>
<td>43</td>
<td>47</td>
<td>5</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>92</td>
<td>3</td>
</tr>
<tr>
<td>Radish</td>
<td>15</td>
<td>15</td>
<td>30</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Tomato (open-field)</td>
<td>0</td>
<td>2</td>
<td>37</td>
<td>52</td>
<td>9</td>
</tr>
<tr>
<td>Tomato (greenhouse)</td>
<td>31</td>
<td>38</td>
<td>16</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Watermelon</td>
<td>0</td>
<td>2</td>
<td>30</td>
<td>67</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
<td>12</td>
<td>27</td>
<td>46</td>
<td>8</td>
</tr>
</tbody>
</table>
6 Major Biotic Constraints in Vegetable Production

The respondents have identified three major diseases and pests in the order of their importance for the major vegetables in their respective countries. The ranking order of a pest was recorded at the scale of 1–3, ‘1’ for the most important and ‘3’ for the least important. To estimate overall ranking of different pests, the order of these ranks was first inverted, i.e., ‘3’ was assigned for the most important pest, and ‘1’ for the least important. Then the weighted average summation of the inverted ranks across all CAC countries was taken, using the relative share in area of the vegetable of each country in the total area of the region as weights. The highest number obtained was considered as the most important pest.

This can be expressed in notation form for the jth pest in a vegetable as follows:

\[ W_j = \sum_{k=1}^{8} X_k D_{i,j} \]  

where \( W_j \) = Weighted score of the jth pest;
\( i \) = Ranking order (1 is the most important rank and 3 is the least important);
\( D_i \) = Weight of the ith rank, which is 3 for \( i = 1 \), 2 for \( i = 2 \), and 1 for \( i = 3 \); and
\( X_k \) = Share of the kth country in total area of the vegetable in the CAC region.

The higher the weighted score of a pest, the greater is its importance.

Appendix 1 lists the major pests in the region, and Appendix 2 lists at the country level for the major vegetables. Table 13 summarizes the three priority insects in the whole region, and indicates aphids and mites are the most common pests.

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Priority 1</th>
<th>Priority 2</th>
<th>Priority 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Common name</td>
<td>Code(^1)</td>
<td>Common name</td>
</tr>
<tr>
<td>Beet, table</td>
<td>Noctuid moth</td>
<td>35</td>
<td>Weevil</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Aphid</td>
<td>21</td>
<td>Noctuid moth</td>
</tr>
<tr>
<td>Carrot</td>
<td>Rust fly</td>
<td>15</td>
<td>Noctuid moth</td>
</tr>
<tr>
<td>Cucumber</td>
<td>Aphid</td>
<td>30, 21</td>
<td>Mite</td>
</tr>
<tr>
<td>Eggplant</td>
<td>Colo. pot. beetle</td>
<td>5</td>
<td>Noctuid moth</td>
</tr>
<tr>
<td>Melon</td>
<td>Melon aphid</td>
<td>25</td>
<td>Aphid</td>
</tr>
<tr>
<td>Onion</td>
<td>Onion fly</td>
<td>14</td>
<td>Tobacco thrip</td>
</tr>
<tr>
<td>Pepper, chili</td>
<td>Aphid</td>
<td>21</td>
<td>Thrips</td>
</tr>
<tr>
<td>Pepper, sweet</td>
<td>Aphid</td>
<td>21</td>
<td>Tomato fruitworm</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>Aphid</td>
<td>30</td>
<td>Mite</td>
</tr>
<tr>
<td>Tomato</td>
<td>Whitefly</td>
<td>19</td>
<td>Mite</td>
</tr>
<tr>
<td>Watermelon</td>
<td>Aphid</td>
<td>30</td>
<td>Mite</td>
</tr>
</tbody>
</table>

\(^1\)Pest species are listed by code number in Appendix 1
Appendix 3 lists the major diseases in the region, and Appendix 4 lists at the country level for the major vegetable. Table 14 summarizes the three priority diseases in the whole region, and indicates Fusarium wilt, downy mildew, and powdery mildew are the most common diseases.

Table 14. Three highest priority diseases infected on different vegetables in CAC region

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Priority 1</th>
<th>Priority 2</th>
<th>Priority 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Common name</td>
<td>Code¹</td>
<td>Common name</td>
</tr>
<tr>
<td>Beet, table</td>
<td>Powdery mildew</td>
<td>F19</td>
<td>Downy mildew</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Olpidium root rot</td>
<td>F29</td>
<td>Downy mildew</td>
</tr>
<tr>
<td>Carrot</td>
<td>Black rot</td>
<td>F4</td>
<td>Septoria leaf spot</td>
</tr>
<tr>
<td>Cucumber</td>
<td>Downy mildew</td>
<td>F41</td>
<td>Powdery mildew</td>
</tr>
<tr>
<td>Eggplant</td>
<td>Brown spot</td>
<td>F26</td>
<td>Fusarium wilt</td>
</tr>
<tr>
<td>Melon</td>
<td>Powdery mildew</td>
<td>F19</td>
<td>Fusarium wilt</td>
</tr>
<tr>
<td>Onion</td>
<td>Downy mildew</td>
<td>F31</td>
<td>Powdery mildew</td>
</tr>
<tr>
<td>Pepper, chili</td>
<td>Fusarium wilt</td>
<td>F22</td>
<td>Verticillium wilt</td>
</tr>
<tr>
<td>Pepper, sweet</td>
<td>Fusarium wilt</td>
<td>F22</td>
<td>Stem and root rot</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>Powdery mildew</td>
<td>F19</td>
<td>Downy mildew</td>
</tr>
<tr>
<td>Tomato</td>
<td>Phytoplasma</td>
<td>P</td>
<td>Tob. mosaic virus</td>
</tr>
<tr>
<td>Watermelon</td>
<td>Downy mildew</td>
<td>F41</td>
<td>Fusarium wilt</td>
</tr>
</tbody>
</table>

¹Pathogen species are listed by code number in Appendix 3

7 Resources for Vegetable Research

Overall, 4.3% of the total resources allocated for agricultural research go to vegetable research. The vegetable subsectors get even a lesser share of human resources (Table 15). These shares are in proportion with the vegetable sector’s share in total crop area, but far below the sector’s contribution in creating income and employment. This laxity in allocating resources for vegetable R&D appears more acute when the number of crops and constraints is considered.

Table 15. Resource allocation (percentage share) of agricultural funds and scientific manpower going to vegetable R&D in the CAC region

<table>
<thead>
<tr>
<th>Country</th>
<th>Funds</th>
<th>M.Sc. and Ph.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armenia</td>
<td>3.9</td>
<td>6.9</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>7.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Georgia</td>
<td>1.3</td>
<td>2.5</td>
</tr>
<tr>
<td>Kazakhstan</td>
<td>4.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Kyrgyzstan</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>10.0</td>
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</tr>
<tr>
<td>Turkmenistan</td>
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<td>NA</td>
</tr>
<tr>
<td>Uzbekistan</td>
<td>2.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Overall</td>
<td>4.3</td>
<td>3.4</td>
</tr>
</tbody>
</table>

NA = not available
8 Prioritization of Research Issues

8.1 Researchable issues

The respondents have prioritized a number of R&D issues in such a way that all scores add up to 100 for a given commodity. The priority score for a vegetable for the region was estimated by multiplying the individual country priority scores with the country share for that vegetable in the total area of the same vegetable in the region. The priority for an issue for overall vegetables was estimated by multiplying the score for each issue across vegetables (in each column) in the region with the area share of each vegetable in the total area of all vegetables of the region.

The analysis reveals that improved technology for adoption is the highest priority theme. This is followed by collection and utilization of germplasm, and development of the seed and seedling industry. The next three important R&D themes in their order of priority are 1) variety improvement for increased yield; 2) variety improvement for disease resistance; and 3) development of information systems (Table 16).

There are variations for priority issues across individual crops. For example, in tomato, development of an information system, collection of germplasm, and variety improvement for disease resistance are placed before management technologies. In radish and cauliflower, improving post-harvest technologies is one of the most important issues.

Table 16. Prioritization of research themes by vegetables in the CAC region by crop

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet, table</td>
<td>21</td>
<td>15 8 7 6 7 7 10 14 1 4 5 2</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cabbage</td>
<td>16</td>
<td>12 5 7 5 7 27 11 1 2 5 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrot</td>
<td>14</td>
<td>9 5 5 6 7 25 15 3 4 6 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Cauliflower</td>
<td>6</td>
<td>12 7 11 12 9 9 15 3 5 6 5</td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Cucumber</td>
<td>13</td>
<td>12 6 14 3 7 19 13 4 4 3 2</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
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<td>Garlic</td>
<td>5</td>
<td>20 7 10 3 4 14 13 3 7 7 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leafy crops</td>
<td>10</td>
<td>18 9 10 11 6 6 6 9 5 5 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lettuce</td>
<td>10</td>
<td>18 9 10 11 6 6 6 9 5 5 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Melon</td>
<td>19</td>
<td>10 8 11 3 9 17 11 4 4 4 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-traditional</td>
<td>15</td>
<td>15 5 10 15 10 10 10 2 3 3 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Onion</td>
<td>21</td>
<td>10 4 7 4 7 22 15 1 4 3 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pea</td>
<td>14</td>
<td>12 9 11 7 5 15 5 3 7 6 6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pepper, chili</td>
<td>8</td>
<td>16 8 10 7 4 11 13 4 4 8 7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pepper, sweet</td>
<td>18</td>
<td>11 8 13 7 9 11 9 2 4 6 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumpkin</td>
<td>13</td>
<td>10 6 6 1 5 25 15 6 4 7 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pumpkin, bush</td>
<td>10</td>
<td>15 10 20 5 15 10 5 2 2 3 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radish</td>
<td>5</td>
<td>15 10 10 15 5 5 15 5 5 5 5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomato</td>
<td>15</td>
<td>8 5 12 2 4 9 13 1 17 5 9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watermelon</td>
<td>17</td>
<td>22 8 11 1 4 16 10 2 3 4 2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>16</td>
<td>13 6 10 3 6 17 12 2 7 4 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In leafy greens, the development of improved high-yielding varieties is the single most important theme.

The respondents have also prioritized abiotic constraints of tomato, chili pepper, sweet pepper, carrot, and cucumber in such a way that all scores add up to 100 for a given commodity. The procedure to sum up these constraints at the regional level was the same as in the above. The analysis reveals that drought and heat are the major abiotic constraints with almost equal importance in all five crops. Flooding is a concern for carrot, while chilling for tomato and sweet pepper. Salinity is of concern for carrot and tomato, while nutrient deficiency only for tomato (Table 17).

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Flooding</th>
<th>Drought</th>
<th>Heat</th>
<th>Chilling</th>
<th>Salinity</th>
<th>Nutr. deficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrot</td>
<td>17</td>
<td>33</td>
<td>33</td>
<td>0</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Cucumber</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pepper, chili</td>
<td>0</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pepper, sweet</td>
<td>0</td>
<td>43</td>
<td>43</td>
<td>14</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tomato</td>
<td>0</td>
<td>38</td>
<td>38</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

8.2 Agro-ecological dimensions of vegetable research

The relative importance of agro-ecosystem as an issue at the CAC region level was estimated by taking the weighted average score for each issues across countries, where weights was the relative share of each country in the total regional area of all vegetables.

The analysis reveals that peri-urban is the most important production system in the CAC region. In fact, little variation exists in assigning peri-urban system as the top researchable theme. The wheat/cotton-based intensive system and home gardening, both have almost similar importance among researchable issues (Table 18). The production system dimension of various researchable issues is in line with the relative importance of these systems in supplying vegetables.

In terms of researchable issues for different ecologies, highest priority was given to summer in tackling varietal improvement for disease resistance, developing technologies to reduce pesticide use, and exploiting modern information technology, while autumn is more important for the collection and utilization of indigenous vegetables, and development of post-harvest technologies (Table 19).
Table 18. Prioritization of vegetable R&D issues by production system in the CAC region

<table>
<thead>
<tr>
<th>Research and development areas</th>
<th>Peri-urban</th>
<th>Wheat/cotton-based</th>
<th>Home garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-economic and policy research</td>
<td>52</td>
<td>21</td>
<td>27</td>
</tr>
<tr>
<td>Collection and utilization of indigenous vegetables</td>
<td>54</td>
<td>11</td>
<td>35</td>
</tr>
<tr>
<td>Varietal improvement for productivity</td>
<td>55</td>
<td>19</td>
<td>26</td>
</tr>
<tr>
<td>Varietal improvement for quality</td>
<td>55</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Varietal improvement for disease resistance</td>
<td>58</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>Developing technologies to reduce pesticide use</td>
<td>55</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td>Exchange improved materials, technologies for adoption</td>
<td>49</td>
<td>31</td>
<td>20</td>
</tr>
<tr>
<td>Exploitation of modern information technology</td>
<td>54</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>Development of post-harvest technology</td>
<td>60</td>
<td>26</td>
<td>14</td>
</tr>
<tr>
<td>Enhancing R&amp;D efficiency through training</td>
<td>58</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>Development of seed and seedling business</td>
<td>52</td>
<td>24</td>
<td>24</td>
</tr>
</tbody>
</table>

Table 19. Prioritization of vegetable R&D issues by ecology in the CAC region

<table>
<thead>
<tr>
<th>Research and development areas</th>
<th>Feb–Mar</th>
<th>Apr–May</th>
<th>Jun–Jul</th>
<th>Aug–Sep</th>
<th>Nov–Jan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-economic and policy research</td>
<td>10</td>
<td>27</td>
<td>23</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Collection and utilization of indigenous vegetables</td>
<td>7</td>
<td>13</td>
<td>27</td>
<td>45</td>
<td>8</td>
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<tr>
<td>Varietal improvement for productivity</td>
<td>10</td>
<td>30</td>
<td>30</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td>Varietal improvement for quality</td>
<td>11</td>
<td>30</td>
<td>27</td>
<td>21</td>
<td>11</td>
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<tr>
<td>Varietal improvement for disease resistance</td>
<td>13</td>
<td>28</td>
<td>33</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Developing technologies to reduce pesticide use</td>
<td>9</td>
<td>26</td>
<td>35</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td>Exchange improved materials, technologies for adoption</td>
<td>12</td>
<td>27</td>
<td>24</td>
<td>8</td>
<td>29</td>
</tr>
<tr>
<td>Exploitation of modern information technology</td>
<td>19</td>
<td>21</td>
<td>22</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Development of post-harvest technology</td>
<td>2</td>
<td>7</td>
<td>24</td>
<td>45</td>
<td>22</td>
</tr>
<tr>
<td>Enhancing R&amp;D efficiency through training</td>
<td>14</td>
<td>27</td>
<td>20</td>
<td>16</td>
<td>23</td>
</tr>
<tr>
<td>Development of seed and seedling business</td>
<td>5</td>
<td>32</td>
<td>29</td>
<td>27</td>
<td>7</td>
</tr>
</tbody>
</table>

9 Prioritization of Development Strategies

Respondents were given options for strategies to develop the vegetable sector in their respective countries, and asked to assign scores to each option in a way that the sum of the scores for all options is 100. Results of this analysis are discussed herein.

9.1 Options to produce safe vegetables

Among the three options to produce safe leafy vegetables (i.e., production technology, biological control, and farmers’ training), the former was ranked as the best way to go. Respondents would like to allocate about half of the resources designated to reduce pesticide use on the development of safe vegetable production technologies, such as low tunnels, greenhouses, etc. The remaining 50% was almost equally distributed among
biological control and farmers’ training (Table 20). A small variation for individual vegetables can be seen, but allocation for production technology remained high in the range of 40–70%.

9.2 Types of information

Respondents gave highest ranking to information related to improved varieties in alternative cropping systems. This was followed by information on the optimum use of inputs, major diseases and their control, major insects and their control, and seed sources (Table 21).

Among the types of information required for policy development, respondents gave the highest priority to generate forecasts on supply, demand and prices of major vegetables in their respective countries; second in importance was information on production costs of major vegetables in various production systems. Next to these in importance was information on markets costs, forecast of supply, demand, and prices in other countries, and international quality standards (Table 22). This clearly indicates there is a strong demand for initiating projects that can generate information of commodity forecasts and production costs. Such information will not only improve policy formulation related to the

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Biological control</th>
<th>Production technology</th>
<th>Farmers’ training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bean</td>
<td>29</td>
<td>43</td>
<td>28</td>
</tr>
<tr>
<td>Beet, table</td>
<td>9</td>
<td>51</td>
<td>40</td>
</tr>
<tr>
<td>Cabbage</td>
<td>30</td>
<td>49</td>
<td>21</td>
</tr>
<tr>
<td>Carrot</td>
<td>29</td>
<td>40</td>
<td>31</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>33</td>
<td>45</td>
<td>22</td>
</tr>
<tr>
<td>Cucumber</td>
<td>32</td>
<td>41</td>
<td>27</td>
</tr>
<tr>
<td>Dill</td>
<td>13</td>
<td>49</td>
<td>38</td>
</tr>
<tr>
<td>Eggplant</td>
<td>18</td>
<td>53</td>
<td>29</td>
</tr>
<tr>
<td>Garlic</td>
<td>15</td>
<td>49</td>
<td>36</td>
</tr>
<tr>
<td>Leafy greens</td>
<td>28</td>
<td>41</td>
<td>31</td>
</tr>
<tr>
<td>Lettuce</td>
<td>28</td>
<td>41</td>
<td>31</td>
</tr>
<tr>
<td>Melon</td>
<td>35</td>
<td>41</td>
<td>24</td>
</tr>
<tr>
<td>Non-traditional</td>
<td>20</td>
<td>60</td>
<td>20</td>
</tr>
<tr>
<td>Onion</td>
<td>12</td>
<td>54</td>
<td>34</td>
</tr>
<tr>
<td>Pea</td>
<td>23</td>
<td>50</td>
<td>27</td>
</tr>
<tr>
<td>Pepper, chili</td>
<td>11</td>
<td>52</td>
<td>37</td>
</tr>
<tr>
<td>Pepper, sweet</td>
<td>17</td>
<td>46</td>
<td>37</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>13</td>
<td>47</td>
<td>40</td>
</tr>
<tr>
<td>Pumpkin, bush</td>
<td>20</td>
<td>70</td>
<td>10</td>
</tr>
<tr>
<td>Radish, garden</td>
<td>20</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>Tomato</td>
<td>24</td>
<td>49</td>
<td>27</td>
</tr>
<tr>
<td>Watermelon</td>
<td>26</td>
<td>46</td>
<td>28</td>
</tr>
<tr>
<td>Overall</td>
<td>24</td>
<td>48</td>
<td>28</td>
</tr>
</tbody>
</table>
vegetable sector, but also help reduce the seasonal and annual fluctuation in supply and prices.

Table 21. Prioritizing information types to be developed for improving the vegetable sector in the CAC region

<table>
<thead>
<tr>
<th>Information type</th>
<th>Priority score (%) of total score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved varieties and their yield potentials in alternative production systems</td>
<td>30</td>
</tr>
<tr>
<td>Optimum input requirements and yield of available production technologies in different crops</td>
<td>13</td>
</tr>
<tr>
<td>Major diseases in major vegetables, with the most effective control measures</td>
<td>13</td>
</tr>
<tr>
<td>Major insects in major vegetables, with the most effective control measures</td>
<td>12</td>
</tr>
<tr>
<td>Information about seed source</td>
<td>12</td>
</tr>
<tr>
<td>Potential of crop varieties when grown in off-season with alternative production technologies</td>
<td>11</td>
</tr>
<tr>
<td>Optimum planting time for different varieties of a crop</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 22. Prioritizing information for policy development in the CAC region

<table>
<thead>
<tr>
<th>Information type</th>
<th>Priority Index (% of total score)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forecast of supply, demand, and prices of major vegetables in the country</td>
<td>21</td>
</tr>
<tr>
<td>Estimated production costs of major vegetables in various production systems in the country</td>
<td>19</td>
</tr>
<tr>
<td>Estimated market costs of major vegetables in various marketing systems</td>
<td>14</td>
</tr>
<tr>
<td>Forecast of supply, demand, and prices of major vegetables in the trading countries</td>
<td>13</td>
</tr>
<tr>
<td>Quality standards in various international markets</td>
<td>10</td>
</tr>
<tr>
<td>Trade flow of major and total vegetables by country in various regions of the world</td>
<td>10</td>
</tr>
<tr>
<td>Comparative advantage in international market for the major vegetable produced in the country</td>
<td>8</td>
</tr>
<tr>
<td>Rules and regulations for the export of vegetables in various markets</td>
<td>5</td>
</tr>
</tbody>
</table>

9.3 Technology transfer

Respondents were of the opinion that on-farm training of production technologies in a participatory mode is the most effective means of technology transfer. This is followed by demonstration trials. Providing guide sheets on new technologies to farmers and extension agents was also considered important (Table 23).

Table 23. Preferences among technology-transfer packages in the CAC region

<table>
<thead>
<tr>
<th>Information packaging</th>
<th>Importance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-farm training of production technologies in participatory mode</td>
<td>37</td>
</tr>
<tr>
<td>Demonstration trials</td>
<td>35</td>
</tr>
<tr>
<td>Guide sheets</td>
<td>21</td>
</tr>
<tr>
<td>Decision making computer tools</td>
<td>7</td>
</tr>
</tbody>
</table>
9.4 Strengthening the research capacity of national agricultural systems

As regards to the priorities for improving R&D capacity in the CAC region, the respondents gave the highest priority for collaborative adaptive research trials and variety trials (Table 24). Through these trials, the researchers not only can gain access to elite lines, but also improve their skill of advancing plant material and developing new varieties. Gemplasm exchange, which is needed to improve varieties and to develop new technologies, is also important.

Table 24. Prioritizing areas for improving research capacity of CAC countries

<table>
<thead>
<tr>
<th>Means of efficiency improvement</th>
<th>Importance (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collaborative adaptive research trials</td>
<td>21</td>
</tr>
<tr>
<td>Variety trials</td>
<td>20</td>
</tr>
<tr>
<td>Gemplasm exchange</td>
<td>16</td>
</tr>
<tr>
<td>Information exchange</td>
<td>12</td>
</tr>
<tr>
<td>Demonstration of improved materials and technologies</td>
<td>10</td>
</tr>
<tr>
<td>Training of the trainees</td>
<td>6</td>
</tr>
<tr>
<td>Short-term courses</td>
<td>6</td>
</tr>
<tr>
<td>Long-term degree training of the trainers</td>
<td>6</td>
</tr>
<tr>
<td>Collaborative socio-economic research</td>
<td>3</td>
</tr>
</tbody>
</table>

10 Summary and Conclusions

In the CAC region, the share of vegetables goes as high as 8% in the diet (Kazakhstan and Turkmenistan) and 12.5% in the cropping system (Azerbaijan). Vegetable cultivation in the region has great challenges as well as opportunities. Firstly, their supplies are extremely seasonal (only 15% come during November–March) as they are too costly to grow during extreme winter. Secondly, relatively poor farm-to-market infrastructure, absence of well-defined market network, and primitive post-harvest handling make it extremely costly to connect local producers with the consumers in the domestic and international markets, causing high seasonal and annual fluctuations in vegetable prices. Thirdly, the farmers cannot afford to invest on vegetable cultivation because the purchasing power of domestic consumers is limited. The limited labor supply is further constraining the cultivation of vegetables. Lastly, the desire for self-sufficiency in cereals has downgraded production of high value vegetable crops in certain countries. Despite all these challenges, however, the moderate summer provides an opportunity to exploit the increasing demand for hygienic vegetables in the international market, as the infestation of diseases and insect pests under such an environment is low and yields of these vegetables are relatively high compared to those in the tropics with relative little use of crop protection measures.

The growth in the vegetable production in the CAC region seems impressive on the surface. After recovering from the shocks of open-market policy reforms, it has grown
at an average growth rate of 4.1% during 1993–2004 and has reached beyond the level before independence. However, most of this growth came from area expansion, especially in those countries where cereal production suffered from the grain self-sufficiency drive. The increase in vegetable production in the region, therefore, does not seem to be supported by technological innovation in the production and institutional innovation in the marketing system. The export of vegetables remained erratic and low compared to its potential. Moreover, the export potential of the hygienic vegetables produced in the favorable environment with minimum chemical use remained almost untouched.

The density and diversity in population, different experiences in tackling poverty, and different levels of development and economy structures in the region can be used as a basis for joining hands to achieve a broad objective of a prosperous CAC region. The intensive competition from outside the region has posed challenges to sustain the national agriculture system, but also has generated opportunities for collaboration to tackle the diverse nature of problems with declining public support for agriculture. The increasing demand for quality products that necessitates adjustments in the production and marketing systems has elevated the importance of collaboration as such adjustments can more efficiently be tackled with sharing and learning experience of each other.

Collaboration for vegetable systems is important because of diverse crop species and varieties and their entailed issues to be tackled. Expansion in the cultivation of vegetables in the region can be one of the promising options to tackle poverty, malnutrition, and unemployment. To adopt this option, however, one has to understand the risky and fast changing demands for vegetable products, and develop appropriate human resources, information systems and physical infrastructure that can induce appropriate production and marketing systems to meet these demands. This task can be better performed through effective collaboration with the regional and international partners, including the private sector. The networking arrangements provide opportunity to share experiences and materials for strengthening capabilities of individual nations as well as for improving the collective ability of the region, which will improve quality vegetable production and supply to meet the market demand (Ali et al. 2002). Moreover, with limited resources devoted to agriculture R&D, one country can specialize in certain researchable issues for certain agro-ecologies, and leave other issues and other agro-ecologies on others. Then they can share the information across issues and agro-ecologies. Among various areas for collaborative efforts, adaptive research and variety trials were considered the most effective means to improve vegetable R&D capacity of the national agricultural system, and on-farming training of the farmers for the development of the vegetable sector in the region was also judged as important. The collaboration between the private sector and public organization is also considered valuable, but its mode of collaboration remains undefined.

To identify the constraints limiting the production in a sector needs comprehensive data at disaggregated level. From the aforementioned, it is clear that vegetable supplies face serious seasonal fluctuations. Vegetable cultivation is mostly concentrated during autumn and summer seasons, but little is grown during winter and early spring, which are
quite long in some countries. Moreover, diversity in vegetable production and consumption is low—only three vegetables (tomato, watermelon, and cabbage) cover about 60% of the total supplies. These vegetables have low micronutrient contents. Therefore, high vegetable consumption and micronutrient deficiency co-exist in the region. The new suitable crops and technologies for winter need to be identified and tested to overcome seasonality in supplies and expand biodiversity in production. Special attention should be given to introduce micronutrient-rich vegetables. Another approach could be to encourage vegetable production where winter is mild, and link supplies from such regions to the regions where winter production is costly. To adopt such an approach, however, infrastructure (especially transport and storage) needs to be improved. Moreover, the governments have to remove the biases toward cereal self-sufficiency, and adopt policies that can promote competitiveness in the agriculture sector. The export potential in the high-income markets demanding low pesticide use vegetables should be exploited. Moreover, markets in the tropics where vegetables are in short supply during the summer should be explored to export surplus vegetables from the region during this season.

The analysis of vegetable distribution across production system suggests that peri-urban is the major system supplying more than 50% of overall total vegetable supplies. Therefore, establishment of vegetable storage and processing facilities in peri-urban areas and integrating vegetable producers with these facilities will certainly enhance vegetable supplies to remote areas of the region as well as enhance intra-region trade in vegetables. However, as the relative contributions of various production systems vary across vegetable species, researchers should focus on the major production system for each vegetable in order to enhance their supplies. This survey identified aphids and mites as the most common pests, and Fusarium wilt, downy mildew and powdery mildew the most serious diseases. Protective shelters such as low net-tunnels and greenhouses were considered as the best measures to control insects.

While this survey helps to prioritize the production system and ecologies with respect to vegetable supplies, crop protection, and development issues, this is not a complete substitute for detail surveys conducted on these issues and data collected by statistical bureaus from throughout the country. Therefore, it is suggested to establish institutions and procedures for conducting more detail surveys for the purpose of having more complete and accurate data on various aspects of the vegetable sector.

**Literature Cited**


### Appendix 1. *Major pests on vegetables in the CAC region*

<table>
<thead>
<tr>
<th>Order/Code</th>
<th>Scientific name</th>
<th>Order/Code</th>
<th>Scientific name</th>
</tr>
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</tr>
<tr>
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<tr>
<td>2</td>
<td><em>Bruchus pisorum</em> (Bruchidae)</td>
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<tr>
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<td>(Chrysomelidae)</td>
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<td>4</td>
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<td>5</td>
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<td>38</td>
<td><em>Depressaria</em> spp. (Oecophoridae)</td>
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<td>6</td>
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<td><em>Pieris brassicae</em> (Pieridae)</td>
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<td>7</td>
<td><em>Cryptorhynchus</em> spp. (Curculionidae)</td>
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<td><em>Pieris rapae</em> (Pieridae)</td>
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<td>(Tenebrionidae)</td>
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<td>Orthoptera</td>
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<td>11</td>
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<td><em>Gryllus desertus</em> (Gryllidae)</td>
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<td><em>Delia platura</em> (Anthomyiidae)</td>
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<td>13</td>
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<td><em>Gryllotalpa vulgaris</em> (Gryllotalpidae)</td>
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<td>16</td>
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<td>Hemiptera</td>
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<td>Thysanoptera</td>
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<td><em>Frankliniella fusca</em> (Thripidae)</td>
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<td><em>Thrips tabaci</em> (Thripidae)</td>
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<td>21</td>
<td>(Aphididae)</td>
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<td><em>Acythosiphon onobrychis</em> (Aphididae)</td>
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<td><em>Acythosiphon</em> sp. (Aphididae)</td>
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<td><em>Aphis fabae</em> (Aphididae)</td>
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<td><em>Aphis gossypii</em> (Aphididae)</td>
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<td>26</td>
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<td>30</td>
<td><em>Macrosiphum</em> sp. (Aphididae)</td>
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<td>33</td>
<td><em>Cicadellidae</em> sp. (Cicadellidae)</td>
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## Appendix 2. Three highest priority pests\(^1\) by vegetable and country in the CAC region

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Armenia</th>
<th>Azerbaijan</th>
<th>Georgia</th>
<th>Kazakhstan</th>
<th>Kyrgyzstan</th>
<th>Tajikistan</th>
<th>Turkmenistan</th>
<th>Uzbekistan</th>
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<tr>
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<td>Beet, table</td>
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<td>Carrot</td>
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<td>Cauliflower</td>
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<td>Cucumber</td>
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<td>5 19 21</td>
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<td>51 26 -</td>
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<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
<td>11 49 49</td>
<td>50 3</td>
</tr>
<tr>
<td>Leafy greens (other)</td>
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<td>54 21</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
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<td>- - -</td>
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<tr>
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<td>- - -</td>
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<td>21 50</td>
<td>25 25 19</td>
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<td>14 35 47</td>
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<td>Pepper, chili</td>
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<td>- - -</td>
<td>- - -</td>
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<td>- - -</td>
<td>19 27 49</td>
<td>21 49 19</td>
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<td>Pepper, sweet</td>
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<td>- - -</td>
<td>- - -</td>
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<td>- - -</td>
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<td>19 25 17</td>
<td>30 50</td>
</tr>
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<td>Radish, garden</td>
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<td>35 21</td>
<td>28 - -</td>
<td>- - -</td>
<td>45 49 27</td>
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<tr>
<td>Tomato</td>
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<td>20 36</td>
<td>5 36 19</td>
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<td>21 50</td>
<td>36 19 49</td>
<td>19 50 21</td>
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<tr>
<td>Watermelon</td>
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<td>25 53</td>
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<td>30 50</td>
<td>21 - -</td>
<td>7 19 36</td>
<td>50 19 30</td>
</tr>
</tbody>
</table>

Overall\(^2\): 21 50 30 30 50 36 28 20 36 35 21 15 5 21 35 21 47 50 7 19 36 50 19 30

---

\(^1\) Pest species are listed by code number in Appendix 1.

\(^2\) The specification in equation (1) in the text was used to identify three priority insect pests in overall vegetable production; however, the weights used here represent the relative share of a vegetable in total area of the country, rather than of the whole CAC region.
### Appendix 3. Major diseases on vegetables in the CAC region

<table>
<thead>
<tr>
<th>Disease code</th>
<th>Pathogen</th>
<th>Common name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fungal diseases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td><em>Albugo candida</em></td>
<td>White rust</td>
</tr>
<tr>
<td>F2</td>
<td><em>Alternaria brassicae</em></td>
<td>Alternaria leaf spot</td>
</tr>
<tr>
<td>F3</td>
<td><em>Alternaria dauci</em></td>
<td>Late blight</td>
</tr>
<tr>
<td>F4</td>
<td><em>Alternaria radicina</em></td>
<td>Black rot</td>
</tr>
<tr>
<td>F5</td>
<td><em>Alternaria solani</em></td>
<td>Early blight</td>
</tr>
<tr>
<td>F6</td>
<td><em>Ascochyta melonis</em></td>
<td>Ascochytose</td>
</tr>
<tr>
<td>F7</td>
<td><em>Ascochyta pisi</em></td>
<td>Leaf and pod spot</td>
</tr>
<tr>
<td>F8</td>
<td><em>Ascochyta spp.</em></td>
<td>Phoma blight</td>
</tr>
<tr>
<td>F9</td>
<td><em>Botrytis allii</em></td>
<td>Neck rot, botrytis stalk rot</td>
</tr>
<tr>
<td>F10</td>
<td><em>Botrytis cinerea</em></td>
<td>Gray mold, botrytis leaf blight</td>
</tr>
<tr>
<td>F11</td>
<td><em>Cercospora beticola</em></td>
<td>Cercospora leaf spot</td>
</tr>
<tr>
<td>F12</td>
<td><em>Cladosporium fulvum</em></td>
<td>Leaf mold</td>
</tr>
<tr>
<td>F13</td>
<td><em>Colletotrichum coccosides</em></td>
<td>Black dot root rot, anthracnose</td>
</tr>
<tr>
<td>F14</td>
<td><em>Colletotrichum lagenarium</em></td>
<td>Anthracnose</td>
</tr>
<tr>
<td>F15</td>
<td><em>Colletotrichum lindenuthianum</em></td>
<td>Anthracnose</td>
</tr>
<tr>
<td>F16</td>
<td><em>Colletotrichum melongenae</em></td>
<td>Anthracnose fruit rot</td>
</tr>
<tr>
<td>F17</td>
<td><em>Colletotrichum nigrum</em></td>
<td>Anthracnose</td>
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<td>Powdery mildew</td>
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<td><em>Erysiphe cichoracearum</em></td>
<td>Powdery mildew</td>
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<tr>
<td>F20</td>
<td><em>Erysiphe pisi</em></td>
<td>Powdery mildew</td>
</tr>
<tr>
<td>F21</td>
<td><em>Erysiphe umbelliferaum</em></td>
<td>Powdery mildew</td>
</tr>
<tr>
<td>F22</td>
<td><em>Fusarium oxysporum</em></td>
<td>Fusarium wilt, damping-off</td>
</tr>
<tr>
<td>F23</td>
<td><em>Fusarium proliferatum</em></td>
<td>Fusarium bulb rot</td>
</tr>
<tr>
<td>F24</td>
<td><em>Fusarium spp.</em></td>
<td>Fusarium wilt</td>
</tr>
<tr>
<td>F25</td>
<td><em>Leveillula taurica</em></td>
<td>Powdery mildew</td>
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<tr>
<td>F26</td>
<td><em>Macrosorum solani</em></td>
<td>Brown spot</td>
</tr>
<tr>
<td>F27</td>
<td><em>Macrosorum spp.</em></td>
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<tr>
<td>F28</td>
<td><em>Melanosphora sp.</em></td>
<td>Not available</td>
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<td>F29</td>
<td><em>Olpidium brassicaceae</em></td>
<td>Olpidium seedlings disease</td>
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<tr>
<td>F30</td>
<td><em>Pterospora brassicae</em></td>
<td>Downy mildew</td>
</tr>
<tr>
<td>F31</td>
<td><em>Pterospora destructors</em></td>
<td>Downy mildew</td>
</tr>
<tr>
<td>F32</td>
<td><em>Pterospora schachtii</em></td>
<td>Downy mildew</td>
</tr>
<tr>
<td>F33</td>
<td><em>Phoma betae</em></td>
<td>Heart rot, root rot, clamp rot</td>
</tr>
<tr>
<td>F34</td>
<td><em>Phoma lingam</em></td>
<td>Black leg, phoma root rot</td>
</tr>
<tr>
<td>F35</td>
<td><em>Phoma rostrupii</em></td>
<td>Phoma brown rot</td>
</tr>
<tr>
<td>F36</td>
<td><em>Phomopsis vexans</em></td>
<td>Phomopsis blight</td>
</tr>
<tr>
<td>F37</td>
<td><em>Phytophthora infestans</em></td>
<td>Late blight</td>
</tr>
<tr>
<td>F38</td>
<td><em>Phytophthora parasitica</em></td>
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<td>Clubroot</td>
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<td>F40</td>
<td><em>Plasmopara crustosa</em></td>
<td>Downy mildew</td>
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<td>F41</td>
<td><em>Pseudoperonospora cubensis</em></td>
<td>Downy mildew</td>
</tr>
<tr>
<td>F42</td>
<td><em>Puccinia allii</em></td>
<td>Rust</td>
</tr>
<tr>
<td>F43</td>
<td><em>Pythium debaryanum</em></td>
<td>Stem and root rot</td>
</tr>
<tr>
<td>F44</td>
<td><em>Rhizoctonia violaceae</em></td>
<td>Violet root rot</td>
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</table>
### Appendix 3. (continued)

<table>
<thead>
<tr>
<th>Disease code</th>
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<tbody>
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<td><em>Sclerotinia sclerotiorum</em></td>
<td>Watery soft rot, cottony rot</td>
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<tr>
<td>F46</td>
<td><em>Sclerotium cepivorum</em></td>
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</tr>
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<td><em>Septoria lycopersici</em></td>
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<td><em>Septoria</em> sp.</td>
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<td>F49</td>
<td><em>Stemphylium radicinum</em></td>
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<td><em>Thielaviopsis basicola</em></td>
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<td>F51</td>
<td><em>Urocystis cepulae</em></td>
<td>Smut</td>
</tr>
<tr>
<td>F52</td>
<td><em>Uromyces betae</em></td>
<td>Rust</td>
</tr>
<tr>
<td>F53</td>
<td><em>Uromyces</em> spp.</td>
<td>Rust</td>
</tr>
<tr>
<td>F54</td>
<td><em>Verticillium albo-atrum</em></td>
<td>Verticillium wilt</td>
</tr>
<tr>
<td>F55</td>
<td><em>Verticillium</em> spp.</td>
<td>Verticillium wilt</td>
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<tr>
<td></td>
<td><strong>Bacterial diseases</strong></td>
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</tr>
<tr>
<td>B1</td>
<td><em>Bacillus betae</em></td>
<td>Not available</td>
</tr>
<tr>
<td>B2</td>
<td><em>Erwinia carotovora</em></td>
<td>Bacterial soft rot</td>
</tr>
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<td>B3</td>
<td><em>Pseudomonas lachrymans</em></td>
<td>Angular leaf spot</td>
</tr>
<tr>
<td>B4</td>
<td><em>Pseudomonas</em> spp.</td>
<td>Bacterial fruit rot, top rot of fruit</td>
</tr>
<tr>
<td>B5</td>
<td><em>Xanthomonas campestris</em></td>
<td>Bacterial black rot, bacterial leaf blight</td>
</tr>
<tr>
<td></td>
<td><strong>Virus diseases</strong></td>
<td></td>
</tr>
<tr>
<td>V1</td>
<td>Potato virus Y</td>
<td>Potato virus Y</td>
</tr>
<tr>
<td>V2</td>
<td>Squash mosaic virus</td>
<td>Squash mosaic virus</td>
</tr>
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<td>V3</td>
<td>Tobacco mosaic virus</td>
<td>Tobacco mosaic virus</td>
</tr>
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<td>V4</td>
<td>Tomato ringspot virus</td>
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</tr>
<tr>
<td>V5</td>
<td>Virus complex</td>
<td>Virus complex</td>
</tr>
<tr>
<td></td>
<td><strong>Phytoplasma</strong></td>
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</tr>
<tr>
<td>P</td>
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</table>
### Appendix 4. Three highest priority diseases\(^1\) by vegetable and country in CAC region

<table>
<thead>
<tr>
<th>Vegetable</th>
<th>Armenia 1</th>
<th>Armenia 2</th>
<th>Armenia 3</th>
<th>Azerbaijan 1</th>
<th>Azerbaijan 2</th>
<th>Azerbaijan 3</th>
<th>Georgia 1</th>
<th>Georgia 2</th>
<th>Georgia 3</th>
<th>Kazakhstan 1</th>
<th>Kazakhstan 2</th>
<th>Kazakhstan 3</th>
<th>Kyrgyzstan 1</th>
<th>Kyrgyzstan 2</th>
<th>Kyrgyzstan 3</th>
<th>Tajikistan 1</th>
<th>Tajikistan 2</th>
<th>Tajikistan 3</th>
<th>Turkmenistan 1</th>
<th>Turkmenistan 2</th>
<th>Turkmenistan 3</th>
<th>Uzbekistan 1</th>
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</thead>
<tbody>
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<td>Bean</td>
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<td>F43</td>
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<td>F22</td>
<td>V1</td>
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<td>P</td>
<td>F12</td>
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<td>F19</td>
<td>F22</td>
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<td>F45</td>
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<td>B3</td>
<td>F14</td>
<td>-</td>
<td>F41</td>
<td>F19</td>
<td>F22</td>
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<tr>
<td>Overall(^2)</td>
<td>F41</td>
<td>F19</td>
<td>F30</td>
<td>F22</td>
<td>F14</td>
<td>F37</td>
<td>F1</td>
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<td>F14</td>
<td>-</td>
<td>F41</td>
<td>F19</td>
<td>F22</td>
</tr>
</tbody>
</table>

\(^1\)Pathogen species are listed by code number in Appendix 3

\(^2\)The specification in equation (1) in the text was used to identify three priority diseases in overall vegetable production; however, the weights used here represent the relative share of a vegetable in total area of the country, rather than of the whole CAC region.
AVRDC – The World Vegetable Center’s Role in the Conservation of Biodiversity

L.M. Engle
AVRDC – The World Vegetable Center, P.O. Box 42, Shanhua, Tainan 74199, Taiwan

Introduction

AVRDC – The World Vegetable Center was established in 1971 to promote the production, marketing and utilization of vegetables in Asia and beyond, with an ultimate purpose of improving the health of people in the tropics through an adequate supply of plant proteins, vitamins and minerals. AVRDC’s mission is to enhance the nutritional well-being and raise the incomes of poor people in developing countries through improved methods of vegetable production, marketing and distribution, which take into account the need to preserve the quality of the environment. This can be made possible by promoting vegetable production and consumption. Thus, AVRDC has set up many research units to work together to achieve this goal.

In the beginning years of AVRDC, the crop improvement program worked toward variety development of vegetables adapted to tropical conditions. Examples of successes are high-yielding mungbean, and heat-tolerant Chinese cabbage and tomato varieties. In subsequent years, breeders, assisted by entomologists and pathologists, bred resistance to pests and diseases. At present, emphasis is on improving production systems and the nutritional value of vegetable varieties.

One of the units that have contributed to the improvement of varieties is the Genetic Resources and Seed Unit (GRSU). This unit houses the genebank. In the early years, GRSU assembled germplasm of the AVRDC’s principal crops which at that time included six crop groups (Fletcher 1993). These were tomato, soybean, mungbean and closely related species, sweet potato, white potato and Chinese cabbage. In the 1980s it accepted the responsibility for the global base collection of mungbean and the duplicate global base collection of Capsicum (IBPGR 1990).

Ex situ Conservation Center

Now AVRDC houses one of the largest collections of vegetable germplasm in the world (Table 1). Over 50,000 accessions are held in trust for the global community. The germplasm originates from 151 countries and includes 434 species in 153 genera. More than 40,000 accessions are made up of its principal crops; these are the globally important crops. More than 10,000 are vegetable species indigenous to Africa, and South and Southeast Asia. Therefore, AVRDC serves as the ex situ conservation center for a diverse array of vegetable species including species with global importance, species with
regional importance, and species indigenous to several regions. For the globally important crops, the goal of AVRDC is to have representatives of the primary, secondary and tertiary gene pool (Harlan and de Wet 1971) of the cultivated species. The collection includes wild relatives of the cultivated species. The valuable collection carries many traits necessary to produce improved vegetable varieties. It also includes a diverse array of vegetables including indigenous types from which one can choose the right type to fit a particular production system.

Table 1. Accessions of vegetable germplasm conserved at AVRDC as of March 2005

<table>
<thead>
<tr>
<th>Crop</th>
<th>Accessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Crops</td>
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<tr>
<td>Glycine</td>
<td>15,312</td>
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<tr>
<td>Capsicum</td>
<td>7,569</td>
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<tr>
<td>Lycopersicon</td>
<td>7,230</td>
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<td>Vigna radiata</td>
<td>5,658</td>
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<td>Solanum</td>
<td>2,908</td>
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<td>Brassica</td>
<td>1,767</td>
</tr>
<tr>
<td>Allium</td>
<td>1,078</td>
</tr>
<tr>
<td><strong>Sub-total</strong></td>
<td><strong>41,522</strong></td>
</tr>
<tr>
<td>Non-principal Crops</td>
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</tr>
<tr>
<td>Vigna unguiculata ssp. unguiculata</td>
<td>1,388</td>
</tr>
<tr>
<td>Luffa</td>
<td>704</td>
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<tr>
<td>Phaseolus</td>
<td>635</td>
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<tr>
<td>Amaranthus</td>
<td>508</td>
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<tr>
<td>Vigna mungo</td>
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<td>Cucumis</td>
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<td>Cucurbita</td>
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<tr>
<td>Abelmoschus</td>
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<tr>
<td>Vigna unguiculata ssp. sesquipedalis</td>
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<tr>
<td>Lagenaria</td>
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<td>Lablab</td>
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<td>Pisum</td>
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<tr>
<td>Vigna unguiculata ssp unguiculata</td>
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<tr>
<td>Others</td>
<td>5,493</td>
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<tr>
<td><strong>Sub-total</strong></td>
<td><strong>11,825</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>53,347</strong></td>
</tr>
</tbody>
</table>

The accessions conserved at AVRDC were acquired as donations from international, regional and local institutions, and private individuals. Since the early 1990s, with the support of various funding agencies and the cooperation of national agricultural research systems (NARS), expeditions to collect vegetable germplasm consisting of landraces, traditional varieties and wild species have been conducted in several regions. Samples collected are divided into two parts. One part goes to AVRDC for long-term conservation and the other part is left with the country where it was collected. Therefore, materials collected are now conserved in both NARS genebanks and at AVRDC.

The germplasm are stored in the form of seeds in cold rooms at low temperature in airtight containers. These conditions ensure that the seeds will stay alive for long periods of time. The coldest room is about –16°C. Seeds stored in this condition are expected to stay alive for more than 50 years. Germplasm stored in this condition fall under base collections.

The genebank also maintains active collections which are made available for utilization purposes and working collections which are kept for relatively short periods of time. Active collections are kept under medium-term conditions of 0 to 10°C and 45% relative humidity (RH), and the working collection under short-term conditions of 15°C and 45% RH. Seeds are dried to 4 to 7% moisture content and packed in laminated aluminum foil envelopes before storage.
Thus, AVRDC serves also as a vegetable germplasm conservation center. It holds germplasm needed in all kinds of vegetable research work and at the same time protects this germplasm from getting lost in nature due to rapid development. To make sure that vegetable germplasm is available for use by researchers all over the world, AVRDC continues to undertake the collection of additional germplasm and regenerates at least 2,000 accessions every year.

**Distributing Vegetable Germplasm**

AVRDC also serves as a distribution center for vegetable germplasm. AVRDC distributes a wide array of vegetable germplasm accessions averaging almost 3,000 accessions each year to researchers all over the world. This is in addition to improved materials that the breeding units distribute. The materials provide a broader genetic base for breeding programs and a safety net that protects against the dangers of a limited and highly uniform gene pool.

To have seeds for the base and active collection as well as for safety duplication, newly received accessions are regenerated. Regeneration of large numbers of accessions is made possible through partnership with NARS and the support of funding agencies. Regeneration is done every year making sure that genetic integrity of the accessions is maintained. Net cages are used to prevent insect-mediated cross-pollination.

To enhance utilization of germplasm, data related to the collection are assembled in the genebank. These include passport data, characterization data, evaluation data and indigenous knowledge. Information generated is made available to the public through the internet. The sites through which AVRDC genebank databases can be accessed include the AVRDC home page (<www.avrdc.org>) and follow the link to germplasm and the AVRDC Vegetable Genetic Resources Information System [AVGRIS]) and SINGER (System-wide Information Network for Genetic Resources, <www.singer.grinfo.net>).

During regeneration, the materials are characterized morphologically and evaluated for selected traits. Evaluation for selected traits is done by AVRDC specialists from many fields, such as virologists who evaluate resistances to viruses and nutritionists who evaluate health promoting factors.

With aid of molecular fingerprinting, core collections were developed to facilitate evaluation of the materials. At present there is a core collection for *Capsicum* and *Lycopersicon*.

Part of the activity of the genebank is promoting conservation and utilization of germplasm accessions. This is based on the premise that sustainable utilization of germplasm will ensure sustainable conservation of genetic resources. Promotional activities designed to encourage utilization of indigenous vegetables target women, children, farmers, traders and other consumers. Indigenous vegetables are introduced to school children through indigenous pilot school gardens to increase knowledge, increase appreciation, increase utilization and increase conservation of indigenous vegetables.
AVRDC Guiding Principles for Intellectual Property Rights

The distribution of germplasm follows AVRDC’s guiding principles for intellectual property rights, which consists of three protocols. Protocol 1 involves germplasm accessions. This includes a material transfer agreement (MTA) on germplasm accessions. Protocol 2 involves breeding lines, elite germplasm, and hybrid parental lines. This includes the MTA on improved genetic materials. Protocol 3 involves inventions and materials related and derived from genetic engineering. AVRDC’s activities on germplasm are in line with the Convention on Biodiversity, and the International Treaty on Plant Genetic Resources for Food and Agriculture. Moreover, AVRDC follows national seed laws, bioprospecting laws and quarantine regulations.

In general, AVRDC facilitates the flow of germplasm within the global community. The MTAs are based on two key principles that AVRDC subscribes to: 1) unrestricted availability of the genetic resources it holds in trust; and 2) free access to materials developed by the Center.

Training in Vegetable Germplasm Conservation

AVRDC also serves as center for training in vegetable germplasm conservation. With support from funding agencies AVRDC offers both in-country and special purpose training (the latter at its headquarters and its regional centers) on genebank management and in various aspects of vegetable germplasm conservation, i.e., collection, characterization, regeneration, seed drying, and documentation.

In its 35-year history, with funding from the governments of Japan, Korea and Taiwan, and the Asian Development Bank (ADB), AVRDC has trained 83 undergraduate students, 48 research or production interns, 15 research fellows, 18 special purpose trainees, 6 postdoctoral fellows or visiting scientists, and 1 research scholar.

International Cooperation

The work on conservation and utilization of vegetable germplasm is tremendous. To be successful, cooperation among many people, institutes and countries is required. AVRDC has served as a mover in this activity. With funding from ADB, the governments of Germany, Japan and Taiwan, as well as cooperation of many countries, AVRDC is able to effectively coordinate several activities on the conservation and utilization of vegetable germplasm.

AVRDC has led several special projects on the conservation and utilization of vegetable germplasm. In 1999, ADB funded the project “Collection, Conservation, and Utilization of Indigenous Vegetables”. Scientists from Bangladesh, Indonesia, Philippines, Thailand, and Vietnam participated in this project. As a result of this 3-year effort, 4,405 accessions were collected for conservation, 3,497 were characterized and 109 were selected as promising. In addition, 16 individuals received training on various aspects of
germplasm conservation. Through this project AVRDC protected indigenous vegetables from the dangers of genetic erosion and found a new place for them in modern production systems. This project was succeeded by the project “Promoting Utilization of Indigenous Vegetables for Improved Nutrition of Resource-Poor Households in Asia”.

In 2001, AVRDC and Taiwan’s Council of Agriculture (COA) collaborated in a project “Collecting Indigenous Vegetable Germplasm in Taiwan”. A total of 215 accessions belonging to 71 species were collected from Hualien, Ilan, Taitung, the Penghu Islands and Green Island. The materials are now conserved in the genebank of AVRDC. In 2002, COA funded the project “Conservation and Multiplication of Vegetable Genetic Resources of Ethnological and Local Importance”. From this cooperative project, 892 accessions of various vegetables were duplicated at the National Plant Genetic Resources Center of the Taiwan Agricultural Research Institute.

AVRDC is also coordinating activities of the ASEAN-AVRDC Regional Network on Vegetable Research and Development (AARNET). One of the activities of AARNET is the collection, conservation and evaluation of indigenous vegetables of ASEAN (Association of Southeast Asian Nations). Another collaborative effort is between AVRDC, the International Plant Genetic Resources Institute (IPGRI) and the International Seed Federation (ISF) on the web enabling of the AVRDC germplasm database and its inclusion into SINGER of the CGIAR (Consultative Group on International Agricultural Research).

With the help of many countries, other international organizations and funding agencies AVRDC hopes to continue playing a lead role in conserving and promoting the utilization of a veritable treasure trove of vegetable germplasm.

**Literature Cited**


Conservation, Exchange and Use of Indigenous Vegetable Resources in Central Asia and the Caucasus

Ravza Mavlyanova
AVRDC Regional Office for Central Asia and the Caucasus, c/o Program Facilitation Unit of the CGIAR Program for Central Asia and the Caucasus, P.O. Box 4564, Tashkent 700000, Uzbekistan

Introduction

Central Asia and the Caucasus (CAC) is the primary center of origin of onion, garlic, carrot, spinach, coriander, turnip and basil. These are essential foodstuffs for the growing population, and important components for cropping systems. During the past centuries, many other vegetables from other parts of the world were also introduced to the CAC region and have become major crops. Throughout the years of adaptation to the local environment and of farmers’ selection, many local varieties and landraces were derived from these introduced vegetables. Currently, potato, tomato, onion and carrot are the main vegetables grown in the region. Cabbage, pepper, eggplant, cucumber, melon, watermelon and pumpkin are of secondary importance.

Various indigenous vegetables of either original species or introduced species occupy more than half of the total vegetable production and serve as the key to the food security in the region. Beside large-scale production, indigenous vegetables have been popular for cultivation in the plots adjoining the houses. Yield potentials of many indigenous vegetables are comparable with the large-scale cultivated, commercial varieties. These crops have many valuable traits, e.g., early maturity, tolerance to abiotic stresses, and resistance to diseases and insect pests, and can serve as good sources for the development of new varieties and cropping systems.

CAC as the Center of Origin of Many Vegetables

Vavilov (1987) has identified two important centers of origin for cultivated plants. The west Asian center covers Asia Minor, the Caucasus, Iran, and mountainous Turkmenistan. And the central Asian center includes northwest India, Afghanistan, Tajikistan, Uzbekistan, and western Tian Shan. Both centers are the primary and secondary centers of origin for many vegetable crops (Table 1). Great diversity of related vegetable species occurs in these two centers. Some species are found only within these two centers. Below are brief descriptions of unique indigenous vegetables from the CAC region:

Onions. Many wild Allium species grow in CAC. Common ones are wild relatives of cultivated bulb onion (A. cepa L.) such as A. pskemense B. Fedtsch., A. oschaninii O. Fedtsch., A. vavilovii M. Pidov et Vved., A. altaicum Pall., A. praemixtum Vved. and
### Table 1. Vegetable crops and their diversity in Central Asia and the Caucasus

<table>
<thead>
<tr>
<th>Location/Region</th>
<th>Common name</th>
<th>Significance for biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Asian Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Allium cepa</em> L.</td>
<td>Bulb onion</td>
<td>Secondary center</td>
</tr>
<tr>
<td><em>A. porrum</em> L.</td>
<td>Garden leek</td>
<td>Wild relatives exist</td>
</tr>
<tr>
<td><em>A. ampeloprasum</em> L.</td>
<td>Wild leek</td>
<td>Wild relatives exist</td>
</tr>
<tr>
<td><em>Brassica campestris</em> ssp.</td>
<td>Turnip</td>
<td>Secondary center</td>
</tr>
<tr>
<td><em>Beta vulgaris</em> L.</td>
<td>Table beet</td>
<td>Secondary center</td>
</tr>
<tr>
<td><em>Brassica oleracea</em> L.</td>
<td>Broccoli, cabbage,</td>
<td>Endemic species in Anatolia</td>
</tr>
<tr>
<td></td>
<td>cauliflower, kohlrabi</td>
<td></td>
</tr>
<tr>
<td><em>Crocus sativus</em> L.</td>
<td>Saffron</td>
<td>One of the centers</td>
</tr>
<tr>
<td><em>Cucumis melo</em> L.</td>
<td>Melon</td>
<td>Diversity exists</td>
</tr>
<tr>
<td><em>C. agrestis</em> Pang. and</td>
<td>Wild melons</td>
<td>Diversity concentrates in West Asia</td>
</tr>
<tr>
<td>microcarpus (Alef.) Pang.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. flexuosum</em> L.</td>
<td>Serpent melon</td>
<td>Primary center</td>
</tr>
<tr>
<td><em>C. sativus</em> L. ssp.</td>
<td>Wild cucumber</td>
<td>Specific land race</td>
</tr>
<tr>
<td><em>antasiaticus</em> Gabaev</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cucurbita pepo</em> L.</td>
<td>Pumpkin</td>
<td>Diversity exists</td>
</tr>
<tr>
<td><em>Daucus carota</em> L.</td>
<td>Carrot</td>
<td>Species diversity in Anatolia</td>
</tr>
<tr>
<td><em>Eruca sativa</em> Mill.</td>
<td>Rocket</td>
<td>One of the centers</td>
</tr>
<tr>
<td><em>Lactuca sativa</em> L.</td>
<td>Lettuce</td>
<td>Wild relatives exist</td>
</tr>
<tr>
<td><em>Lepidium sativum</em> L.</td>
<td>Cress</td>
<td>Secondary center</td>
</tr>
<tr>
<td><em>Petroselenium</em> hortense</td>
<td>Purslane</td>
<td>Secondary center</td>
</tr>
<tr>
<td>Hoffm.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Portulaca oleracea</em> L.</td>
<td>Purslane</td>
<td>One of the centers</td>
</tr>
<tr>
<td>Central Asian Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Allium cepa</em> L.</td>
<td>Bulb onion</td>
<td>Primary center, wild relatives exist</td>
</tr>
<tr>
<td><em>Allium sativum</em> L.</td>
<td>Garlic</td>
<td>Primary center, wild relatives exist</td>
</tr>
<tr>
<td><em>Brassica campestris</em> L.</td>
<td>Turnip</td>
<td>Primary center</td>
</tr>
<tr>
<td>ssp. rapifera Sinsk.</td>
<td></td>
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</tr>
<tr>
<td><em>Cucumis melo</em> L.</td>
<td>Melon</td>
<td>Secondary center</td>
</tr>
<tr>
<td><em>Daucus carota</em> L.</td>
<td>Carrot</td>
<td>Primary center</td>
</tr>
<tr>
<td><em>Lagenaria siceraria</em> St</td>
<td>Bottle gourd</td>
<td>Secondary center</td>
</tr>
<tr>
<td>andl.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ocimum basilicum</em> L.</td>
<td>Basil</td>
<td>Primary center</td>
</tr>
<tr>
<td><em>Portulaca oleracea</em> L.</td>
<td>Purslane</td>
<td>Secondary center</td>
</tr>
<tr>
<td><em>Raphanus sativus</em> L.</td>
<td>Radish</td>
<td>Secondary center</td>
</tr>
<tr>
<td><em>Spinacia oleracea</em> L.</td>
<td>Spinach</td>
<td>Primary center, wild relatives exist</td>
</tr>
</tbody>
</table>

*A. aflatunense* B. Fedtsch.; giant onions such as *A. giganteum* Regel and *A. altissimum* Regel1; and rhizomatous onions from the *Rhizirideum* section of the Genus *Allium*. They grow in either the arid areas or mountains; some are frost-resistant and may tolerate −30 to −40°C. They are often harvested from the wild and serve as important food sources in the mountain region. Because of this practice, some indigenous races are rapidly disappearing. Southern subspecies of *A. cepa* (ssp. *australe* Trof.) comprises four geographic groups in CAC with different horticultural traits. Indigenous cultivated onion varieties
have their unique horticultural traits depending on the cultivation sites. White onions are grown up to 400 m above sea level (asl), violet onions with dry peel around 800 m asl, and blue onions around 2,200 m asl. Many indigenous onion varieties are named after the location of climatic and soil adaptation, e.g., ‘Farabskiy’, ‘Margilanskiy dlinniy’, ‘Leninabadsksiy ploskiy’, ‘Kulcha piyoz’, ‘Fayzabadsksiy’, ‘Pamirskiy’, ‘Dunganskiy’ and ‘Kaahkinskiy’.

Garlic. Cultivated Allium sativum L. is deemed to have originated from A. longicuspis Regel, which is native to and grown in Central Asia. The varieties ‘Uzbekskiy violetoviy’, ‘Andijansliy’ and ‘Ferganskiy’ are grown in Uzbekistan, while ‘Mestnyi violetoviy’ and ‘Issyk Kulskiy’ are grown in Tajikistan. These indigenous varieties vary in morphology.

Carrots. Daucus carota L. contains both domesticated and wild forms, which are widely distributed in CAC. The wild forms are grouped in ssp. carota, whereas the domesticated forms are in ssp. sativus. Several cultivated varieties with different root colors (e.g., yellow, violet, dark purple, pink and orange) and shapes (e.g., cylindrical, conic and spindle) are grown in the region, and are important sources for diversifying cropping systems and diets.

Melons. A native, wild melon (Cucumis melo ssp. agrestis Pang.) is consumed for its bitter fruit pulp. Central Asia in general and Khorezm Oasis of Uzbekistan and Karakalpakstan in particular are considered as the primary centers of melon diversity. Selections of cultivated melon by the farmer in the past centuries have resulted in over 200 varieties with differences in maturity, keeping capacity, fruit size and shape, and eating quality. In Turkmenistan, indigenous varieties include ‘Payandaki mestnaya’, ‘Tashauzskaya mestnaya’, ‘Ak-gulyabi 803’, ‘Vakharman 499’, ‘Gok-gulyabi 670’ and ‘Zaami 672’. Usually the farmers prefer late maturing varieties for storage to sell at a later time. The production concentrates in Chardzhev and Dashkhovuz along Amu Darya. In Tajikistan, distinguished varieties include early maturing ‘Khandalyak’ and ‘Zamcha’, medium maturing ‘Alocha’ and ‘Gurs-ketti’, and autumn-winter melons ‘Gurchak’ and ‘Tukman’. Production is concentrated in Leninabad oblast, and Vakhsh and Hissar Valleys.

Pumpkins. Although its cultivation is limited, medium and late maturing varieties of Cucurbita maxima Duch. are grown for fodder. For fruit, early and medium maturing varieties of C. pepo L. and late maturing varieties of C. moschata Poir. are grown in the region. Late ripening ones are most popular.

Bottle gourd. Lagenaria siceraria Standl. is grown in small plots mainly for its dried fruits used as ornamental vessels. Large fruits are used for holding water, milk, and kumys (fermented milk), and small ones for chewing tobacco leaves (nasvar).

Beets. Most cultivated and wild beets occur in CAC belong to the Corollinae section of the Genus Beta. They are extremely diverse with tolerance to various abiotic stresses. Beta perennis Freyn, a perennial, grows in the Caucasus. B. lomatogona Fish et Mey., a tetraploid, resists drought and frost. B. macrorhiza Stev. is large-rooted, frost-resistant, winter-hardy, and hygrophytic. B. corolliflora Zos. is winter-hardy. B. trigyna
Wald et Kit. grows as polymorphic weeds in the highland areas of the Caucasus, Balkan Peninsula and Crimea; its Caucasian subspecies is tetraploid, and Crimean subspecies hexaploid.

Brassicas. Cultivated Brassica oleracea subspecies and varieties in CAC include bolting tolerant ‘Pontiyskaya’ and ‘Trapezuanskaia’ of ssp. oleracea (colewort or field cabbage); bolting tolerant ‘Trans-Caucasian’ and ‘Turkestan’ of ssp. gongylodes (Asiatic kohlrabi); and ‘Marnopolka’, ‘Likurishka’, ‘Zavadov’, ‘Leninakan’ and ‘Georgian’ varieties of ssp. capitata (cabbage).

Peas. Wild forms include Pisum syriacum Lehman, which is easily interbred with cultivated P. sativum L., in all over the lowland Caucasus except in the south; small-seeded P. sativum ssp. asiaticum Govorov in Central Asia; and colored, small-seeded ssp. transcaucasicum Govorov in the meadows of sub-alpine Caucasus. Subspecies sativum is the major one grown in the region.

Beans. Vigna radiata Wilczek, V. mungo Hepper, and Glycine max Merr. are cultivated up to 1,800 m asl in the region, but most of them are introduced varieties.

Greens and herbal plants. Some leafy greens and herbal plants are either grown or collected from the wilderness in the region. They include parsley (Petroselenium crispum A.W. Hill), lettuce (Lactuca sativa L.), spinach (Spinacia oleracea L.), dill (Anethum graveolens L.), asparagus (Asparagus officinalis L.), basil (Ocimum basilicum L.), savory (Satureja hortensis L.), caraway (Carum carvi L.), cress (Lepidium sativum L.), horseradish (Armoracia rusticana Gaertn. et al.), purslane (Portulaca oleracea L.), sorrel (Rumex acetosa L.), rhubarb (Rheum palmatum L.), artichoke (Cynara cardunculus L.), tarragon (Artemisia dracunculus L.), and mint (Mentha piperita L.).

Collection and Conservation of Plant Genetic Resources

From 1911 to 1914, N. Shavrov and R. Shreder first studied and described vegetables that were grown in various locations of Central Asia (Sharov 1911). From the 1920s to 1990s, researchers of the All-Union Institute of Plant Industry of the former Soviet Union (current name: N.I. Vavilov All-Russian Research Institute of Plant Industry [VIR]) conducted various expeditions in the CAC region to collect landraces and wild relatives of cultivated plants to expand the VIR’s germplasm collection.

At present, wild relatives of some vegetables still can be found in nature. Moreover, even now CAC farmers are growing a good number of landraces of various vegetables. The characterization and preservation of these plant materials have not yet been properly made. It is imperative to initiate collection, characterization and conservation of these valuable genetic resources before they come to the verge of extinction.

At present, CAC republics have different program levels on plant genetic resources, and are taking efforts to strengthen these programs with the help of international organizations. Today the Uzbek Research Institute of Plant Industry (UzRIPI) has the largest ex situ collection. UzRIPI is maintaining 35 species with 5,175 accessions of vegetables.
This includes 1,762 for melons, 926 for pumpkin, 546 for tomato, 102 for onion, 202 for garlic, and 2,733 for other vegetables. At present, landraces and wild relatives of vegetables account for only 10% of the total collection combined from various institutions in the CAC region.

From 1929–1931, E.N. Sinskaya and her associates studied ontogenesis and taxonomy on a series of wild and cultivated plants in different climatic zones within the CAC region (Sinskaya 1949). Their studies have expanded scientific knowledge of crop diversity and laid the foundation for classifying certain vegetables. Later researchers from various research institutions of the Central Asian republics of the former Soviet Union have conducted extensive studies of local floras in the region, and compiled, revised and updated all the database in a voluminous “The manual of the Central Asia plants” (Vvendensky and Kamelin 1993).

For the former Soviet Union, VIR was the only institution working on the whole complex of problems related to genetic resources of cultivated plants, including indigenous vegetables, and their wild relatives. VIR was actively involved in exploration and germplasm collecting not only in CAC but also throughout the world, maintaining the collected germplasm in its genebank and providing it to various users, carrying out characterization and preliminary evaluation of the accumulated genetic stocks, developing documentation, and training specialists. VIR possessed a vast network of 19 experiment stations, which maintained working collections, carried out research, and regeneration of accessions. All the databases were compiled in 30 volumes of “Flora of the USSR” (Komarov et al. 1960) and 6 to 10 volumes of cultivated flora for individual republics. The former tome treats 22,000 plant species in 216 families. Nowadays, several CAC republics have also prepared red books of plant species that were at risk of extinction. Based on these red books, the CAC governments have enacted various laws and regulations to strive for the preservation of plants genetic resources, including wild relatives of vegetable crops.

Nowadays, Uzbekistan has computerized databases for the ex situ collections, developed using international lists of descriptors. In other CAC countries, computerized databases are in the process of creation through support from the international community.

Use of Plant Genetic Resources

Thousands of years of selection, performed by farmers and nature, have produced local varieties and genotypes of crop plants adapted to the different places and to cultivation practices which were determined by climate and other environmental factors. Today, the spectrum of valuable variation in crop plants is enormous. One of the good examples in the CAC region is diverse fruit types of melons. However, the variation does not limit to morphological features; it includes also not-so-easily observable characteristics such as local adaptation, disease resistance and chemical composition. Better deployment of these plant genetic resources (PGR) could be used in the diversification of agriculture and diet. Moreover, it could also reduce the vulnerability of crop plants to disease and insect pest
outbreaks, at the same time reducing dependence on pesticides, and to drought, heat and salinity stresses.

Unfortunately, PGR are currently underutilized in the CAC region, which limits agricultural development for the long-term economic and social benefits. There are various obstacles to making greater use of conserved crop materials. These include lack of information on the characteristics and value of conserved materials as well as the method to use them; and poor communication between genebanks, plant breeders and other users in within and between the republics in the CAC region. A further problem is the lack of incentive for both public and private sectors in the region to become actively involved in the many activities essential for the effective use of PGR. This includes programs of characterization and pre-breeding selections, which make genetic material more easily used in variety development programs. There is limited involvement from both public and private sectors in developing vegetable crops essential to the economic and micronutrient security in the region; increases in government commitment and public support for these activities are imperative. Furthermore, national capacities in plant breeding and in seed production and distribution in the region vary widely, and insufficient capacity in these areas often limits the effective use of PGR.

Currently, vegetable breeding in CAC is mainly conducted in public institutions. Efforts include studies of ontogenesis and phylogenetic relationship of local varieties and wild relatives of vegetables, and employ cross breeding, inbreeding, and both individual and mass selections for variety development. To deal with the existing and new cropping systems and value-chains in the region, breeding targets are set on earliness, high yield, bolting resistance, heat tolerance, disease resistance, long storability, and high nutrition value. Table 2 lists specific targeted traits of certain vegetables. Newly developed vegetable varieties are subject to the testing conducted by the state variety commissions before they can be released. At present, the state registers of CAC republics comprise about 35 vegetable species with 350 varieties of both open-pollinated and hybrid varieties. However, the seed production system of registered vegetable varieties, despite their potential market values, is yet to be fully developed.

**Table 2. Desirable horticultural traits of major vegetable crops in Central Asia and the Caucasus**

<table>
<thead>
<tr>
<th>Crop</th>
<th>Desirable horticultural traits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet, table</td>
<td>Round or oval root, soft dark pulp without rings</td>
</tr>
<tr>
<td>Cabbage</td>
<td>Round and flat-rounded heads, heat resistance in July</td>
</tr>
<tr>
<td>Carrot</td>
<td>Orange color with short root, high pulp quality, high carotene content, good keeping quality, bolting resistance</td>
</tr>
<tr>
<td>Garlic</td>
<td>High keeping qualities, high dry matter</td>
</tr>
<tr>
<td>Greens, leafy</td>
<td>Marketable view, good taste</td>
</tr>
<tr>
<td>Melon</td>
<td>High sugar content and transportability</td>
</tr>
<tr>
<td>Onion, bulb</td>
<td>High contents of dry matter and sugar, good keeping quality, early ripening</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>High carotene content, fruit of “a la carte” type</td>
</tr>
<tr>
<td>Radish, black</td>
<td>Bolting resistance, good taste</td>
</tr>
<tr>
<td>Radish, garden</td>
<td>Bolting resistance, crisp pulp</td>
</tr>
</tbody>
</table>
There are few in-region activities on hybrid breeding. F₁ hybrid seeds for greenhouse tomato and cucumber productions come mainly from outside the region. There are experienced personnel in the public sector for hybrid breeding and seed production such as identification of cytoplasm male sterility on local carrot and onion varieties; however, they are constrained in engaging in these tasks because of limited funding.

CAC’s International Participation and Cooperation on PGR

The future of agriculture depends on international cooperation and on the open exchange of PGR. No country is self-sufficient in PGR. All depend on crops and the genetic diversity within these crops from other countries and regions. Toward this end, more than 160 member states have signed the Convention on Biological Diversity (CBD) since the 1992 Earth Summit in Rio de Janeiro, Brazil. Among CAC countries, Azerbaijan, Armenia, Kazakhstan and Uzbekistan have signed this treaty, and the others have accessed it. CBD serves as an international legal framework for the exchange of PGR and conservation of biodiversity; as well as a platform for meaningful and just collaboration and functional partnerships. Moreover, it recognizes sovereign rights of states over PGR, and the authority to determine access.

One of the tasks for CBD is to develop a multilateral system to facilitate access and benefit sharing for PGR for food and agriculture. Under this premise, the Food and Agriculture Organization of the United Nations (FAO) adopted the Global Action Plan for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture in 1996. The Global Action of Plan seeks to create an efficient system for the conservation and sustainable use of PGR through better cooperation, coordination and planning and through the strengthening of capacities. Many CAC countries have benefited from the national PGR programs set up under this Global Action of Plan. Activities of the national PGR programs, with technical supports of such organizations as International Plant Genetic Resources Institute (IPGRI), International Center for Agricultural Research in the Dry Areas (ICARDA) and International Maize and Wheat Improvement Center (CIMMYT) include inventorying, exploration and collecting of PGR; conservations in situ and ex situ; characterization and evaluation; documentation; regional exchange of PGR; and capacity building.

In accordance to the Global Action of Plan, FAO adopted the International Treaty on Plant Genetic Resources for Food and Agriculture in 2001. This legally binding treaty covers all PGR relevant for food and agriculture, and is to ensure the continued availability of PGR that countries will need to feed their people. However, the CAC countries are yet to sign this treaty.

Future Activities

The following activities need to be strengthened to promote economic development, micronutrient security, sustainable vegetable systems and the maintenance of biodiversity through the conservation and utilization of PGR in the CAC region:
• Socio-economic surveys on preservation and use of local vegetables.
• Refinement of legislation on biodiversity and PGR for mutual benefits.
• Participation of environment protection organizations in national PGR programs.
• Development of monitoring mechanisms for effective management and use of PGR for food and agriculture.
• Comprehensive exploration, collection and documentation of landraces, local varieties, and rare and endangered wild relatives of vegetable crops.
• Establishment of modern long-term storage facilities of PGR in the region.
• Characterization and evaluation of PGR for expanding the number of core collections to facilitate utilization.
• Regeneration of threatened ex situ accessions.
• Genetic enhancement and variety improvement through expanded use of PGR for priority vegetables with marker-assisted selection, hybrid breeding, cytoplasm male sterility.
• Expansion of viable seed production and distribution systems of local varieties at the local level.
• Establishment of comprehensive and unified PGR information systems.
• Organization of PGR networks among regional research institutions and international agricultural research centers.
• Capacity building of national PGR programs and young scientists.

Literature Cited


Opportunities for Developing the Market-oriented Vegetable Production System in Central Asia and the Caucasus

W.H. Schnitzler
Vegetable Sciences – Quality of Vegetal Foodstuff, Technische Universität Munich, Germany

Introduction

During the last decade, most countries have experienced an increase in vegetable production. This was made possible through not only improved varieties and integrated production technologies but also changing eating habits and increasing consumer demands for diverse and health-promoting vegetables. Nevertheless, intensive vegetable production is impacting various aspects of agro-ecological systems because of its high inputs, soil disturbances, and the lack of crop diversity. These practices often are not sustainable and contribute to the depletion of valuable water and other resources.

Water and Salinity in Vegetable Production

Quality water, previously available for crop production, is progressively consumed by expanding urban centers. This is a global phenomenon. Of all water resources, only about 0.9% is suitable for consumption. Between 1950 and 1990, the water consumption in the African continent had increased 300%, whereas Europe more than 500%. Other continents have a similar trend. In dry regions, three billion people will face periodic water shortage or chronic scarcity by 2025. There will be no other way but to develop innovative tools for water preservation in crop cultivation.

Quality vegetable production demands high quantities of quality water throughout the growing season. While the actual quantity depends on crop/agroecological couplings, the need is usually greater in vegetable crops than cereals. Inappropriate timing and volume applications exacerbate water demand. Throughout the world, there is a general need for water-saving vegetable production systems. Toward this end, an European Union (EU)-supported consortium, involving scientists from European and Mediterranean countries, is currently developing environmentally-sound hydroponic production system under the title of “ECOPONICS” (5th Framework Programme INCO-MED, ICA 3-CT-2002-10020). Preliminary results in Jordan have shown considerable water saving with the system.

Growing crops in hydroponics is a complex system. It has two types: 1) the open system which allow the leftover nutrient solution to run off; and 2) the closed system which re-circulate the nutrient solution. The latter system is environmentally friendly...
with high water use efficiency (WUE). Bradley and Marulanda (2000) showed that the closed hydroponics used less water than the open hydroponics for the same yield.

Ruthenberg (1980) classified hydroponic cultivation as a “high input, high output, but high risk” system. In fact, the current techniques require sophisticated management and high financial investments (Schwarz 1995). There is a need to simplify hydroponic systems to meet different farming systems and environmental conditions. Without any doubt, there remains an enormous gap of knowledge concerning the methods for how to improve WUE.

ECOPONICS is an innovative production technology for high quality vegetables in which hydroponics of both closed and open systems are integrated with other methods such as grafting, bio-control and other agents in order to improve WUE. Seedlings are conditioned under drought and poor quality water in different substrates before transplanting to the field. Integrated pest management (IPM) measures for safe vegetables are used to assure less use of pesticides. Socio-economic studies are also conducted on three different levels: farming system; input supply chain, and product supply chain for both domestic and export markets.

Although access to adequate quantities of water is a prerequisite, water quality is also important, with high salt content becoming a major concern. About 20% of all irrigated lands already have salinity problems; this is more than 20 million ha worldwide (Ghassemi et al. 1995). The yearly cost in agriculture due to salinity amounts to over US$12 billion. Constrains by limited water and salinity must be solved under economical and ecological considerations; otherwise, there will be no sustainability in vegetable production.

Salinity inhibits crop production in three ways: water deficit, ion toxicity, and nutrient imbalance. Growth may be adversely affected by salinity-induced nutritional disorders which result from the effect of salinity on nutrient availability, competitive uptake, transport or partitioning within the plant (Grattan and Grieve 1999). For example, salinity limits phosphate uptake and accumulation in crops by reducing availability or by competitive interactions. Salinity can directly affect nutrient uptake, such as sodium reducing potassium uptake (Grattan and Grieve 1999). Most plants are more sensitive to salinity during germination than other stages. This is usually due to the fact that salt accumulates near the soil surface as water evaporates (Abrol et al. 1988). There are means to decrease negative effects of salinity. Some have shown ways to ameliorate the adverse effect of salinity by the introduction of plant growth-promoting rhizobacteria (PGPR).

Adjusting the salinity of the nutrient solution, on the other hand, allows growers to modify the osmotic and ionic effects of the electrical conductivity (EC) and subsequently yield and quality. At some point, increases in salinity limit tomato marketable yield. Under high ECs, tomato fruit size is inversely related to EC while the dry matter content of the fruit is linearly increased by the EC. The exact rate of yield decline varies with interactions between varieties, environmental factors, composition of the nutrient solution, and crop management. According to different studies and growth conditions, salinities higher than 5.0 mScm\(^{-1}\) result in an undesirable yield reduction (Maas and Hoffmann 1977),
while improve tomato fruit quality (Petersen et al. 1998). The Netherlands currently employs high ECs to improve taste and aroma of tomato fruits in the commercial production on rockwool.

Increasing the EC reduces titratable acids, but increases organic acids, soluble solids (°Brix), beta-carotene, carotenoids, lycopene and vitamin C, and enhances the sweetness of fruit and improves the overall flavor intensity of tomato (Cuartero and Fernandez-Munoz 1999). Figure 1 summarizes all internal and external quality parameters of tomato fruit influenced by salinity. Therefore depending upon the composition of the saline solution, ion toxicities or nutritional deficiencies may arise because of a predominance of specific ion or competition effects among cations and anions. Keeping the proper nutrient levels and ratios between all the nutrients in the root environment for each growth stage of a crop should be properly managed in order to achieve high yields and high quality products throughout the cropping season.

![Figure 1. Quality changes of tomato fruit under higher salinity](image)

**Biocontrol Agents for Stress Relief in Vegetable Production**

PGPR are soil bacteria that colonize the roots of plants following inoculation onto seed and that enhance plant growth (Kloepper et al. 2004). They enhance plant growth by direct and indirect means (Figure 2). Direct mechanisms of plant growth promotion involve a variety of mechanisms: increases in specific ion fluxes at the root surface, solubilization of minerals (Nautiyal et al. 2000, Richardson et al. 2001, Idriss et al. 2002), and synthesis of phytohormones (Steenhoudt and Vanderleyden 2000). PGPR that indirectly enhance plant growth via suppression of phytopathogens (Smith et al. 1999) do so by a
variety of mechanisms. These include the ability to synthesize anti-fungal metabolites such as antibiotics, fungal cell wall-lysing enzymes, or hydrogen cyanide, which suppress the growth of fungal pathogens; the ability to successfully compete with pathogens for nutrients or specific niches on the root (Dekkers et al. 1998); and the ability to induce systemic resistance (ISR), which provide long-lasting resistance (Reddy et al. 1999, Van Loon et al. 1998, Zhang et al. 2004). PGPR strains may use one or more of these mechanisms in the rhizosphere.

Several PGPR formulations are currently available as commercial products and separated into two groups as biofertilizer and biocontrol products (Bashan and Holguin 1998). The first category often contains mixtures of several bacteria, the latter often single species. However, little effort is made to understand why the mixing type is preferred over the single type. Much study has to be done to elucidate synergistic effects of the mixing type (Kloepper et al. 2004).

The application of PGPRs in controlled environment systems such as soilless culture, hydroponics and greenhouse production shows considerable promise due in part to consistent environmental conditions and stable microorganism population. Achieving consistent performance in the field where there is heterogeneity of abiotic and biotic factors and competition with indigenous organisms is more difficult. Knowledge of these factors can aid in determination of optimal concentration, timing and placement of inoculant, and of soil and crop management strategies to enhance survival and proliferation of the inoculant. The concept of managing the rhizosphere to enhance PGPR function by manipulation of the host plant, substrates for PGPR, or through agronomic practices, is gaining increasing attention. Development of better formulations to ensure survival and activity in the field and compatibility with chemical and biological seed treatments is
another area of focus; approaches include optimization of growth conditions prior to formulation and development of improved carriers and application technology (Kilian et al. 2000). A preferred application of PGPRs is pre-treatment or hardening of the young plants prior to transplanting into the field for better starting conditions (Vavrina 1999, Kokalis-Burelle et al. 2002). Recent progress in our understanding of their diversity, colonization ability, mechanisms of action, formulation, and application should facilitate their development as reliable components in the management of sustainable agricultural systems.

**Product Quality Issues**

A global trend toward broad adoption of safety and quality protocols is in the best interest of all producers as it facilitates transition into higher-value markets and prevents contamination of marketing chains with poor quality product. The modern market for vegetables is changing rapidly and new procurement strategies, fueled in part by the growth of supermarkets around the world, increasingly requires producers to meet stringent quality, consistency and quantity standards, as well as environmental stewardship. Retaining post-harvest quality of vegetables is becoming imperative to compete in the new global economy.

Quality is the composite of those attributes that contribute to the acceptability of a product by the customer. Thus, it becomes essential to identify and define what those attributes are before one can measure quality or establish quality standards or grades. The quality attributes include both objective and subjective traits. The objective attributes consist of appearance (size, shape, color, gloss, freedom from defects and decay, and bruise susceptibility), texture (firmness, crispness, juiciness, mealinness, and toughness), flavor (sweetness, acidity, astringency, aroma, and off-flavors), nutritive value (vitamins, minerals, dietary fiber, and health-promoting phytochemicals), and residual concentrations of pesticides and nitrate/nitrite. The subjective attributes more or less related to esthetics, social value, life experience, etc. In Europe, vegetable quality assessment centers on appearance and critical concentrations of pesticides and nitrate.

The relative importance of each quality component depends on the commodity and the consumer’s interest. Most producers are product-oriented in that quality is described by specific attributes of the product itself, such as sugar content, color, or firmness. In contrast, consumers describe quality attributes by what they want and need. Although consumers purchase fresh produce based on appearance and textural quality, their repeat purchases depend upon their satisfaction with flavor (taste and aroma). Furthermore, they are interested in the health-promoting attributes and nutritional quality, but concerned about the negative factors such as pesticide residues and nitrate contents.

A consistently good quality supply of fresh vegetable products to the consumers requires an effective quality control and assurance system throughout the handling steps between harvest and retail display. The system usually entails certification of the procedure and labeling of the products derived from the certified procedure. Among various
information, the label usually provides information on place of origin and cultivation method. The survey has showed that European consumers are willing to pay more for the vegetable products with labels. This arises because consumers regard protected products as ‘authentic,’ and of ‘high quality’ and believe their support will bring benefits to the area and people from where the product originated. Presently, consumers in Europe can find labelled products from three types of production: 1) conventional; 2) integrated; and 3) organic. In a recent survey conducted in Germany for healthy foodstuff, environment friendly, and trustworthy of fruits and vegetables labeled with the aforementioned three types of production, the integrated and organic methods of production were ranked high. The conventional method of production likely will be phased out in the near future.

In June of 1997, the EU has published the European Standard EN ISO 14040 covering principles of environmental management entitled Life Cycle Assessment (LCA). This was driven by the need of environmental protection and concern of its impacts on consumed products. EN ISO 14040 has minimal requirements as follows:

- Compiling an inventory of relevant inputs and outputs of a product system.
- Evaluating the potential environmental impacts associated with those inputs and outputs.
- Interpreting the rules of the inventory analysis of the impact assessment.

LCA, referred as to “eco-balance,” prescribes the term for compilation and evaluation of inputs and outputs and the potential environmental impact of a product system throughout its life cycle. To enable an inventory analyses of all production steps one has to look at all unit processes in a product system. Inputs are materials, energy, water, land use, plants, animals, etc., with expected outputs of not only yields and products, but also emissions to the air, water and soil, and waste. These parameters could be used to assess impacts on the environment, product and its quality, and sale volume. Figure 3 illustrates the analysis of weak points for the production of bunched onions and radish. With this kind of analysis, various cultural practices can be assessed in terms of eco-balance and designing good agricultural practices (GAP) to reduce risks and to profitable products under local conditions.

In Europe, three major agencies are implementing quality assurance systems of foodstuff. “Quality Safety Assurance” started in Germany but later expanded to Central Europe, “Bio” is an EU label for organic foodstuff, and EurepGap stands for Euro Retailers Produce Working Group combined with GAPs for horticultural crops. EurepGap has worldwide members of producers, marketing cooperatives, food companies, chemical companies, food processors, and restaurant chains. EurepGap provides regulations to certify quality and safety of products, and to ensure environmentally sound production.
Implications for Central Asia and the Caucasus

To strengthen market-oriented vegetable production systems in Central Asia and the Caucasus (CAC), meeting local demands is a sensible approach. Farming systems, environmental conditions, technical skills, traditions, financial situations, infrastructure, value chains, and consumers’ expectations for vegetables as daily food all need to be recognized. Toward this end, the CAC region has to develop its own standards for vegetable quality based on the requirements from local and international markets. Some major issues that need to be addressed include:

- Improvement of economically viable and efficient production of high-value vegetables.
- Introduction of simple, but highly water-use-efficient growing systems.
- Production of vegetables of superior quality with different management methods.
- Protection of the environment combining with the traditional and new production practices.
- Assistance to smallholders with restricted access to financial and knowledge resources.

**Figure 3. Weak point analysis for the production of onions and radish based on energy consumption**
Literature Cited


Development of Safe Plant Protection Strategy

Gwo-Chen Li¹ and Sue-Sun Wong²
¹National Science and Technology Program for Agricultural Biotechnology, Academia Sinica, Nankeng, Taipei, Taiwan; ²Taiwan Agricultural Chemicals and Toxic Substances Research Institute, Wufeng, Taichung, Taiwan

Introduction

Due to increases of world population, it is expected that in the next three decades we must produce as much food as we have produced since the beginning of history. It is necessary to maximize crop yields on the limited land available.

It is estimated that weeds, plant diseases, and insect pests currently destroy 45% of the world crops. There are many methods of controlling diseases and insect pests, such as application of pesticides, breeding and cultivation of resistant varieties, and biological control. This paper will discuss new technologies being incorporated into these methods and how they may be used in future integrated pest management strategies.

Pesticide Applications and Residues

According to a recent survey, the use of pesticides is one of the most important control measures for crop diseases and insect pests and will remain so in the future. Thus, it is imperative for crop protection specialists not only to ensure the effective use of pesticides but also the safe use of pesticides in order to protect farmers’ health, assure the safety of crop products, and preserve the environment. There are two approaches toward this end. One is to obtain adequate baseline information for pesticide registration under agricultural chemical regulation laws; the other is to provide proper education and guidance to farmers and dealers on the proper handling and use of pesticides.

Baseline information for the pesticide registration

Each country has its own data requirements for pesticide registration. In general, registration is given only after satisfactory data are provided on the effectiveness, physical and chemical properties, toxicity, residue tolerance and impacts on the local environment. The aforementioned data are also important sources of information for crop protection specialists to design proper application procedures of pesticides. For the latter, the information should include: 1) the physical and chemical properties of pesticides to ensure their quality; 2) the toxicity to mammals to ensure the safety of pesticide products; 3) the toxicity to avian and aquatic animals and to natural enemies of pests to minimize the negative impact on the environment; 4) the distribution and degradation of pesticides in soil and water to reduce the pollution; 5) the metabolism and residues of pesticides in the plant to limit the number of applications; and 6) the efficacy and phytotoxicity to ensure
the pesticides’ effectiveness. The integration of these information forms the basis of proper application of pesticides.

**Tolerances levels for pesticide residues**

In recent years, the presence of pesticide residues on food has become a major concern. In response to this, most national authorities have taken the challenge to ensure the safety of the food supply. An extensive pesticide residue survey and evaluation data is now required and will continue to be so in the future.

Before a pesticide can be registered, a tolerance for residues on that pesticide must be established. A “tolerance” is the legal maximum residue concentration of a pesticide allowed in the national food supply. It is usually set high enough to cover the registered use and, in the meantime, to meet the safety requirement.

In Taiwan, before a pesticide is registered, supervised trials are conducted by the Taiwan Agricultural Chemicals and Toxic Substances Research Institute (TACTRI) in cooperation with other institutes. The pre-harvest intervals (PHI) are recommended by comparing residue data from supervised trials with the maximum residue tolerance level established for a specific pesticide.

The requirement for setting tolerances involves specificity of a given pesticide and crop consumption information. The pesticide specificity includes information on its chemistry, acute and chronic toxicity, animal and plant metabolism, field residues, and entailed processes of the studies. The chronic toxicity and field residue information are the most important. The actual residue levels found on each crop group resulting from the pesticide application at recommended rates are obtained from the field residue data. The acceptable daily intake (ADI) of the pesticide is derived from the chronic toxicity data. The ADI values of the registered pesticide in Taiwan are listed and published by TACTRI (Wong 2000). The MPI (maximum permissible intake) of a pesticide by Taiwanese people is calculated from the ADI using an average body weight of 60 kg.

The average daily consumption of each crop per person is obtained from large-scale survey data. For the survey, crops are classified into 19 different groups based on the edible part of the plant, expected distribution of residues, and residue accumulation patterns. Some examples of the daily consumption data are shown in Table 1 (Pan et al. 1999).

The tolerance level for each group of crops is set in accordance with the maximum amount of residue that could be present at harvest time. However, the total number of crop groups for which a pesticide is registered is limited by the MPI value. In other words, the total actual amount of pesticide residue on a specific crop group for which a pesticide had been registered could never exceed the established MPI value. Table 2 shows the tolerances established for benomyl on different crops. The calculated intake is about 0.569 mg/person/day, which accounts for 47% of MPI for benomyl. Thus, benomyl can be registered for use on some additional crops without exceeding MPI. The sub-
Table 1. The daily consumption data of vegetable and fruit groups

<table>
<thead>
<tr>
<th>Crop</th>
<th>Daily consumption (g)</th>
<th>% Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leafy greens</td>
<td>83</td>
<td>8.56</td>
</tr>
<tr>
<td>Brassicas</td>
<td>66</td>
<td>6.74</td>
</tr>
<tr>
<td>Root and tuber vegetables</td>
<td>50</td>
<td>5.16</td>
</tr>
<tr>
<td>Cucurbits</td>
<td>29</td>
<td>2.97</td>
</tr>
<tr>
<td>Solanaceae</td>
<td>22</td>
<td>2.28</td>
</tr>
<tr>
<td>Leguminous vegetables</td>
<td>12</td>
<td>1.17</td>
</tr>
<tr>
<td><strong>Fruits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citrus</td>
<td>66</td>
<td>6.82</td>
</tr>
<tr>
<td>Melons</td>
<td>56</td>
<td>5.71</td>
</tr>
<tr>
<td>Small berry</td>
<td>41</td>
<td>4.26</td>
</tr>
<tr>
<td>Pome fruits</td>
<td>30</td>
<td>3.01</td>
</tr>
<tr>
<td>Large berry</td>
<td>28</td>
<td>2.83</td>
</tr>
<tr>
<td>Stone fruits</td>
<td>12</td>
<td>1.19</td>
</tr>
</tbody>
</table>

MPI, also known as the theoretical maximum daily intake (TMDI) is equivalent to the tolerance times the daily consumption of crop groups. The SMPI is the sum of sub-MPI.

Tolerance levels for the pesticides registered for different crop groups have been adopted by TACTRI (Wong 1997). Up to 2002, 386 pesticides were registered for use in Taiwan and its department of health had issued 1,287 tolerance levels of 307 pesticides on vari-

Table 2. The tolerances established for benomyl on different crop groups

<table>
<thead>
<tr>
<th>Crop group</th>
<th>Tolerance (ppm)</th>
<th>Daily consumption (kg/day)</th>
<th>TMDI (mg/day)</th>
<th>Residue (ppm)</th>
<th>Actual intake (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fruit vegetables</td>
<td>1.0</td>
<td>0.022</td>
<td>0.022</td>
<td>0.29</td>
<td>0.060</td>
</tr>
<tr>
<td>Root vegetables</td>
<td>0.2</td>
<td>0.050</td>
<td>0.010</td>
<td>0.02</td>
<td>0.001</td>
</tr>
<tr>
<td>Melons</td>
<td>2.0</td>
<td>0.055</td>
<td>0.110</td>
<td>1.61</td>
<td>0.088</td>
</tr>
<tr>
<td><strong>Fruits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small berry</td>
<td>2.0</td>
<td>0.041</td>
<td>0.083</td>
<td>0.20</td>
<td>0.008</td>
</tr>
<tr>
<td>Large berry</td>
<td>1.0</td>
<td>0.0280</td>
<td>0.028</td>
<td>0.01</td>
<td>0.003</td>
</tr>
<tr>
<td>Pome fruit</td>
<td>3.0</td>
<td>0.0290</td>
<td>0.088</td>
<td>2.79</td>
<td>0.081</td>
</tr>
<tr>
<td>Citrus</td>
<td>3.0</td>
<td>0.066</td>
<td>0.198</td>
<td>2.78</td>
<td>0.183</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rice</td>
<td>0.2</td>
<td>0.148</td>
<td>0.030</td>
<td>0.02</td>
<td>0.003</td>
</tr>
<tr>
<td>Tea</td>
<td>5.0</td>
<td>0.002</td>
<td>0.009</td>
<td>0.50</td>
<td>0.001</td>
</tr>
</tbody>
</table>

SMPI$^2$ = 0.569
Actual intake (mg/day) = 0.428

$^1$ The acceptable daily intake (ADI) established by the World Health Organization is 0.1 mg/kg/day and the maximum permissible intake (MPI) is 1.2 mg/person/day

$^2$ TMDI = theoretical maximum daily intake and SMPI = sum of MPI
ous edible crops (Anonymous 2000). All the tolerances have been compiled in the “Guide to pesticide tolerance on crops in Taiwan” (Wong 1997).

**Multi-residue analysis method**

Rapid residue screening methods are imperative in supporting the “Inspection-education program.” The method should be for both quality and quantity; that is, the type and level of pesticide residues in the products. The multi-residue method meets this requirement. A total of 211 pesticides were selected to develop a multi-residue analysis for selected fruits and vegetables. Figure 1 shows the flow chart of the multi-residue determination in Taiwan.

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**Figure 1. Method for multi-residue determination used in Taiwan**
The multi-residue method used in California is able to detect 204 pesticides with residue levels in the range of 0.02–0.2 ppm. For Taiwan’s method, which is similar to California’s, one person can analyze 15–20 samples per day.

**Risk assessment in application exposure**

In Taiwan, farmers’ exposures to pesticides are monitored. Alpha-cellulose pads are usually placed on working cloth for measuring the dermal exposure, and air samples are collected for measuring the inhalation exposure during the pesticide application with airblast sprayers. The percentage of toxic dose per hour (PTDPH) represents the acute toxicity of exposure. The margin of safety (MOS) represents the chronic toxicity of exposure. PTDPH is calculated by dividing the sum of dermal exposure/10 and the inhalation exposure within one hour with the LD$_{50}$ of the pesticide investigated. MOS is calculated by dividing no observe effect level with the sum of dermal exposure/10 and inhalation exposure. It is risky to the farmer if MOS value of a pesticide is less than 100.

A similar program with the growers of peanut, mango, cabbage, tea, grape, and citrus is ongoing to develop a prediction system. Hopefully, this system could be used to predict the safety of a pesticide to farmer under the recommend rate of application before the registration of a particular pesticide.

**Risk assessment in dietary exposure**

TACTRI has conducted two “market basket survey” programs during 1992–1993 and 1999–2000. These programs were carried out by taking samples based on area population sizes, sample types based on consumption data, and evaluations based on ADI values. A total of 962 samples, including 90 rice, 644 vegetable and 228 fruit, were collected from 11 markets during 1992–1993. Samples were analyzed using the multi-residue method (MRM) to assess 77 pesticide residues. A total of 31 pesticides were found in various samples. Twelve pesticides were found in more than 1% of samples. The toxicological risk was then calculated by comparing the actual residue contribution (ARC) with the acceptable daily intake (ADI) for the pesticides. The risk assessment indicated that the ARC of 11 pesticides, except monocrotophos, accounted for only 0.54 to 15.5% of their acceptable daily intake (Wu 1992). A total of 3,262 samples, including 1,064 rice, 1,178 vegetable and 1,202 fruit, were collected from 17 markets during 1999–2000. Samples were analyzed using an improved multi-residue method that could be used to detect 113 pesticides on vegetables and 125 pesticides on fruits. A total of 69 different pesticides were detected in various samples. After calculating the ARC of these pesticides, it was found that the ARCs of 16 pesticides were between 1.15 to 22.63% of their ADI, 18 pesticides between 0.12 to 0.97%, 24 pesticides between 0.02 to 0.09%, and 10 pesticides below 0.01% of ADI. Based on these two surveys, the risk of dietary pesticide exposure is considered low (Wong et al. 2000).
Farmers’ Education on Pesticide Application

Teaching farmers to follow the guidelines is important to ensure the proper use of pesticides. It does increase farmers’ knowledge but sometimes still does not solve farmers’ on-site problems. For the purpose of enforcing farmers to follow the rule of pesticide uses, TACTRI set up an inspection-education program (Figure 2) in 1989. This program combines residue monitoring, farmer education on pesticide use, and pesticide law enforcement.

![Diagram of the working system used by TACTRI and partners to prevent pesticide residue problems on fruits and vegetables.]

**Figure 2. Working system used by the Taiwan Agricultural Chemicals and Toxic Substances Research Institute (TACTRI) and partners to prevent pesticide residue problems on fruits and vegetables.**

TACTRI’s 15 working stations scattered in different locations are responsible for the analysis of pesticide residues on fruits and vegetables, and farmer education based on results obtained. For each vegetable sample, 81 commonly used pesticides are analyzed; and for each fruit sample, 24 to 42 pesticides are analyzed depending upon the type of fruit. If results of these long-term and wide-area surveys indicate that a pesticide residue violates the tolerance level, an investigation is commenced to understand possible causes, such as cultural practices and methods of pesticide application. The development of pest resistance to the pesticides is also assessed. The education of farmers follows after the problem is identified. About 15,000 samples are analyzed annually. Since the establishment of the inspection-education program, the number of vegetable samples violated tolerance has been greatly reduced, from about 30% in 1985 to less than 5% in 2002 (Tuan 2003).
To encourage farmers to use pesticides prudently, Taiwan has implemented the good agricultural practice (GAP) approval program since 1994. The local farmers’ associations organize specific crop growing groups for the farmers to enroll in the GAP program. The program records the pesticide farmers use, and analyzes pesticide residues. The safe products are certified with GAP seals. Up to 2002, 512 fruit groups with 7,104 farmers, and 770 vegetable groups with 11,274 farmers are certified in the GAP program (Tuan 2003).

**Pest Resistance to Pesticides**

All pests can develop resistance to the pesticides that are used to control them. Pesticide resistance has undermined pest control programs and posed a considerable challenge to the industry, research community and farmers. It was estimated several years ago that 504 species of insects and mites were resistant to insecticides (Georghiou and Saito 1983); over 100 species of fungi to fungicides (Georghiou and Saito 1983); and 81 species of weeds to herbicides (LeBaron 1991).

Many tools for managing resistance have been developed. However, single strategies all have the potential for failure and may exacerbate existing resistance problems. The best hope for saving crops and safeguarding health therefore lies in integrating pesticide applications with biological and physical control measures to delay the emergence of resistance. Future research needs include improvements in the diagnosis, monitoring and prediction of resistance. Training and extension are also required to protect future pesticide inputs.

It has been realized for some time that an ability to predict accurately the build-up of resistance to pesticides would be valuable. This information could be used, in particular, to formulate anti-resistance strategies for the commercial application of new materials. Attempts, though, to develop prediction systems applicable to field situations have not been successful.

Most mathematical models for predicting an increase in resistant forms of a pest are difficult to validate and remain largely theoretical. Denholm et al. (1990) have emphasized the need for good experimental work to allow models to be adequately tested during development, and they advocated an integrated approach. With increasing availability of data, and the aid of computers, it is possible to produce more realistic resistance development models.

Predicting the risk of resistance to a given pesticide under specified conditions is becoming easier. Prediction combines the mode of action of the chemical; the degree of pesticide use; the fecundity and ease of dispersal of the target organism; and ease of resistance development in controlled environment studies (Brent 1987). A good understanding of pest-pesticide-crop interaction is also required.

Simple techniques for determining the frequency of resistance and the subsequent monitoring of any resistance build-up in pest populations would be useful as the basis for
more rational resistance management. Knowing background resistance in pest populations before chemical selection is applied would be particularly helpful, together with information on any regional differences.

For these reasons a great deal of research is being carried out on diagnostic techniques in order to develop biochemical, immunological and bioassay tests. Brent et al. (1990) pointed out that such systems will respond to known resistance factors, but new resistances may not be so readily detected, and that this possibility needs to be considered. Furthermore, the rapid development of resistance to certain fungicides may not be easily detected at an early enough stage to avoid control failure (Brent et al., 1990).

**Integrated Pest Management**

With fewer “new chemical” pesticides becoming available on the market, there is increasing pressures on existing materials for crop protection. Where high-risk situations are identified, appropriate integrated resistance management strategies must be promoted through advice and training of farmers. The economics of production of particular crops can sometimes encourage over-reliance on cheap pesticides, or conversely can encourage lower application rates. With increasing knowledge of the development of pesticide resistance, it is becoming possible to reduce control problems. Although it seems likely that pesticide resistance will continue to arise, the increasing adoption of integrated pest management (IPM), an effective and environmentally sensitive approach to pest management that relies on a combination of rational methods, likely will ensure that the negative impact will be less than in previous years.

**Monitoring of pests**

A geographic information system (GIS) is a computer software system with which spatial information may be captured, stored, analyzed, displayed and retrieved. GIS has been used for detecting pest infestations and early stages of insect outbreaks on regional and national levels. GIS also makes it possible to quantify and evaluate relationships among pest distribution, climatic variables, topographic attributes, crop mortality and economic loss. With the help of GIS, farmers and extension services are able to decide an acceptable response before pests have time to cause much damage. A global positioning system (GPS), which provides full-time and rapid ground coordinates within a meter of accuracy, has been used to record latitude-longitude coordinate data of infested localities. Precise location data obtained from GPS fit nicely into GIS and, combined with other multiple data sets, allow a more accurate monitoring of pest dynamics.

**Biological control**

Biological control is the use of living organisms as pest control agents. Many natural enemies have been used for the control of insect pests in history. The use of biological control in the early part of the 21st Century was due to a severe blow by the advent of
synthetic organic pesticides in the 1950s. Compared to these new products, natural enemies were seen as inefficient and unreliable. Mounting problems with pesticide resistance and environmental pollution led scientists in the 1970s to develop the concept of IPM. This was an attempt to free from the domination of chemical control by the addition of other technologies, among them biological control.

Recently, many scientists have begun to acknowledge the potential value of biological control in IPM. However, relatively little thought has been given to what kinds of biological control we need to develop, or how we will truly integrate them with other control measures. More importantly, almost 40 years of preoccupation with chemical pesticides have left most scientists, industrialists, policymakers and farmers poorly informed about the role of natural enemies on crop pests. Before biological control can be developed and implemented, it will be necessary to re-establish an understanding of the impact of natural enemies on crops. This is essential to the development of IPM. If we know which natural enemies are contributing the most to pest depression at critical times, we can select them for conservation or augmentation.

Conservation involves modifying cropping practices to improve the action of biological control agents. These practices may include the destruction of crop residues, cultivation, and the pattern and timing of planting. Increasing crop diversity improves pest control by enhancing the action of natural enemies.

In Taiwan, biological control has been practiced for many years. Many natural enemies have been tested for insect pest control (Table 3). Studies on the conservation of these enemies in the field have been carried out. The experience of this recent effort is that the more we study the problem, the more complex it becomes. Establishing a population of natural enemies in the field seems to be impossible because of the pesticide applications and the lack of diversity of the crops (Kao and Tzeng 1989a, 1989b). Future research is needed to modify pesticide use patterns so as to enhance the action of natural enemies. In the future, efforts at conservation should be based on an understanding of important natural enemies in a given crop, and targeted at their action, rather than increasing natural diversity. This will only improve the chances for successful conservation of natural enemies.

**Table 3. Natural enemies used for pest control in Taiwan**

<table>
<thead>
<tr>
<th>Natural enemies</th>
<th>Target pests</th>
<th>Crop</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Cotesia plutellae</em></td>
<td>Diamondback moth</td>
<td>Cabbage</td>
</tr>
<tr>
<td><em>Diadegma eucerophaga</em></td>
<td>Diamondback moth</td>
<td>Cabbage</td>
</tr>
<tr>
<td><em>Eretomocerus orientalis</em></td>
<td>Whitefly</td>
<td>Poinsettia</td>
</tr>
<tr>
<td><em>Encarsia transvena</em></td>
<td>Whitefly</td>
<td>Strawberries, papaya, tea, eggplant</td>
</tr>
<tr>
<td><em>Mallade bassalis</em></td>
<td>Mites, thrips</td>
<td>Indian jujube</td>
</tr>
<tr>
<td><em>Trichogramma chilonis</em></td>
<td>Sugarcane borer</td>
<td>Sugarcane</td>
</tr>
<tr>
<td><em>Trichogramma ostrinae</em></td>
<td>Sugarcane borer, Asian corn borer</td>
<td>Sugarcane, corn</td>
</tr>
</tbody>
</table>
On some occasions, the conservation of natural enemies is not sufficient to increase their useful contribution to pest management. This may be due to the lack of resources in modern monoculture, or the lack of continuity in resources such as seasonal crops. In such instances, methods are available for the augmentation of natural enemies, or the addition of natural enemies to crops for a short-term effect over, or within a single season. This approach also depends on an understanding of the action of natural enemies in crops, so that this can be predicted, and the right number of enemies introduced at the right time. It is another example of how ecological research will improve the cost efficiency and success of biological control in the decades to come.

Improvements in the mass production of insects, and possibly in artificial diets for parasitoids and predators, may also allow new species of insect natural enemies to be augmented commercially in future. In the meantime, plant protection specialists in Taiwan suggest that biological control measures should be used only in agriculture under structures (greenhouses or nethouses), where environmental conditions and pesticide applications are easily manipulated.

Biological control is also an attractive alternative for the control of diseases. It could reduce disease incidence or severity by direct or indirect manipulation of microorganisms. The principle may be eradication or protection, depending on specific target disease to be controlled. In recent years, the highly virulent isolates of antagonistic microorganisms for the control of plant diseases have been selected in Taiwan. The microorganisms include *Trichoderma* spp., *Bacillus* spp., *Giocladium* spp., *Streptomyces* spp., and *Penicillium* spp. They are mainly applied as soil amendments or organic fertilizers.

**Development of biopesticides**

Biopesticides are the most rapidly growing technology of biological control. They rely on the action of pathogens of insect pests or plant pathogens which, although highly virulent, do not spread through crops. This makes them appropriate for mass production and targeted release.

Biopesticides have many advantages. They are friendly to the environment and fit well into IPM programs. In some cases, they provide long-term control. They should be easier to register and less expensive than chemical pesticides. Considering all the hidden cost of chemical agents, the public and farmers generally favor their use. Such agents should also be less resistant, should be easily mass produced, and may be the only available control strategy as chemical agents lose their efficacy.

A number of biopesticide products were developed in the 1970s, but these failed to survive in the marketplace. There were two reasons for their lack of success. First, the market was not easy to penetrate. IPM had not taken off as anticipated, and few niches were available where a biopesticide would not face competition from an established, conventional product. More important, insufficient work had been done on ensuring the field efficacy of these products, and they proved variable in their efficacy. This was largely because of the influence of the environment on the survival of formulations.
In the 1990s, we have seen a new surge of interest in biopesticides, and much greater prospects of success. Exciting new markets have been created by the reduction in use of broad-spectrum pesticides in many agricultural areas where the IPM concept has been implemented. Furthermore, companies are reluctant to register chemical pesticides for certain uses, because of their low profitability relative to their high cost of registration and environmental exposure. This has boosted the development of biopesticides.

The other impetus of biopesticide development comes from the advance of modern technology such as fermentation technology, formulation technology, and biotechnology. These not only increase the field efficacy of biopesticides, but also improve their persistence in their environment and their shelf life. The most important point is that modern technology reduces the cost of mass production of biopesticides.

In Taiwan, it has become government policy to speed up the development of biopesticides. Scientists have formed many multidiscipline teams. The target microorganisms include *Bacillus subtilis*, *Trichoderma* spp. and *Streptomyces* spp. for diseases control; and *Bacillus thuringiensis*, *Beauveria bassiana*, *Metarhizium anisopliae*, *Verticillium lecanii*, *Hirsutella thompsonii* and *Nomuraea rileyi* for insect pest control.

**Use of resistant varieties**

Varietal resistance to diseases and insects plays a major role in pest management programs. Major advances have been made in developing varieties with multiple resistance to diseases and insects. In the past, genetic improvement for pest resistance was achieved mainly through the application of classical Mendelian genetics and conventional breeding methods. Breeders have relied upon crop germplasm, including wild species and induced mutants, as sources of resistance. However, recent advances in cellular and molecular genetics have led to the development of new tools for producing resistant varieties. It is now possible to introduce novel genes against insect pests or pathogens from unrelated organisms into desired crops. Tissue culture has helped broaden the gene pool for resistance through the production of wide range of hybrids among distantly related species, and through in vitro selection of useful mutants. Pest resistance genes, when tagged with molecular markers, can be moved more rapidly from one variety to another. Nucleic acid probes allow the detection of pathogens in breeding materials and aid in the selection process. The resistant variety thus developed forms the backbone of pest management programs.

In Taiwan, the breeding of horticultural crops resistant to insect pests has been emphasized in order to minimize the use of pesticides. Current studies focus on the source of resistance, mechanism and inheritance, interaction of resistance with crop morphology, biochemical analysis of resistance, and various breeding methods.

Papaya (*Carica papaya*) is one of the most widely grown fruits of the tropics and subtropics. A destructive disease caused by papaya ringspot virus (PRV) is a major obstacle to its wide-scale planting. The virus was first recorded in southern Taiwan in
Within four years, the virus had destroyed most of the papaya production in commercial orchards along the west coast of the country. The total yield of papaya dropped from 41,595 t in 1974 to 18,950 t in 1977. During the same period, the wholesale price increased sixfold, from NT$3.67/kg to NT$20.70/kg. (In 1999, 1 US$ = 33 NT$).

Wang et al. (1994) constructed the coat protein (CP) of a local mosaic strain of papaya ringspot virus (PRV YK) in the Ti-vector for generation of transgenic papaya resistant to PRV infection. The CP gene with a GUS marker as the PRV leader sequence was transferred to embryogenic tissues derived from immature embryos of papaya via Agrobacterium–mediated transformation that was assisted by carborundum-wounding treatment. The plants of CP-transgenic lines were established by micropropagation. A total of 45 transgenic lines were tested for their resistance to PRV YK infection by mechanical inoculation. Among these, 16 lines showed some degree of resistance to infection, but there was no significant delay in development of severe symptoms. Ten lines were highly resistant, with a 4–7 week delay in the development of symptoms. Two lines did not show any symptoms over a test period of four months. Negative results in ELISA detection and bioassays indicated that the replication of the challenge virus was suppressed in these two lines.

The ten highly resistant lines and the two immune lines were selected for further evaluation against different strains of PRV under greenhouse conditions. The results revealed that the transgenic lines with a higher degree of resistance to the Taiwan strain YK also had a higher degree of resistance to the Hawaii strain (HA), the Thailand strain (TH), and the Mexico strain (MX). The two lines which were immune to YK were also immune to HA, TH and MX strains.

Results of field trials over 18 months indicated that the CP transgenic lines have great potential for control of papaya ringspot virus (PRSV) in Taiwan. Open-field trials in different locations of Taiwan will proceed after more tests under isolated conditions. It is expected that the transgenic lines will be deregulated for commercialization after the field experiments are completed. Based on the greenhouse evaluation, it is believed that these transgenic lines carrying the coat protein of the Taiwan PRV vs. PRSV strain can be used for control of PRV vs. PRSV in other areas.

Ingredients for Effective IPM Programs

To establish an effective IPM program, the following basic guidelines should be followed:

1. Understand the biology of the crop or resource, especially in the context of how it is regulated by the surrounding ecosystem.

2. Identify the key pests, know their biology, and recognize the kind of damage they inflict and initiate studies on their economic status.

3. Identify the key environmental factors that impinge (favorably or unfavorably) upon pest and potential pest species in the ecosystem.
4. Consider concepts, methods and materials that, individually and in concert, will help to permanently suppress or restrain pest and potential pest species.

5. Structure the program so that it will have the flexibility to adjust to change, i.e., avoid rigidity in a program that cannot be adjusted to variations from field to field, area to area, or year to year.

6. Anticipate unforeseen developments, expect setbacks, and move forward with caution. Above all, be constantly aware of the complexity of the resource ecosystem and the changes that can occur within it.

7. Seek the weak links in the armor of the key pest species and direct control practices as narrowly as possible at these weak links. Avoid broad impact on the resource ecosystem.

8. Whenever possible, consider and develop methods, which preserve, complement and augment the biotic and physical mortality factors that characterize the ecosystem.

9. Whenever possible, try to diversify the ecosystem.

10. Insist that technical surveillance for programs must be available (i.e., monitoring).

These guidelines are rooted in ecological thinking. Inadequate gathering of information limits the progress of IPM programs. For the past years, IPM has been slow to move from theory to practice. This failure might be caused by the lack of baseline information. With the help of modern information technology, it is possible to speed up the gathering of information and the implementation of IPM.

Since 1998, Taiwan has been implementing a “monitoring system for plant pests” (Figure 3). The system includes an information center, a diagnosis center, and eight district surveillance and monitoring centers. Twenty specialists from different research institutes and ten working staff form the information center. The information center is responsible for the collection and analysis of information and the formulation of pest control strategies. The diagnosis center identifies diseases and insect pests. The district surveillance and monitoring centers monitor insect pests and plant diseases in their districts. A district center will dispatch a specialist to the field doing monitoring job with the help of contracted farmers. Each specialist handles 3–8 counties. In each county, a few well-trained farmers are contracted for the routine monitoring work. A total about of about 320 counties are covered by the system.

All the components in the system are linked through a computer network. Different levels of training classes are held for specialists and farmers. The plant protection databank built up by the specialist in the information center provides information that can be easily accessed. Data obtained from the field is rapidly transferred to the center.

Over 70 insect pests and plant disease are under surveillance. The pests are classified into four categories, i.e., quarantine pests, epidemic pests, endemic pests and pests that need further study. Among the pests, 16 are under constant monitoring (Table 4). Strong IPM programs are being developed as a result of the monitoring system.
Figure 3. Monitoring system of plant pests in Taiwan

Note: TARI = Taiwan Agricultural Research Institute; TACTRI = Taiwan Agricultural Chemicals and Toxic Substances Research Institute

Table 4. Pests and diseases under constant monitoring on vegetable and ornamental plants

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Monitoring method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pests</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bactrocera curcubitae</td>
<td>Melon fruit fly</td>
<td>Cue-lure traps</td>
</tr>
<tr>
<td>Bactrocera dorsalis</td>
<td>Oriental fruit fly</td>
<td>Methyl eugenol traps</td>
</tr>
<tr>
<td>Bemisia argentifolii</td>
<td>Silverleaf whitefly</td>
<td>Yellow sticky traps</td>
</tr>
<tr>
<td>Chrysochroica medinalis</td>
<td>Rice leaf roller</td>
<td>Light traps</td>
</tr>
<tr>
<td>Helicoverpa armigera</td>
<td>Corn earworm</td>
<td>Pheromone traps</td>
</tr>
<tr>
<td>Liriomyza bryoniae</td>
<td>Tomato leafminer</td>
<td>Yellow sticky traps</td>
</tr>
<tr>
<td>Liriomyza trifolii</td>
<td>Gerbera leafminer</td>
<td>Yellow sticky traps</td>
</tr>
<tr>
<td>Nilaparvata lugens</td>
<td>Planthopper</td>
<td>Light traps</td>
</tr>
<tr>
<td>Spodoptera litura</td>
<td>Tobacco cutworm</td>
<td>Pheromone traps</td>
</tr>
<tr>
<td>Spodoptera exigua</td>
<td>Beet armyworm</td>
<td>Pheromone traps</td>
</tr>
<tr>
<td>Tetranychus kanzawai</td>
<td>Kanzawa spider mite</td>
<td>Visual count</td>
</tr>
<tr>
<td><strong>Diseases</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acidovorax avenae</td>
<td>Bacterial fruit blotch</td>
<td>Visual count</td>
</tr>
<tr>
<td>Colletotrichum gloeosporioides</td>
<td>Anthracnose</td>
<td>Visual count</td>
</tr>
<tr>
<td>Magnaporthe grisea</td>
<td>Rice blast</td>
<td>Visual count</td>
</tr>
<tr>
<td>Raidopholus similis</td>
<td>Burrowing nematode</td>
<td>Visual count</td>
</tr>
<tr>
<td>Xanthomonas oryzae var. oryzae</td>
<td>Bacterial leaf blight</td>
<td>Visual count</td>
</tr>
</tbody>
</table>
Literature Cited


Development of Integrated Pest Management for Vegetable Production in Central Asia and the Caucasus

Bakhtiyar Baghirov
“EMA”, Gorodskoe shosse, Box Sabunchu, Baku, 1034, Azerbaijan

Introduction

Agriculture is an essential sector of the economy of Central Asia and the Caucasus (CAC). Cereal crops, potatoes and vegetables are extensively cultivated. In 2004 the area under vegetables in the CAC region was about 640,000 ha, producing 10.1 million t of vegetables. The average yield was 15.2 t/ha. This level is relatively lower than those of developed countries in the temperate region. The difference could be attributed to crop damage or loss, ranging from 10–50%, caused by insect pests, diseases and weeds. In the past, certain diseases have reached to epidemic levels.

Vegetable production in the CAC region requires sound crop protection systems; however, confronting this are vegetable crops being grown in diverse agro-ecosystems, fuel and chemical pesticides in short supply, and limited techniques for pesticide applications.

Past and Current Pest Management Approach in CAC

Intensification was used to increase food production in the CAC region, leading to the heavy use of pesticide for the control of diseases, insects and weeds, reaching maximum levels in the 1980s. In Armenia, Azerbaijan and Uzbekistan, for example, average pesticide use then was about 10–30 kg/ha, a lot higher than other countries, by state farms in the 1980s. For cotton production, this figure even increased to 30–100 kg/ha during that time. This process can be stopped and reversed only if sustainable cropping systems are introduced.

Biological control was introduced in the early 1980s after chemical pesticides became ineffective and residues, especially persistent organochlorine compounds, were found in water, soil and food. The break-up of the centrally planned economy of the Soviet Union, however, has led to a deterioration of facilities for the mass rearing of beneficial predators and parasitoids to control insect pests.

During the 1990s the amount of pesticides used in the CAC region decreased dramatically, to less than 1 kg/ha, as a result of the collapse of the traditional distribution system, reduced cropped area, and financial means. Actually, large farm areas, especially in mountainous areas, have been free from pesticides for many years. This has reduced some of the environmental pressures from agriculture. Nevertheless, the sharp
drop in use of pesticides, in some cases, does not reflect the products that are being traded on the black market with little or no supervision. In fact, farm privatization, especially for vegetable farms, is leading to more intensive agriculture with an increasing use of chemical pesticides, much of them imported.

The overuse of pesticides has negative effects on human health and the environment. Apart from human health, many soils, groundwater sources, irrigation channels, and water bodies are polluted by the pesticide residues in certain hot spots in the CAC region. The pollution of soil and water with pesticide residues still linger.

Despite a general trend of decreased use of pesticides in the CAC region, several studies showed that the existing approaches to control pests are linked with a list of problems:

- Dependence on chemical control methods, especially for large areas of monocropped species.
- Use of WHO Class 1 and unregistered chemicals.
- Poor labeling on chemical pesticides about their application methods, rates, efficiency, and toxicity.
- Inappropriate handling and management of pesticides.
- Unsound disposal of chemicals and packaging.
- Inadequate enforcement of laws and regulations on labeling and sales of pesticides.
- Low level of awareness among officials, sale agents, and farmers.
- Poor sense for safe use of pesticides.

Future consideration on the proper use of pesticides for the CAC region must be given to the improvement of targeting chemicals at specific pests. In particular, leaching of excess chemicals into the groundwater and irrigation channels must be reduced.

Currently several CAC countries have state commissions and committees on chemical utilizations, chemical security, plant protection and nature protection. These commissions and committees stipulate sanitary standards and rules, control the transportation, storage and usage of pesticides, process the registration of pesticides, evaluate the direct and indirect impacts of pesticide applications on beneficial insects and other environmental issues, and refine the management of pesticide resistance. Much work has to be implemented by these agencies for the formation and realization of a unified strategic policy to reduce the use of chemical pesticides.

**Current Practices in Vegetable Protection**

Although the former Soviet Union was at the leading edge of biological crop pest control, today most of the pest control on vegetables in the former Soviet republics in the CAC
region is undertaken through chemical means, mostly because of unavailability of predators and parasitoids from bio-control facilities. Below are some of chemical pesticides commonly used in the CAC region:

**Insecticides**

Organophosphorous (OP) compounds are the major type of chemical insecticides used in the CAC region. Chlorpyrifos is used to kill insects by disrupting their nervous system, and has an advantage over other OP insecticides in that it is effective against a wide range of plant-eating insects. Dimethoate is another systemic insecticide to control a broad range of insects such as thrips, aphids and whiteflies, and mites on a number of vegetables. Malathion is a nonsystemic OP insecticide for the control of sucking and chewing insects on vegetables. Diazinon is a nonsystemic OP insecticide to control a wide variety of sucking and leaf-eating insects. Methyl parathion is a nonsystemic OP stomach poison to control chewing and sucking insects. It has been reported that resistance to OP insecticides occurs in many insect and mite species if the same insecticide is used for a sufficient period of time. Resistance arises as a result of the natural existence of resistant individuals (initially at very low levels in the pest population) and the selective killing of susceptible individuals each time an insecticide application is made. If there is no immigration from outside, the whole population will eventually become resistant.

Synthetic pyrethroid insecticides were developed as a synthetic version of the naturally occurring pesticide pyrethrin, which is found in chrysanthemums. They have been modified to increase their stability in the environment. Some synthetic pyrethroids are toxic to the nervous system. At present, about 22% of insecticides sold in the CAC region are synthetic pyrethroids. Those used on vegetables include supermethrin, deltamethrin, alphamethrin (alpha-cypermethrin), cyhalothrin, fenpropathrin, and others. Because of their long-lasting effects, resistance to synthetic pyrethroids and control failures (for example, on aphids and fruit worms) has been of particular concern lately.

Apart from organophosphate and synthetic pyrethroid insecticides, nereistoxin and alpha-pyrromonazole have been widely applied in the region during last years. As for nereistocynes, acetamiprid for the control of aphids in cole crops and tomato is popular, and fipronil from the alpha-pyrromonazole group of preparation is also applied very often.

**Fungicides**

The farmers in the CAC region use both contact and systemic fungicides for disease control on vegetables. Popular contact fungicides include copper sulphate, mancozeb, maneb, metiran, cartan, zineb, propineb and famoxadon. Commonly used systemic fungicides include benomyl, carbendazim, metalaxyl, penconazol, cymoxanil, triadimefon, dimetomorph, kresoxim-methyl and mefenoxam. These fungicides are used in both open-field and protective vegetable production. However, disease management with fungicides is not extensively used due to high prices of fungicides and lack of mechanization for spraying.
Herbicides

The pre- and post-emergent herbicides used on vegetables include trifluralin, pendimethalin, rimsulfuron, oxyfluorfen, ioxynil, fluoroxypr and quizalofop-ethyl. Most of them are employed on tomato, cabbage, carrot, and table beet. Nevertheless, herbicides are not extensively used for other vegetables; whereas manual weeding is still the mainstay of weed control in protected vegetable production.

Issues of pesticides used on vegetables

The above pesticides are available in following formulations: dust, granule, liquid, powder, aerosol, seed dressing, wettable powder, emulsifiable solution, and bait. Because they are fast-acting, versatile, easy to apply, and relatively cheap, there is a tendency of overuse and/or misuse of the pesticides. There were cases when the use of unknown pesticides caused destruction of agricultural crops. Development of small-scale farming in the CAC region is conducive to this trend.

Current practices of using broad spectrum or non-targeted pesticides in the CAC region have a deleterious effect on bees, birds, domestic animals, and predators, which could lead to ever increasing doses at shorter intervals, ultimately resulting in pesticide resistance by insects/pathogens, accumulation of harmful residues in the food products and environment, and increased product prices.

Development of Integrated Pest Management

In order to increase vegetable production without risking human health and the environment, many CAC republics are employing strategies to promote the use of biological or environmental control methods and to reduce the reliance on synthetic chemical pesticides. Integrated pest management (IPM) combines natural forms of control, taking advantage of ecological relationships in the agricultural system, with economically derived rules for application of pesticides with low toxicity to minimize negative effects on human health, beneficial organisms, and the environment. An effective IPM program usually includes the following components:

Cultural and crop management controls

The use of resistant varieties is the most effective approach in managing disease and insect problems on vegetables. On the other hand, crop rotation and removal of diseased or infested plant parts or residues prevent build-up of pathogens and insects in the following crops. Other management measures to prevent build-up of pathogens and insects include the use of pest-free seed and healthy seedlings, sticky boards or tapes for control of flying insects, physical barriers such as row covers or trenches to prevent insects from reaching the crop, inter-row hoeing, various trapping techniques, refuge management, mulching, field sanitation, and intercropping. Conversely, balanced fertilizer application and proper irrigation promote healthy crop development that prevents pest attacks. Be-
cause of financial constraints, hand removal of diseased or infested plant parts or insect eggs and larva is widely practiced in the small-scale farms in the CAC region. Nevertheless, the method could be applied only to certain pests. Much of other cultural and crop management control measures need to be promoted in the CAC region.

**Biological controls**

With less use of chemical insecticides in the field, populations of many predatory insects such as ladybird beetle (coccinellids), lacewings, and *Orius* spp., which control mites, aphids, thrips and whiteflies, increase. The use of the natural enemies (often called beneficials) as a biological control measure to control crop pests involves more than predatory insects. It includes also parasitoids and insect pathogens. Environmentally friendly chemical interventions such as the use of pheromones, feeding attractants and biopesticides, for example, are specific and beneficial friendly insecticides.

Egg-parasitoid *Trichogramma* wasps and larvae-parasitoid *Bracon* wasps seek out and sting eggs or wandering-stage larvae. These wasps lay a group of eggs on the egg or body of the paralyzed caterpillar, and wasp larvae hatch out and feed gregariously on the host. Moreover, lacewing (aphid lion, *Chrysopa* sp.), which is the immature or larval stage of the golden-eye or green lacewing, is another good aphid predator. The mottled green and brown spindle-shaped larva has a pair of long, curved mouth parts by which it pierces and removes the aphid’s body contents.

Dendrobacillin (based on *Bacillus thuringiensis* ssp. *dendrolimus*) and bitoxibacillin (based on *B. thuringiensis* ssp. *thuringiensis*) have been developed to control Lepidoptera. Boverin is a bio-insecticidal preparation of conidiospores of a strain of entomogenous fungi *Beauveria bassiana*, which is selected for its activity against larva of Coleoptera and Lepidoptera. Abamectin is a natural fermentation product of an actinomycete bacterium, *Streptomyces avermitilis*, found in soil. Abamectin, consisting of a complex of insecticidal/miticidal toxins, offers superior control for a broad range of leaf-eating mites and insects such as leaf miners and diamondback moth, as well as sucking pests like psylla and thrips.

Baculoviruses are pathogens that attack insects and other arthropods. The majority of baculoviruses used as bio-insecticides are in the genus Nucleopolyhedrovirus (NPV). They are safe and selective, and have been used against many insect pests, mainly Lepidoptera in cabbage and tomato. On the other hand, the high specificity of NPV is also cited as a weakness, since growers may want one product to use against a variety of pests. The NPV-based product, Virin-X, is currently produced on an industrial scale. Its mixture with *Bacillus thuringiensis* (Bt) is useful to overcome the very narrow spectrum of NPV activity. Other problems that have limited expansion of NPV use include slow killing speed, technical and economical difficulties for in vitro commercial production, timing of application based on frequent host population monitoring, variability of field efficacy due to climatic conditions, and farmers’ attitudes toward pest control, which have been based on application of fast-killing chemical insecticides. Strategies to coun-
teract some of the limitations of NPV have been investigated. These include the use of chemical or biological substances added to virus formulations.

Trichothecin has been developed as a biological bactericide to combat bacterial infection in the vascular system. BIOACT-WG is a recent development of bionematicide for controlling a broad spectrum of plant parasitic nematodes. It has been formulated with *Paecilomyces lilacinus* strain 251. Deep distribution of this bionematicide around the root zone provides a high protection for the plant without the risk of possible biopollution of the groundwaters after an application of BIOACT-WG. This bionematicide is likely to gain acceptance in the region.

The aforementioned biological control agents may constitute a cost effective, environmentally friendly and self-regulating alternative to large-scale pesticide applications. In recent years, several CAC countries such as Turkmenistan and Uzbekistan have taken efforts to revitalize the rearing efficiency for a large-scale production of parasitoids and other biological control agents. However, doubt remains as to the overall success rate of biological control and their possible effects on natural communities, and as to the capacity of CAC institutions to produce control agents.

**Chemical pesticides**

Biologically based pest control strategies may often be feasible only in the long term. In such cases, rationalization of existing patterns of pesticide use may be the first step toward making more sustainable pest management. The chemical pesticide use in IPM differs from the approach used in conventional pest control. When possible, IPM relies on chemical pesticides that target specific pests, can be applied at lower rates, and are less toxic to beneficial organisms. New application methods are being developed that employ biological materials such as pheromones and feeding attractants to lure the target pest to the pesticide. Application rates, timing, and frequency are chosen to minimize effects on beneficials. Pesticides that can be substituted for one another are interchanged to slow the development of pest resistance to pesticides. Important questions at this step are: What is the best chemical insecticide for the target pest? What is the optimal rate? Is it legal? What are the safety requirements and use restrictions?

**Monitoring and strategic controls**

IPM cannot be implemented effectively without accurate estimates of pest and natural enemy population densities, or without reliable assessments of crop damage and its effects on yield. The amount and frequency of monitoring required for decision-making depends upon the crop and its pests.

Monitoring is particularly important for the CAC region, considering its diverse pest problems. Besides assisting in proper selection of the aforementioned control measures, the information collected will facilitate in setting strategic controls in terms of planting location, timing of planting, and timing of harvest.
Conclusions

IPM is a knowledge intensive and interactive methodology that is concerned with crop management in its entirety beginning from soil preparation and fertilization, to seeding and planting techniques, and pest and weed treatment. Its success will depend on good communication and capacity building arrangements to ensure that the national IPM policies and programs are implemented effectively at regional and local levels.

At present, IPM capacity for small-scale vegetable farms owned by new farmers after land distribution ranges from advanced to minimal. The CAC governments have to strive to:

• Develop national IPM policies and programs.
• Address the absence of an efficient technology transfer mechanism for IPM.
• Rehabilitate biological control programs and capacities to rear parasitoids and predators for major pests on a cost-effective, commercial basis.
• Build capacity for basic, applied, adaptive research and technology transfer to farming communities.
• Train IPM supply chains from input providers/traders/applicators.
Post-harvest Processing of Vegetables in Central Asia and the Caucasus

Kurmanzhan Osmonalieva
Kyrgyz Agrarian University, 68 Mederov Str., Bishkek 720027, Kyrgyzstan

Introduction

The food processing industry has been one of the important means for the Central Asia and the Caucasus (CAC) region to make vegetables affordable and available when and where they are needed. Moreover, it has been one of the important income sources of many CAC republics. After the disruption of Soviet economic ties in 1991, however, most CAC republics lost not only the market but also the financing of the food processing industry. Many CAC republics now depend on imports of processed vegetable products.

Historical Perspective

The following describes the development of the food processing industry in the former Soviet Union:

Before 1930s. Canning of fruits and vegetables in various places of the Soviet Union with cottage-type facilities and limited outputs.

1930s. The Soviet government established canneries in Krasnodar Krai, Tiraspol, Kiev, Yerevan, Tashkent and other Soviet republics and cities. This was a first step of modernizing the food processing sector in CAC (Gorenkov et al. 1987, Donchenko and Nadykta 2002).

1941–1945. World War II markedly damaged the processing industry. Most canneries were evacuated to CAC, where a number of large-scale vegetable processing enterprises were established later.

Late 1940s. The government set up the agenda to rehabilitate the food processing industry, and increase and diversify outputs (Fan-Yung et al. 1956, Gorenkov et al. 1987, Kovalskaya et al. 1988).

1950–1965. The government earmarked resources for food-processing industries to upgrade their equipment and facilities. Up to 800 large-scale food-processing plants were put into operation. Some 2,000 existing food enterprises were reconstructed. Most of these newly constructed or renovated enterprises were for staple foods.

1965. The government resolved to increase food production, including processed products. However, the production of fruits and vegetables remained low.

1982. To resolve the looming food problem, the government moved forward the agro-industrial complex (AIC) program to integrate all the sub-sectors (including fruits and vegetables) of the agri-food sector (USSR Food Program 1984, Kovalskaya et al. 1988). AIC entailed integrated programs of contracts on scheduled production and procurement, and improved storage, transportation, and processing technologies to guarantee the sustainable production of foodstuffs, including canned fruits and vegetables. At that time, the government channeled about 230 billion rubles to AIC. AIC made it possible to bring the processing enterprises closer to where raw materials were produced, as well as to set up small- and medium-size processing facilities. The period witnessed a steady rise in the construction of storage and refrigerating facilities, streamlining of mechanized production of canned fruits and vegetables, and container shipping of both fresh and processed products of fruits and vegetables to remote places (Gorenkov et al. 1987, Kovalskaya et al. 1988).

1986. The government set the target to produce 16–18 billion cans of fruits and vegetables by 1990, which was accomplished on time (Donchenko and Nadykta 2002).

Late 1980s. By then, the Soviet Union was the second largest producer of canned foods in the world. It is in this period CAC republics had capitalized this favorable condition to serve as main suppliers of both fresh and canned fruits and vegetables to other republics in the Union (Gorenkov et al. 1987, Donchenko and Nadykta 2002). During this period, scientists achieved many fronts for upgrading AIC: 1) new fruit and vegetable varieties suitable for processing and long-term storage; 2) improved technologies for cultivation of newly developed varieties; 3) state quality standards; 4) efficient processing technologies; and 5) identification of health-promoting phytochemicals in fruits and vegetables (Gorenkov et al. 1987, Kovalskaya et al. 1988). The food processing industry became one of the most developed sectors of the Soviet Union.

Current Food Processing Industry in CAC

After the dissolution of the former Soviet Union, the CAC region set out on the path of creating market economies based on private property. The most important, basic elements of the economic reform process in each republic have been:

- The liberalization of prices and markets and the creation of a market-conforming incentive system in the rural sector.
- The privatization of land and transformation of the inherited farming structure.
- The de-monopolization and privatization of processing and trade of agricultural products.
- The creation of a rural financial system.
- The establishment of the institutional structure and system of state administration required by market economies.
The progress toward the economic reform for individual republics differs. However, a number of general facts can be observed on the food processing sector to date:

• Traditionally, the CAC was one of the largest suppliers of both fresh and processed fruits and vegetables for the former Soviet Union. Since 1990, production has dropped for many reasons, including the loss of previous markets after the collapse of the Soviet Union. This is further complicated by a lack of modern farm management. At present, vegetable volumes hardly meet the food processing sector’s demand for raw materials; less than 20% of overall vegetable products were processed.

• Since economic transformation is so complex, the entrepreneurial operation of private farms and privatized food processing plants has been difficult in most CAC republics. Most of food processing manufacturers could hardly get their bearings and identify priorities for food processing enterprises (Livinets 2002).

• The food processing industries in CAC are currently facing various challenges: outdated machinery and equipment, lack of effective management, shortage of working capital, lack of an effective and efficient marketing chain connecting farmers and processors, and the absence of international marketing agencies with permanent links to markets.

The above factors have reduced existing processing capacities to 20–40% operating within 7 months of the year. Many other existing processing factories stand idle. At present, the output of canned vegetables in CAC is only 10–20% of the pre-independence period. The assortment of canned vegetables, consisting of 300 different kinds that met state standards before independence, has been reduced to limited types with questionable qualities.

Specific Issues of Food Processing Industry in CAC

Tomato products, including concentrate for juice, prevail among the different types of processed vegetables produced in CAC. These products accounted for 45% of processed vegetables in 2003, followed by juices with a 25% share. Canned vegetables (e.g., cucumber, bush pumpkin and sweet pepper) had a 19% share. Dried vegetables, including traditional spices, onion, carrot, red beet and potato, accounted for 7%. Drying of tomato, sweet pepper, eggplant and mushrooms is increasing. The remaining 4% includes baby foods made of tomato, carrot, red beet and other vegetables, and snacks. In spite of the aforementioned information, the objective analysis of the vegetable processing industries in CAC encounters several specific issues:

• Inconsistence in the use of output units. Different units such as tons, conditional cans, currency and percent, are used by different CAC countries for the food processing industry. This makes objective socio-economic analysis of the industry from a regionwide perspective difficult.
• **Scarcity of reliable statistical data.** The CAC state statistics committees usually do not have reliable data on food processing enterprises, from small-scale to large-scale, especially related to their storage and processing capacities, quantity and quality of outputs, and volumes of marketing and exporting.

• **No centralized registration system.** There are no centralized systems in CAC countries to register type, production, procurement, marketing and trade of processed food products. At present, most information comes from the customs, which usually is not comprehensive (Wittig et al. 2002).

### Opportunities for Food Processing Industry in CAC

Diverse climatic conditions for agriculture in CAC allow the cultivation of many different products. The privatization of small-scale and medium-scale enterprises has been completed in some CAC countries. Nowadays these CAC governments have set up policies aimed at further diversifying the agri-food sector and supporting the sector’s export potential. Several have identified the food processing industry of fruits and vegetables as a top priority for development. Some of these governments strongly encourage foreign investments and are currently revising legislation to meet the needs.

There are several cold storage and food-processing facilities in CAC using old equipment inherited from the Soviet Union era. If properly rehabilitated and equipped, through joint ventures or loan acquisition, they could provide the basis for major food processing and export activities.

The traditional export markets for CAC’s processed fruits and vegetables are Russia and other former Soviet republics. In addition to these traditional markets, potential high value markets include the European Union, west China and Afghanistan. In this case, the provision of market infrastructure, from transportation to quality control and grading systems, will have a particularly pronounced impact.

The CAC region is the center of origin for many fruits and vegetables; these crops have the potential to become specialty export products from the region. Therefore, it is important to find ways and means to support family farming, including the support of small-scale food processing activities.

Most CAC farmers use very little or no chemical fertilizers, sub-optimal quantities of manure, and no pesticides. Under these conditions, if the process can be internationally certified as organic, it will draw huge exports and foreign currency to further upgrade technical facilities and machinery as well as to introduce Western farm management methods. Organic production in CAC presents a huge potential for investors.

Financial capital is still seriously limiting in the CAC region as a whole. Moreover, it would be unrealistic to think of all the CAC countries as being equally attractive to foreign investment. Nor can one think of the food processing sector as being homogeneous. Some products are more processed than others, and these are probably more
likely candidates for local investment. At the other extreme, the production of homogeneous raw materials in the CAC countries is unlikely to be a magnet for foreign funds, and will be dependent on local funding. Thus, the CAC countries (likely those with the most advanced economic transition) who will invest in the production of raw vegetable materials will likely attract foreign investment in the food processing sector. Equipped with foreign capital investments in technology and infrastructure of the food processing sector, these CAC countries could once again be the breadbasket to their neighboring countries, while also supplying their own domestic markets.

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Assessment of the Vegetable Seed System in Central Asia and the Caucasus

Vladimir I. Zuev
Tashkent State Agrarian University, University Street, Tashkent 700140, Uzbekistan

Introduction

Vegetables play an important role in the diet of people living in Central Asia and the Caucasus (CAC) (Litvinov 2002). However, its production is not meeting the recommended consumption level of 210 kg per capita per year for maintaining good health (Lanska 1989). Table 1 shows the trend of vegetable production and availability for the region in 1990 (just before the collapse of the former Soviet Union) through 2003. Only Armenia, Georgia and Kazakhstan have restored vegetable supply levels to the levels of 1990. Many factors have caused the other republics to struggle in producing an adequate supply of vegetables for their population; these include rapid population growth, detrimental climatic conditions, and extensive post-harvest losses due to poor storage and transportation infrastructure (Azimov 2003, Buriev et al. 2005).

Yields vary considerably among the CAC republics (FAOstat data, 2006). This is partially due to the inconsistent quality of seed used in open field vegetable cultivation throughout the region. In republics where farmers have access to higher quality seeds, yields have improved in the range of 20–25%. Another reason for the differences in yield among republics in the region is that farmers in some regions are using varieties bred for other regions/soils (Kononyhina 2004, Ludilov 2004, Sirota 2005). These facts

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<tr>
<td></td>
<td>Output (000 t)</td>
<td>Pop’n (million)</td>
<td>Per capita supply (kg)</td>
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<tr>
<td>Armenia</td>
<td>640</td>
<td>3.57</td>
<td>179</td>
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<tr>
<td>Azerbaijan</td>
<td>960</td>
<td>7.22</td>
<td>134</td>
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<tr>
<td>Georgia</td>
<td>720</td>
<td>5.45</td>
<td>132</td>
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<tr>
<td>Kazakhstan</td>
<td>1,520</td>
<td>16.30</td>
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<td>Kyrgyzstan</td>
<td>560</td>
<td>4.39</td>
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<td>Tajikistan</td>
<td>710</td>
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<td>541</td>
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<td>Uzbekistan</td>
<td>3675</td>
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Source: Statistic data of CAC republics
bring attention to the importance of using high quality seeds that are specifically developed for the CAC region.

**Vegetable Seed Supply and Demand**

Statistics related to the estimation of seed supply sources in the CAC region are not readily available. Efforts should be made to obtain more accurate estimation of regional supply and demand of vegetable seed. Therefore, this author has had to rely on relevant information from Uzbekistan as an example. It is estimated that 236,500 ha of arable land of Uzbekistan will be under vegetable crops in 2006. To meet this expanse area of vegetable cultivation, 1,420 t of vegetable seed will be required. And the Uzbek Ministry of Agriculture and Water Management estimates that the public seed sector can supply only on about one-third of this amount. For the rest, vegetable growers have to produce their own seed or purchase seed from informal, non-certified systems.

An inadequate supply of certified seed from the public sector has also resulted in an increase of imports of hybrid and other high quality seeds to the CAC region. In most CAC republics, about 100% of seeds required for protected vegetable cultivation are imported. However, much of the imported seeds are not well adapted to the local environment. This leads to crop failures, which in turn, causes farmers to lose confidence in traders. It is now clear that seed production requires the long-term involvement of experienced scientists along with suitable funds.

**Vegetable Seed Supply System**

Before their independence, all CAC republics followed the Soviet Union’s unified vegetable seed supply system. The entire system was under state control, through the respective ministry of agriculture, and had two levels of activities. The first level included 1) breeding of varieties at research institutes, academies of sciences, universities, and experimental stations; 2) evaluations of breeders’ basic or stock seeds at the state seed farms in accordance with the established procedures; and 3) registration and release after the state inspection for quality. The second level was under the auspice of “Soyuzsemovosh,” the ministry’s outlet for the supply of certified seeds. Soyuzsemovosh was responsible for 1) seed multiplication at the state farms; 2) storage of seeds in the designated centers; and 3) seed distribution through “Sorsemovosh,” the state seed associations.

After their independence, most of the CAC republics still follow the principle of centrally planned management for the seed system. In reality, however, because of the breakdown of the old economic order, the outcome now is different from the past. Due to the lack of financial resources, the CAC agricultural research institutes, in collaboration with state commissions for variety testing, carry out breeding activities only on a modest scale. At present, it is difficult to assess to what extent the varieties released after the independence are reaching the farmers. Furthermore, some of the former state seed
associations (Sortsemovosh) have been privatized. With the disappearance of the former collective system, however, the latter-day Sortsemovosh have limited access to certified seeds from state entities and must rely on their own resources, ability and initiative to cope with day-to-day managerial problems and competitive markets.

Currently vegetable seed in CAC is being produced on land belonging to research institutes or experimental farms, on state farms, and on some of the private farms that are emerging from the ongoing privatization process. Normally the access to produce elite seed is granted to farms, public and private, which meet particular requirements in respect of technical know-how, management standards, equipment and financial resources. In some republics, the seed farms receive special support, being either exempted from certain taxes (Tajikistan) or benefiting from subsidies to seed production (Kazakhstan). Unfortunately, however, most of the others have no support or credit and insurance base. In Kyrgyzstan, most of the seed production is done on private farms. In Tajikistan, the state has retained its control over seed production of all the different generations of seed. In Kazakhstan, there are many public and private seed farms. In Uzbekistan, both Uzbek Research Institute of Vegetable, Melon Crops and Potato (UzRIVMCP) and Uzbek Research Institute of Plant Industry (UzRIPI) are producing and selling both elite and certified seeds. In 2004, UzRIVMCP and its experimental stations have sold 367 kg elite seeds of 10 kinds of vegetable, 182 kg of them to Doni private seed firm, which was established in 1994 as part of Sortsemovosh, as well as 6,127 kg of certified seeds to the other farms. Despite the aforementioned, many seed production activities, such as hybrid tomato and cucumber for both open ground and protective facility, have to be terminated due to the lack of funds.

The success of a seed supply program depends on the coordination and complementation of different sub-sectors responsible for basic seed, elite seed, and certified seed (Pivovarov et al. 2003, Ludilov 2004). Currently, there is an undesirable trend in the CAC region that research institutes are not only pursing their own variety development but also seed supply program, and different sub-sectors of the overall vegetable seed system are losing communication. For example, there is no official agreement for the supply of elite vegetable seed in Uzbekistan among UzRIVMCP, UzRIPI, and Uzmevasabzavoturugsanoat (Uzbek Fruit and Vegetable Industry Association). Furthermore, there are also cases where local seed farms are producing non-registered or not-yet-released varieties from within or outside the republics.

Because of the absence of coordination and resources among the different sub-sectors of the vegetable seed system, the amount and quality of vegetable seed produced in the CAC region have declined considerably in recent years. This has led to a virtual standstill in exports of vegetable seeds for the previously exporting republics. Moreover, although there are certified seeds available in the market, a good number of farmers still cannot purchase them due to the absence of credit. Hence, they are forced to utilize and multiply their own seed from now depleted and weak stocks obtained from the past, or exchange seed with other farmers.
Seed Certification and Variety Protection

After their independence, most CAC republics have gradually adopted a number of variety and seed legislations, e.g., to protect selection achievements, to promote and protect the seed production sector, and to ensure distinctness, uniformity, stability and value of the seed in cultivation. They also established a number of state agencies such as the state commissions for variety testing of agricultural crops and state registers of varieties of plants to implement the seed legislations and issue seed certifications, which is compulsory for all or many crops. After testing at the regional level (which may take up to 3 years) in various variety-testing stations, the results of testing are submitted for the consideration and approval of the state commission, which consists of expert groups. If the commission approves the variety, it is included in the state register. However, due to scarcity of funds, these procedures are currently giving place to empirically oriented practices in many CAC republics.

In the past decade, the CAC state registers of varieties of plants have experienced an increasing number of local varieties and foreign hybrids registered under their auspices. For example, Uzbekistan has 193 vegetable varieties (including open-pollinated and hybrids) and 58 varieties of melon crops registered in 2005. Unfortunately, most of vegetable hybrids under state registration are of foreign origin and are produced from outside the CAC region. Furthermore, many foreign-based vegetable seed companies (e.g., from the Netherlands, United States and Israel) are importing and selling vegetable seeds of both hybrids and open-pollinated varieties to the CAC republics without proper state registration.

Concurrently, private breeding activities have started in the form of joint ventures between foreign seed companies and CAC partners. However, the high cost of seed produced (often foreign varieties and hybrids) and their insufficient growth adaptability under local conditions, have resulted in the emergence of informal breeding activities among farmers. Considerable quantities of seed of local varieties of valuable genetic resources are thus exchanged between farmers. One of the drawbacks of the seed legislation in some CAC republics is permission for individual persons to get involved in seed production. It is difficult to believe that they are able to produce seeds of the same quality as specialized seed production companies, which have trained human resources and proper equipment. Unstructured seed production and marketing will have a negative impact on the seed quality of vegetable crops (Prohorov and Kryuchkov 1991).

Regional and International Cooperation

Before independence, the collection, maintenance and processing of genebank reserves and the breeding of new varieties were the exclusive responsibility of the Soviet State. Under this system, specific research networks were set up for the breeding of almost all crop species. Following independence, conditions changed radically. Each republic in the CAC region is now, at least in principle, pursuing its own comprehensive variety development and seed supply programs, despite a steep drop in state funding available. This
appears to some extent to be a waste of resources that are already scarce. It also results
in a situation where comparative advantages are not exploited. CAC researchers were
unable to take advantage either of the development trends offered by information tech-
nology or molecular biology for germplasm or breeding research. Not only is it difficult
for the principle of selectivity or compatibility/sterility to prevail in breeding, but the state-
funded breeding of the economically important crops has become anachronistic through-
out the region due to the increasing difficulty to access inbred homozygous lines, as well
as the spread of hybrid varieties developed by multi-national companies. Although some
CAC republics still maintain strong links with the All-Russia Research Institute of Breeding
and Seed-Growing of Vegetable Crops and other related institutions, an extended
network of international cooperation has yet to be achieved.

There are substantial differences both between the various republics in the CAC
region and within the republics themselves as regards the state of development of the
vegetable seed sector. This must not be a barrier to regional cooperation, but should
rather be a source of motivation. The primary objective of this international cooperation
would be 1) improving seed supplies to farmers; 2) enhancing farm production; and 3)
achieving market-oriented seed security in the interests of food security. One of the
important areas of international cooperation would be capacity building. This would include
training and information sharing on seed production and quality control technologies,
testing and certification procedures, marketing, entrepreneurship, as well as joint research
and development. With a further improvement in international cooperation, the state’s
function and responsibilities will gradually change compared to earlier periods.

Revising seed regulations has been and continues to be part of the process of ongoing
changes in seed industries across the CAC region. Unfortunately, many of the changes
in seed regulations, as well as in seed production and trade, have been toward separate
national interests and markets. Governments can foster a return to regional and
international cooperation for their seed industries by 1) harmonizing seed regulations to
the highest international standards; and 2) further harmonizing regulatory details and
decisions according to regional agreements and practices. Harmonization to international
standards is the bottom line to promote a modern seed industry. Many regulatory features
are crucial for the development of a market-oriented seed industry, including, for example,
allowing new seed companies to easily enter the markets, allowing seed companies to
contract with farmers of their choice, allowing seed companies to introduce new varieties,
and giving seed companies responsibility and authority to ensure seed quality. In many
republics in the region, local seed companies have a hard time doing their work because
government certifications are required at so many steps. In such cases, harmonization to
international standards means an overall shift from ex ante controls on seed company
business decisions and production processes, to ex post controls on truth-in-labeling at
the retail level.

Azerbaijan, Kyrgyzstan, Uzbekistan have joined the International Union for the
Protection of New Varieties of Plants (UPOV) to align their seed laws with international
standards and to encourage their breeders to develop new varieties on the basis of
clearly defined principles and intellectual property rights. By putting national seed policies on a par with the international standards, these republics can achieve considerable progress toward sustainable seed supplies and toward establishing the conditions required for seed security and exportation. Thus, other republics in the region may also like to follow the suit. This type of cooperation should also extend to the International Seed Testing Association (ISTA), Asia & Pacific Seed Association (APSA), International Seed Federation (ISF), Organization for Economic Co-operation and Development (OECD), and international agricultural research centers such as AVRDC. More efforts have to be placed in this direction in the near future.

Future Priorities

The challenges discussed above define the future direction for the development of the vegetable seed system in the CAC region. Major issues that need to be addressed include:

- Establish a database including a list of varieties of the most important vegetable species registered in individual republics, and a list of regional seed organizations, genebank collections, breeding programs, institutes, companies and farm communities.
- Collect information on seed requirements and marketing for specific varieties.
- Rehabilitate the integrated seed production system and streamline its operations. The system includes research and development, site selection, and production of various seed types (breeders’ seed, elite seed and certified seed) with appropriate machinery, production and storage technologies, and quality control.
- Revise the laws on selection achievements and seed production to be more non-discriminative and transparent.
- Enforce seed laws and prevent the importation of varieties that are not registered under the state authority.
- Establish state insurance funds for the production of elite seed of selected vegetables and varieties.
- Render state support for the production of local varieties and hybrids through prices regulations, provision of tax holidays, and compensation.
- Establish seed associations or councils to assist the governments in establishing and implementing seed legislations.
- Harmonize regional seed legislations and strengthen international cooperation.
- Mobilize state funds and international supports for vegetable research and development including the seed sector.
Major topics that require research include:

- Identify the most favorable agro-environments for vegetable seed production of both major crops, e.g., tomato, cucumber, melons and onion, as well as minor ones, e.g., cauliflower and radish.
- Collect marketing information related to vegetable seed demand, exports and supplies.
- Improve production of breeders’ seed, elite seed and certified seed, and develop improved harvesting and post-harvest technologies, including basic research on seed pathogens.
- Create inbred lines for heterosis breeding and hybrid seed production.
- Identify and conserve materials that possess desirable traits such as disease resistance.
- Diversify cropping systems with an assortment of non-traditional vegetables.
- Improve seedling and transplant production for major vegetable crops.

Below are the specific research topics that need immediate attention:

- Inbred lines of high yielding and good quality for tomato (with virus resistance) and cucumber (with powdery mildew resistance) that are adapted to the hot-dry climate.
- Inbred lines of high yielding and good tasting melons that are resistant to Fusarium wilt and powdery mildew and adapted to CAC environmental conditions.
- Introduction of cultivation and seed production technologies of non-traditional vegetable crops.

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Opportunities for Developing the Seed Sector of the Market-oriented Vegetable System in Central Asia and the Caucasus

Dae-Geun Oh
Horticulture Biotechnology Division, National Horticultural Research Institute, Republic of Korea

Introduction

Seed is the primary and essential starting point of vegetable production programs. This concept holds true for any scale of production whether it be a large-scale commercial production for supermarkets and processing, or small-scale market gardening for local retailers. The quantity and quality of seed available will have a direct effect on availability of vegetables to the consumers or processors. Quality seed, in terms of improved varieties, purity and seed health, is the key factor to increase the yield of vegetable production; it could account for up to 50% of yield increase. The range of vegetable types and availability of each of them over certain seasons will be affected by the seed supply system, which should provide an adequate amount of quality seeds of various types to the farmers at the right time. The sound seed supply system shall lead to the following specific benefits to vegetable production programs:

- Provide quality seeds to ensure stand uniformity and vigorous growth, which consequently facilitate efficient use of other inputs.
- Supply quality seeds to reduce seed amount required for sowing.
- Impart quality seeds in reducing seed-borne diseases and insect pests in seedbed and field.
- Periodically replace old varieties with new, improved varieties.
- Introduce new crops to regions.
- Generate foreign exchange through trade or reduced seed importation.
- Help rehabilitation from natural disasters such as floods, drought, tsunami, and plant disease epidemics.

Planning the Vegetable Seed Program

A seed program should be an integral part of the national strategy for agricultural development. Its role, basic objectives and relationship to other elements in the scheme should be defined and established at the time the national plan is elaborated. The vegetable seed program could be established on the basis of existing seed programs for other major crop
production. However, an assessment of the vegetable seed situation in a specific country is essential before a recommendation for the establishment of vegetable seed sector can be made. It is therefore important to obtain information on the current vegetable production, different facets of the seed industry and supply, potential benefits of superior varieties, technical basis for development, availability of resources, and the socio-economic environment. The assessment should also study the status of related programs (materials to accelerate uniform seedling production, fertilizers, irrigation, pesticides, credit, etc.), types of agribusinesses and their areas of specialization (leafy vegetables, fruit vegetables, large-scale commercial production, small-scale market gardening, etc.), level of understanding of farmers on the improved seed, and capacity of the public sector.

Experiences in the seed industry development in both developed and developing countries indicate that the private sector’s participation is highly desirable during the initial stage and essential for long-term success. Successful vegetable seed programs in USA, some European countries, Japan and Korea have strong private sector components. In China and elsewhere, on the other hand, governmental agencies undertake the major portion of vegetable seed program because of the national policy. Even in such situations, however, it may be desirable that seed production and seed distribution will gradually be taken over by nongovernmental agencies, such as seed cooperatives, seed growers’ associations and private companies. Participation of the private sector in vegetable seed production and marketing should not only be provided for, but actively encouraged through incentives: special tax reductions, lease and purchase arrangements for facilities and equipment, low rental land, technical assistance, relaxation of restrictions on landholdings, accessibility to parental lines of publicly developed varieties, etc. Cooperative attitudes and mutual trust of both public and private sectors are imperative for the development of a vegetable seed industry. The role of public and private sectors in the development of vegetable seed industries could be differentiated as follows:

**Public sector**

- Leadership in program planning and development.
- Research: development of superior varieties, improvement of cultural practices and cropping patterns, determination of optimum inputs for production.
- Extension: demonstration of improved practices and materials including improved seed.
- Maintenance of germplasm and breeders’ seed stocks developed by public institutions.
- Economic assistance.
- Services: certification, seed testing, marketing information and seed statistics.
- Regulation: control of seed distribution and marketing through legislation, regulations and inspection procedures.
Private sector

- Production, distribution, and marketing of commercial seed of publicly developed varieties and hybrids.
- Development and promotion of private varieties and hybrids.

Participation of foreign seed companies may help the overall vegetable seed program. Foreign seed companies and transnational seed corporations have been involved in the Korean vegetable seed program since 1998. In the beginning, there were hostilities among farmers, policymakers, and seed businessmen, but it turned out that worries over monopolistic domination of a few mega-companies followed by large increases of seed prices were unfounded. On the contrary, the involvement of foreign seed business helped to introduce the most advanced technologies in seed treatment, marketing, and breeding. From the experience in Korea, the following conditions may be attractive for the participation of foreign seed companies in a specific country:

- Consistency in the government’s attitude toward foreign investments and no threat of nationalization.
- Competent, experienced indigenous managers, technicians and workers to carry out seed business.
- Effective extension system to assist in the promotion of improved seeds.
- No hostility of lower echelon officials to foreign investment in agricultural supply enterprises.
- Equal treatment in implementation of seed laws and regulations, and providing same level of services like seed certification and phytosanitary as the national companies.

Components of Vegetable Seed Program

Components of the vegetable seed program are the same as other seed programs. Components of the seed program, as shown in Figure 1, are linked like a chain and each link must work properly so that all components work in unison. The essential ingredients for a seed program to become a successful one are as follows:

- Strong varietal improvement research.
- Flexible and practical extension-education service: changes in agricultural practices brought by the improved seed system are expected and need to be further developed.
- Increasing capabilities of supply of other essential inputs: as the supply of improved seed is ensured, the adoption of new varieties depends on the supply of other materials and inputs.
Both public institutions and private firms usually engage in varietal improvement. At the earlier stage of a vegetable seed program, the contribution of public institutions is often greater than the private firms due to its greater capacity of introducing foreign varieties and genetic resources. Also the public institutions can outperform private firms in breeding vegetables with characteristics that are difficult to introduce, such as multiple disease resistance. The role of public institutions in management of plant genetic resources and/or breeding vegetable crops of low priority for private firms is needed to be continued even after the private sector become stronger in varietal improvement. The role of public institutes as technology clearinghouses needs to be continued to provide technical help to
the breeders at private seed companies. Close cooperation between national institutes and private companies is never over-emphasized.

The technology and procedures for breeding vegetables are essentially the same as for other crops, but vegetable breeding programs should consider more carefully on the consumption pattern of consumers and on processing technology. It is important that breeders analyze the requirements of the consumer and test new lines at the crop’s market outlet. The turnover rate of varieties is much faster in vegetable than cereal crops.

Variatel improvement could be started with the most popular vegetables in the country, and selection among local varieties could be a good start. Hybrid breeding is the goal of the private sector, and several features of reproductive physiology and genetics in vegetables, such as vernalization, male sterility, and self-incompatibility, need to be incorporated in the breeding program. Varieties to be released for seed multiplication must be decided after a series of trials including on-farm trials under a wide range of environmental conditions.

*Seed multiplication and production*

A number of climatic and agronomic factors ensure successful vegetable seed multiplication and production. Among others, listed below are a few important ones:

*Site.* A wide range of climatic, technological and economic factors superimposed to dictate the potential success of a particular site. The seed production land should not be the site that was planted to another variety of the same or similar crop the preceding season. Biennial crops need to be planted in the area with sufficient cold weather during winter, but mild enough to save seed plants from freezing damage. A place with a good water source and dry weather during seed filling and harvesting is needed for a good seed yield.

*Isolation.* One major factor during the course of seed production is to ensure that the possibility of cross-pollination between different cross-compatible plots or fields is minimized. This is achieved either by ensuring that crops which are likely to cross-pollinate are not flowering at the same time (i.e., isolation by time) or that they are isolated by distance. The isolation distance is determined by the mode of pollination of the species and the environmental conditions.

*Roguing.* During the course of variety maintenance or multiplication to increase the quantity of available seed, it is necessary to ensure that the product will be “true to type.” Toward this end, the crop is inspected at stages to ensure that any undesirable material (i.e., off-types, diseased, mixed crops, etc.) is removed as early as possible.

*Contracted production.* The breeder and foundation seeds are produced under strict supervision of the breeders in the breeding stations. Commercial seed production, however, are done under contract by private growers. Seed grown under contract should be limited to large progressive farmers with sufficient land for the required isolations and
equipment to do a good job. A legal contract between the seed producer and the farmer should spell out all the details of operation and the crops should be subject to rigid inspection and control.

**Harvesting and processing**

The harvesting stage usually determines seed quality. Thus, it is generally accepted that the seeds should be allowed to develop fully in the fruit or seed moisture content reach below 25% before extraction. Early harvesting can avoid adverse conditions such as bad weather, molds, insects, birds and rodents. In either case, precautions are taken to prevent damage to the seed, and mechanical mixture with seed of other varieties or crops. After harvesting, all the processing operations such as winnowing, cleaning, separation, drying, grading and packaging must be performed in a careful and timely manner.

**Seed storage**

When seed extraction and drying have been completed, it is necessary to keep the seed under the best possible conditions to ensure that the maximum seed quality factors are maintained. Stored seeds are the primary input of a country’s vegetable production program. In practice it is the combined effect of temperature and relative humidity (RH) which reduces potential viability or longevity of seed throughout its storage life. The reduction of seed viability is usually slow at low RH and temperatures. Copeland and McDonald (2001), on the other hand, pointed out that although temperature and RH interact to determine seed longevity, the control of RH and its subsequent effect on seed moisture content is more critical than storage temperature in achieving optimum storage conditions.

**Seed Legislation and Regulation**

Farmers in the most developing countries generally save their own seed for the following year or exchange seed with their neighbors. This system of agriculture involves almost no seed trade and has little need for seed control legislation. The seed laws, should they need, are usually truth-in-labeling laws, requiring that seed be labeled as to quality, and that such labels truthfully represent the actual seed quality of the seed packages. For such law to be effective, seed testing laboratories must be available, and farmers and dealers are encouraged to use these services.

However, as improved varieties become available, trade in seed naturally follows, leading to the necessity for seed control legislation that harmonizes with world standards, which would be the foundation for a modern seed industry. There are two crucial components to be included in the regulatory system: plant variety protection system and phytosanitary controls. Either component may not be used as a control measure to protect the domestic market.
The International Union for the Protection of New Varieties of Plants (UPOV) provides sample legislation that promotes an effective legal system of plant variety protection with the aim of encouraging the development of new varieties of vegetables. As of September 2005, UPOV (www.upov.int) had 60 member state organizations; among them were Azerbaijan, Kyrgyzstan and Uzbekistan. Plant breeders’ rights or plant variety protection (PVP) has been considered as one of the trade-related aspects of intellectual property rights (TRIPs). If a plant variety protection system is following UPOV’s 1991 revised convention, the breeder of a variety with novelty, distinctness, uniformity and stability, of both sexually and asexually propagated plants, will be able to enjoy exclusive rights to the propagating material of the protected variety. The breeders’ rights enable the breeder to request the prior authorization necessary for the production for purposes of commercial marketing, the offering for sale, and the marketing of propagating material of the protected variety. The duration of protection will be 20 years for most crops, and 25 years for woody plants. In order to conform to international standards guaranteeing intellectual property rights over new varieties of seed, the Korean government established the Seed Industry Law as a sui generis TRIPS system in 1997. Enactment of this law ensured foreign seed companies that they had intellectual property protection for new varieties of seeds that they might produce in Korea. Up to 2004, there were 83 applications approved under the Seed Industry Law.

Seed certification is required in most cases to trade or exchange seeds beyond borders. For this purpose, the International Seed Testing Association (ISTA) is committed to developing, adopting and publishing standard procedures for sampling and testing seeds, and promoting uniform application of these procedures for evaluation of seeds moving in international trade. ISTA (www.seedtest.org) has developed criteria for the purpose to sort out ‘good’ quality seeds.

Regional and International Cooperation

For countries with weak seed industries, it is very difficult to decide whether to open their seed markets to transnational seed corporations. In the long run, however, the competitive environment created by harmonization would nurture native companies to become strong seed companies. To start, cooperation with neighboring countries will bring opportunities to cut costs for required testing and to improve efficiency for the implementation of a PVP system. For popular crops such as cabbage and tomato, there are guidelines compiled by UPOV for the test. To protect local farmers from growing varieties with inferior performance, some countries have developed a national list of varieties that ensure a certain yield level. Unlike cereal crops, however, many countries do not adopt such system for vegetables crops, probably because it may be more difficult to develop criteria to identify superior performance.

The CAC region eventually will opt for market-oriented economics. Therefore, harmonious relationships within the region would be mutually advantageous if the new national seed policies are all based on the same principles, including privatization of the seed sector, laws ensuring the operation of the seed sector and guaranteeing the protection of
intellectual property rights, and internationally compatible quarantine and seed testing systems.

**Literature Cited**

APSA and the Seed Industry in Asia

Jagveer Sindhu
Director, Secretariat of the Asia and Pacific Seed Association, 726, IFRPD Bldg., Kasetsart University Campus, Bangkok 10903, Thailand

Introduction

The Asia & Pacific Seed Association (APSA) is world’s largest regional seed forum with 350 members from over 40 countries. APSA was established in 1994 out of the Food and Agricultural Organization of the United Nations (FAO). The FAO continues to be represented on the APSA Board in an ex-officio capacity and APSA works in close collaboration with other seed related international agencies such as the International Seed Federation (ISF), International Seed Testing Association (ISTA), Consultative Group on International Agricultural Research (CGIAR), Global Forum on Agricultural Research (GFAR), Organisation for Economic Co-operation and Development (OECD), AVRDC – The World Vegetable Center, and others.

Establishment of APSA

In June 1992, an FAO consultation group consisting of 42 scientists and seed industry professionals from 16 countries unanimously resolved to establish a seed association that could promote growth of the seed industry in the region. FAO supported this cause and APSA was thus established formally in September 1994 to serve the following:

- Provide a forum for discussing seed policy issues.
- Encourage public/private sectors interaction by ensuring appropriate representation of the governments.
- Improve collection, compilation and sharing of information on seed production and handling.
- Develop and compile seed market information in the region.
- Arrange trainings on seed quality and other aspects.

In the initial stage of APSA the funding was provided by FAO and for a limited period thereafter by the Danish International Development Agency (DANIDA). Subsequently, APSA grew and flourished at its own. During the past decade, APSA emerged as a vibrant organization meeting aspirations of its members and contributing significantly according to its well-defined objectives.
Objectives and Functions of APSA

There are the following four important objectives of APSA:

- To establish a regional forum for exchange of experience and formulation of positions and recommendations on seed policy issues.
- To stimulate technical and economic co-operation among seed enterprises in the region.
- To arrange systematic interchange of information and experience on various aspects of research and development (R&D), production, conditioning, quality assurance and marketing of seeds.
- To maintain appropriate relationships with FAO, ISF, ISTA and other seed related organizations at international or regional levels.

Membership

The membership is open to the following categories of organizations in the Asia and Pacific region:

1. Seed associations of national or regional levels.
2. Government seed agencies, including regulatory authorities in the ministries of agriculture, national agricultural research systems (NARS), CGIAR centers, and other public support within the framework of the government’s agricultural policy.
3. Public and private seed enterprises producing and distributing seed.
4. Other eligible members include the following:
   - Associate members: institutions and enterprises from outside Asia and Pacific region that are involved in seed or seed related activities.
   - Patron members: bodies or persons deemed eligible by the Executive Committee.
   - Candidate members: small enterprises, non-governmental organizations from developing countries.

APSA membership has grown from 29 members in 1994 to 378 today. This membership is from most of the countries in the Asia and Pacific region and also from outside the region such as Canada, Chile, Denmark, France, Germany, Greece, Holland, Kenya, South Africa, Spain, Switzerland, United Kingdom, and USA. APSA is keen to developing membership in Central Asia and Middle East countries so they could be brought in to the mainstream of seed industry development.
APSA and Vegetable Seed Industry

In the recent years, APSA has been recognized as the best forum to discuss and trade vegetable seeds. Seed persons prefer the Asian Seed Congress over the ISF Congress or any other conference for addressing issues in the vegetable seed sector. An important reason for this is a very close interaction between APSA and AVRDC – The World Vegetable Center. The presence of APSA in this AVRDC conference on vegetable development in Central Asia and the Caucasus suggests APSA’s keenness to assist this activity in this region.

There are more than 145 APSA members involved in vegetable seed R&D, production and marketing throughout the world. By joining APSA, they receive an opportunity to promote their business through close interaction with these members. Furthermore, APSA provides information and training to member staff at frequent intervals. More information on APSA and the Asian Seed Congress is available on our web site (www.apsaseed.com).

Priority Setting for APSA

Important priorities before APSA include the following:

• Harmonization of phytosanitary regulations in Asia.
• ISTA seed testing trainings.
• Intellectual property rights (IPR) and other seed regulations.
• CGIAR and NARS/seed industry interactions.
• Promoting ethics in seed business.

Information on various programs in progress to meet these priorities is also published in our journal, “Asian Seed and Planting Material” which has a readership in more than 100 countries around the world. This is supplied free of cost to APSA members.

Major Activities of APSA

• Organizing regional seminars/conferences to provide a forum for the seed industry to address priorities, problems and policy issues.
• Developing and disseminating technical and seed marketing reports to its members.
• Trainings on new technologies, IPR issues, seed quality control and other related issues.
• Arranging visits and study tours to the seed industry in various countries.
• Organizing the Asian Seed Congress, which provides a forum for discussion, exhibition, and seed trading with the global seed community.

**APSA Publications**

• Asian Seed and Planting Material, a bimonthly publication, is already a very popular magazine with over 2500 readership in more than 100 countries. This is free to APSA members.

• Seed industry reports of various countries, including Australia, Bangladesh, China, India, Indonesia, Philippines, Sri Lanka, Thailand, Vietnam, and several other countries are available and can be made available to members.

• Technological reports on genetically modified (GM) seeds, organic seeds, IPR, plant variety protection (PVP), hybrid rice, biosafety, and other related issues are available.

• Reports on seed imports/exports in different countries of the region are available and can be made available to the members.

The APSA Secretariat is located in Bangkok, Thailand. APSA welcomes interested organizations to become members of this important association. Members can apply online through the APSA web site.
Reciprocal Exchange and Testing of Vegetable Varieties in Uzbekistan and the USA

T. Orton¹, D. Zaurov¹, E. Remmers¹, P. Ballister-Howells², K. Buriev³, V. Zuev³, R. Mavlyanova⁴, and R. Hakimov⁵
¹Department of Plant Biology and Pathology, Cook College, Rutgers University, New Brunswick, NJ, USA; ²New Jersey Farm Bureau, Trenton, NJ, USA; ³Tashkent State Agrarian University; ⁴Uzbek Scientific Research Institute of Plant Industry; ⁵Scientific Research Institute of Vegetables, Melons, and Potatoes, Tashkent, Uzbekistan

Introduction

Central Asia was isolated from the western world from the early 1800s until 1991, when the former Soviet Union was dissolved. During this time, many research institutions in the region worked on important crop species and amassed large and unique sets of germplasm. Since 1991, Central Asian scientists have begun to establish ties with peers in Europe, North and South America, Japan, and Korea. Exchange visits have led to the development of collaborative projects, including the trading and evaluation of germplasm. This contribution describes the outcomes to date of one set of such collaborations, involving Tashkent State Agrarian University (TSAU), the Uzbek Scientific Research Institute of Plant Industry, and the Uzbek Institute of Vegetables, Melons, and Potatoes in Uzbekistan, with Rutgers University in the USA.

Dr. David Zaurov, a former faculty member of TSAU, was instrumental in establishing the initial contacts and facilitation of exchanges. Starting in 1997, scientists from Rutgers began to visit Uzbekistan, followed by delegations of Uzbek researchers to the USA. During these exchange visits, agreements were forged for the reciprocal exchange of seeds and asexual propagules of crop species. Then, in 2001, a grant proposal was funded by US Department of Agriculture/Foreign Agricultural Service (USDA/FAS) for the evaluation of North American vegetable varieties in Uzbekistan. Additional funds were obtained from New Jersey Farm Bureau and from USDA in 2001 and 2002 to support variety trials of Uzbek germplasm in the USA as well.

The partner institutions evaluated exchanged varieties for performance. In addition to evaluations of Uzbek varieties for performance in the USA, considerable efforts were invested into a determination of profit potential of the unique products in actual markets. In these studies, the varieties were grown by commercial vegetable farmers in southern New Jersey (NJ) and packaged and sold in retail food markets in New York City (NYC). Wholesale prices were negotiated with proprietors in a similar fashion as for specialty produce items at local terminal markets (e.g., Hunts Point, Philadelphia).

The following is a summary of results obtained to date pertaining to the field performance of Uzbek varieties in the USA and of USA varieties in Uzbekistan, as well as of market performance of selected Uzbek products in the USA.
Materials and Methods

Seeds bound from Uzbekistan to the USA were generally provided directly by partner institutions to Dr. Zaurov and carried physically through the USDA/Animal and Plant Health Inspection Service (APHIS) entry checkpoint accompanied by the appropriate permits and phytosanitary certificates. Germplasm going the other direction was either hand carried, also with the necessary paperwork, or sent via courier. Seeds were given to individual scientists who maintained them in storage systems that featured cool temperatures (~10°C) and low relative humidity (~30% RH).

Greenhouse trials. A greenhouse study was conducted in 2001 to compare the fruit characteristics of Uzbek and North American melon varieties. Seeds were sown in a 50:50 peat:sand mix in 4 liter plastic pots and irrigated and fertigated regularly using a drip system. Plants were trained onto wooden trellises, and female flowers were pollinated using pistillate flowers from the same variety. Developing fruits were secured in plastic mesh bags fastened onto the trellising.

Field trials. Vegetable crops were grown in the USA during the 1999–2004 seasons using production techniques typical of commerce. Transplants were produced for all. Field testing and production was conducted on raised soil beds at various spacings appropriate to the crop species as they are produced in the Mid-Atlantic USA region. Beds were covered with plastic mulch, and drip irrigation tape (emitters 18 cm in length) was buried at a depth of approximately 12 cm. Irrigation was provided to replace soil moisture lost to evaporation, uptake, and transpiration. Tomato vines were trained onto 2 m stakes by weaving strings down individual rows. Nutrients were provided in aqueous form through the drip tape (fertigation) according to the needs of individual crops and fields. All fields were protected from weeds, pests, and pathogens with cultivation and chemical protectants.

Production methods in Uzbekistan were consistent with those typically used on research farms, and emulated conditions in local production fields. The experimental design varied with location and crop species, but generally featured a randomized complete block with 3–4 replications. Plots were harvested and key parameters measured. The data were then subjected to statistical analyses to identify significant mean contrasts.

A large scale market test was conducted in 2002. Specific methods employed for this experiment were as follows:

Varieties. One early type (‘Buri kally’), one mid-season type (‘Lazzatli’), and one late-season/storage type (‘Khorezimskay’) of melon varieties were chosen. The tomato variety ‘Bodohir’ and pepper variety ‘Dar Tashkenta’ were selected based on the results of previous experiments to determine agronomic and market potentials.

Transplants. A commercial transplant producer in NJ, Cube-Pak of Allentown, was chosen. Transplants were grown according to standard practices, seeds sown on three separate dates, 3 April, 16 April, and 1 May 2002. A growth retardant was inadvertently applied to the tomato transplants to decrease internode length, and this was determined to have a deleterious effect on the variety ‘Bodohir’, resulting in excessive lateness.
Production fields. Six commercial vegetable growers in southern NJ were selected to participate in the study. Growers had a variable schedule, each with a different spectrum of crops and planting dates. Fields were located within a 20-km radius of Vineland, and consisted mainly of sandy loam soils. Production methods were similar or identical to those used in experimental trials described above.

Harvesting. Pepper fruits were harvested into 500-kg fiberglass bins, then washed, sorted and repacked into 10-kg cardboard boxes in a packing facility (covered, conveyor belt). The harvest took place over a prolonged period, from 30 July to 28 October 2002 and up to 13 weeks in a given planting block, and plants continued to set fruit under late season conditions. A significant potential yield was abandoned at the end of the season due to frost or lack of labor.

Melons were sorted for defects and field-packed into standard 12.5-kg one-layer cardboard industry cartons. The number of fruit per package varied due to the broad range in sizes obtained. Fruit of “storage” melons were stored at the Rutgers Fruit Research Center (Cream Ridge, NJ) and sold later, but quality (mostly fruit firmness) diminished prematurely likely due to high humidity under these storage conditions.

Fruits of the Central Asian tomato variety finally began to mature in early September 2002, about 3 weeks later than the USA variety transplanted at the same time. Tomatoes were hand-picked into plastic buckets and transported to a packing facility for final sorting and packing into 10-kg cardboard boxes.

Distribution. The original plan called for the use of a centralized consolidation facility to receive, store, consolidate, and load pallets of product onto a dedicated truck bound for regular deliveries to specialty markets in NYC. Due to the reduction in the number of transplants, modest yields, and late and prolonged harvests, sufficient product volume was never realized to justify a dedicated consolidator and a heavy-duty refrigerated truck. Therefore, cooperating growers possessing cooling and storage facilities were utilized as direct shipping points for the products. Further, small cargo vans were used to retrieve the products from growers on a flexible schedule that were cold-stored (0°C)/consolidated/repacked as necessary at the Rutgers Fruit Research Center. Subsequently, rented trucks and small vans were used to transport product mixes to retail markets, also on a flexible schedule as product availability and market demands dictated.

Selling of products. Small specialty markets catering to recent immigrants from the former Soviet Union, located primarily in southern and central Brooklyn, were targeted for product sales. These establishments had been primed in advance with promotional brochures heralding the appearance of these unique products (funded by New Jersey Farm Bureau). When products began to appear in early August, free samples were provided to a representative sample of potential retail outlets. In mid-August, direct wholesaling of products to retail market outlets commenced, and continued more or less weekly through the end of October. Wholesale prices were established by direct negotiation with buyers who thoroughly inspected the product, often a carton at a time. Sales were accomplished through the commissioned services of a sales agent (Isaac Bun) familiar with
the culture, culinary preferences, business philosophies, and dialects of immigrants (and buyers) from the former Soviet Union. The negotiated prices were recorded according to date, commodity, and outlet.

Market preferences. Tomatoes (‘Bodohir’) were also produced in 2003 using production methods described above, and fruit were provided to buyers and proprietors in a variety of outlets, including retail markets and restaurants. Afterwards, the performance of tomatoes was determined by direct questioning of the buyers or proprietors.

Results and Discussion

Central Asian Varieties in the USA

Melon greenhouse experiment. The Central Asian varieties as a group tended to yield much larger fruits than their USA counterparts (2.19 versus 1.37 kg). While the level of sugars was variable in both groups, two of the Central Asian varieties (‘Oltin tepa’ at 13.1 and ‘Oltin vadii’ at 11.4) exhibited solids (% Brix) that were significantly higher than the highest USA variety ‘Savor’ at 9.7 (Table 1).

Commercial yields. Table 2 summarizes the overall yields of the individual Central Asian melon, tomato, and pepper varieties produced by the cooperating USA commercial growers in the year 2002 marketing study. Data are presented according to kg per transplant, since field planting configuration varied. The timing of product availability is also depicted in Table 2. As expected, the early melons matured first, followed by the late and storage melons. The window of harvest maturity was about two weeks in a given planting. Conversely, pepper fields tended to set and bear fruit continuously, and would have done so well into November if, according to one grower, “the weather had held”. Likewise, the tomato variety set fruit continuously, consistent with its semi-indeterminate growth habit. Results indicate that certain product types were

<table>
<thead>
<tr>
<th>Variety</th>
<th>Fruit wt (g)</th>
<th>Soluble solids (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>North American</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saticoy</td>
<td>1,358</td>
<td>5.10</td>
</tr>
<tr>
<td>Savor</td>
<td>966</td>
<td>9.73</td>
</tr>
<tr>
<td>Alienor</td>
<td>1,191</td>
<td>9.20</td>
</tr>
<tr>
<td>SX M 7119 (Athena type)</td>
<td>1,982</td>
<td>6.40</td>
</tr>
<tr>
<td>Central Asian</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shakar palak</td>
<td>2,031</td>
<td>10.30</td>
</tr>
<tr>
<td>Buri kally</td>
<td>1,547</td>
<td>6.73</td>
</tr>
<tr>
<td>Kokca</td>
<td>2,250</td>
<td>10.5</td>
</tr>
<tr>
<td>Shirali</td>
<td>2,037</td>
<td>10.5</td>
</tr>
<tr>
<td>Suunci</td>
<td>1,708</td>
<td>9.80</td>
</tr>
<tr>
<td>Lazzat driver</td>
<td>2,405</td>
<td>9.90</td>
</tr>
<tr>
<td>Oltin tepa</td>
<td>2,747</td>
<td>13.10</td>
</tr>
<tr>
<td>Rohat</td>
<td>2,034</td>
<td>7.70</td>
</tr>
<tr>
<td>Oltin vadii</td>
<td>1,584</td>
<td>11.40</td>
</tr>
<tr>
<td>Handalyk joltii</td>
<td>1,913</td>
<td>5.93</td>
</tr>
<tr>
<td>Tueona</td>
<td>3,113</td>
<td>6.50</td>
</tr>
<tr>
<td>Khasanbay</td>
<td>2,116</td>
<td>6.50</td>
</tr>
<tr>
<td>Z-42</td>
<td>1,801</td>
<td>9.10</td>
</tr>
<tr>
<td>Khorezimskay</td>
<td>3,170</td>
<td>9.63</td>
</tr>
<tr>
<td>Mirzachulsky</td>
<td>2,330</td>
<td>9.20</td>
</tr>
<tr>
<td>CV</td>
<td>21.2</td>
<td>10.70</td>
</tr>
<tr>
<td>LSD (0.05)(^1)</td>
<td>0.72</td>
<td>1.55</td>
</tr>
</tbody>
</table>

\(^1\) Fisher’s protected least significant difference
not suitable for production in NJ purely due to agronomic considerations, most notably early melons. Differences in yield (and quality) between growers were highly significant.

**Disease responses.** In 1998, the first field trial featuring Central Asian melons was conducted at Rutgers Horticulture Research Farm, New Brunswick, NJ. This field trial consisted of 25 Central Asian varieties and 5 USA varieties. The USA varieties were known to contain genes for resistance to *Fusarium oxysporum* f. sp. *melonis* races 0, 1, and 2 and powdery mildew (Zink and Thomas 1990, Zink 1991). Precipitation in the summer of 1998 in central NJ was relatively high and, in combination with irrigation from an overhead sprinkler system, excess moisture appeared to foster the development of disease. All Central Asian varieties exhibited a range of susceptibility to the disease pathogen (data not shown). *F. oxysporum* was isolated from wilted plants, but the race was not determined. The USA varieties with genes for Fusarium wilt resistance survived.

A second field trial was conducted in 1999 at the Rutgers Agricultural Research and Extension Center, Bridgeton, NJ. This trial featured 37 Central Asian varieties under drip irrigation system, and was replicated. Few Central Asian melon varieties exhibited any disease symptoms in this trial. The quality of fruit harvested from this trial was high (data not shown). The summer of 1999 in NJ was warm and dry relative to climatic averages.

### Table 2. Central Asian field performance summary of 2002, broken down according to grower

<table>
<thead>
<tr>
<th>Crop/Grower</th>
<th>Transplant dates</th>
<th>Harvest dates</th>
<th>No. of transplants</th>
<th>Yield¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peppers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower 1</td>
<td>5/27</td>
<td>8/9 – 10/30</td>
<td>4,352</td>
<td>1.747</td>
</tr>
<tr>
<td>Grower 3</td>
<td>6/3 – 6/10</td>
<td>9/18 – 9/25</td>
<td>6,016</td>
<td>0.906</td>
</tr>
<tr>
<td><strong>Melons (early)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower 1</td>
<td>5/19 – 6/18</td>
<td>8/9</td>
<td>3,384</td>
<td>0.101</td>
</tr>
<tr>
<td>Grower 2</td>
<td>5/18 – 6/18</td>
<td>8/6 – 8/26</td>
<td>4,392</td>
<td>1.278</td>
</tr>
<tr>
<td>Grower 3</td>
<td>5/19 – 6/17</td>
<td>8/8</td>
<td>3,240</td>
<td>0.475</td>
</tr>
<tr>
<td><strong>Melons (mid-season)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower 1</td>
<td>5/19 – 6/18</td>
<td>None</td>
<td>5,112</td>
<td>0.000</td>
</tr>
<tr>
<td>Grower 2</td>
<td>5/18 – 6/18</td>
<td>8/8 – 8/28</td>
<td>2,520</td>
<td>2.662</td>
</tr>
<tr>
<td>Grower 4</td>
<td>5/19 – 6/17</td>
<td>8/19 – 8/26</td>
<td>4,320</td>
<td>0.942</td>
</tr>
<tr>
<td><strong>Melons (late/storage)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower 2</td>
<td>5/18 – 6/18</td>
<td>9/12 – 9/25</td>
<td>2,232</td>
<td>1.848</td>
</tr>
<tr>
<td>Grower 3</td>
<td>5/19 – 6/17</td>
<td>9/9</td>
<td>2,952</td>
<td>1.956</td>
</tr>
<tr>
<td>Grower 4</td>
<td>5/19 – 6/17</td>
<td>None</td>
<td>1,296</td>
<td>0.000</td>
</tr>
<tr>
<td><strong>Tomatoes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grower 1</td>
<td>5/19 – 6/10</td>
<td>8/28 – 10/30</td>
<td>6,776²</td>
<td>0.576</td>
</tr>
<tr>
<td>Grower 5</td>
<td>6/10</td>
<td>9/11 – 10/8</td>
<td>6,048³</td>
<td>2.790</td>
</tr>
</tbody>
</table>

¹ Yield comparisons are expressed by kg per transplant, since growing configurations were variable; multiply by number of transplants per ha to get per ha figures
² Ground culture
³ Staked
After completing the 1998 and 1999 field studies, it was concluded that Central Asian melon varieties exhibited comparable yield and quality as compared with USA varieties, but appeared to be more susceptible to diseases. A breeding program was initiated, therefore, to transfer disease resistance genes from resistant USA melon varieties into Central Asian varieties via backcross, in order to retain the desirable characteristics of the Central Asian varieties. Fifteen of the Central Asian varieties were crossed with selected USA melon varieties carrying genes for multiple disease resistances (*F. oxysporum* f. sp. *melonis* races 0, 1, and 2, and powdery mildew) (Zink and Gubler 1987). These F₁ hybrids were also tested in field trials along with USA and Central Asian parents. The year 2000 trials were severely stricken with various diseases rendering it impossible to collect meaningful yield and quality data, although sufficient fruits were harvested to permit limited marketing studies.

The 2000 production season in southern and central NJ was considerably cooler and wetter than normal. Total accumulated heat units (degree days above 10°C) were –59, –21, and –105 respectively at southern, central, and northern NJ trial locations over this same period. It was particularly cool and wet during the period 17 July–27 August when vine establishment and fruit set were occurring. The cool temperatures, lack of solar radiation, and high moisture levels combined to create conditions that predisposed genetically susceptible melon plants to numerous fungal and bacterial diseases.

Trial A (year 2000) exhibited symptoms consistent with both bacterial wilt (*Erwinia tracheiphila*) and powdery mildew (*Erisyphe cichoracearum*), and both pathogens were isolated from necrotic lesions or vascular tissues of affected plants. Trials B and D (year 2000) were infested with the downy mildew pathogen (*Pseudoperonospora cubensis*), and both trials exhibited substantial foliar necrosis.

Trials C and E (year 2000) both exhibited a profound overall vine collapse during early September, 2000. Analyses of necrotic plants in these trials indicated the involvement of both *F. oxysporum* f. sp. *melonis* and *Pythium* sp. In trial F, most vines collapsed rapidly during mid-September, 2000, and the causative agent of Alternaria leaf blight (*Alternaria cucumerina*) was isolated from necrotic tissues. Plants from nearly all of the trials wilted and necrosed as the first fruit were maturing, and most fruit never reached maturity as a consequence.

In trial A (year 2000), it was not possible to record reliable data on the relative resistance of entries to the causative pathogens of vine collapse because vines wilted randomly throughout the trial, and collapse appeared to be a consequence of the interaction of bacterial wilt and powdery mildew. Likewise, plants in trial B were found to be infected with downy mildew, and did not exhibit any notable differences in resistance among entries tested. It was clear from the results of the disease severity among different entries in trial C, however, that certain Central Asian varieties appeared to exhibit genetic resistance to whatever race or races of *F. oxysporum* f. sp. *melonis* was/were present in that particular field plot (Table 3). The USA variety ‘Athena’ (F₁ hybrid; SunSeeds lot SXM 7119) exhibited the highest level of resistance in the trial, statistically significant from 7 of the other 8 entries, and the Central Asian variety ‘Lazzatli’ was
significantly more resistant or tolerant than 6 others.

Analysis of the disease severity data from trial D demonstrated that there appears to be a broad range of resistance to the causative pathogen of downy mildew among USA × Central Asian F₁ hybrids tested (Table 4). The most resistant, ‘Khorezimskay’ × ‘Athena’, was statistically different from 15 other entries, while the least resistant or tolerant was statistically distinct from 10. Four of the entries exhibited segregation patterns for disease resistance within at least two of the four replications, a further indication that levels of resistance may be attributable to genetic factors.

Trials E and F both included USA × Central Asian F₁ hybrids. Trial E never reached the point of full vine establishment and began to succumb to diseases (presumably Fusarium wilt and Pythium rot) before set fruit had gained any size. No notable differences in tolerance were observed among trial entries. A cursory observation of patterns of vine collapse in trial F showed also showed little if any differences among the entries, so it appeared unlikely that the entries in this trial embodied any genetic variability for resistance to Alternaria leaf blight.

A small trial of Central Asian varieties was conducted at the Rutgers Agricultural Research and Extension Center in 2004. A substantial epidemic of downy mildew (P. cubensis) occurred on all cucurbit crops that season, including muskmelons. The Central Asian melon variety ‘Rohat’ was observed to harbor resistance to downy mildew while other varieties and controls were highly affected.

Value-added potential. With regard to melons, garnering of premium wholesale prices was highly inconsistent, probably due to the lack of variety distinction in sales reports (e.g., early versus mid season and late/storage types). A premium of up to 61% was realized in mid season when the late types were prevalent, consistent with the demand for these types voiced by buyers. Over the whole season, only a 3% premium was obtained, but this statistic also combines the three types together. It was generally concluded from interactions with buyers that the “early” and “late/storage” categories were marginal or unsuccessful, but the mid-season elongated types elicited higher demand.

The early varieties did not perform well in 2002. The small, flattened/round fruit were extremely thin-rinded and soft, many splitting prematurely in the field. After harvest, fruit of these varieties tended to rot quickly, even under refrigeration. Moreover, they did not elicit any notable market demand, even among Central Asian and Russian emigrants and despite excellent flavor. Conversely, fruit of the mid-season varieties were of high qual-

<table>
<thead>
<tr>
<th>Variety</th>
<th>Origin</th>
<th>Disease rating¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athena</td>
<td>North America</td>
<td>1.75 a</td>
</tr>
<tr>
<td>Lazzatli</td>
<td>Uzbekistan</td>
<td>4.00 ab</td>
</tr>
<tr>
<td>Shakar pilak</td>
<td>Uzbekistan</td>
<td>6.50 bc</td>
</tr>
<tr>
<td>Oltin tepa</td>
<td>Uzbekistan</td>
<td>8.00 c</td>
</tr>
<tr>
<td>Oltin vadii</td>
<td>Uzbekistan</td>
<td>8.00 c</td>
</tr>
<tr>
<td>Alienor</td>
<td>North America</td>
<td>8.50 c</td>
</tr>
<tr>
<td>Khasanbay</td>
<td>Uzbekistan</td>
<td>8.75 c</td>
</tr>
<tr>
<td>Handalyk joltii</td>
<td>Uzbekistan</td>
<td>9.25 c</td>
</tr>
</tbody>
</table>

¹ Mean disease rating 1–10, 10 most severe. Mean separation at P < 0.05
ity, but yields were generally low due to diminished fruit set. Market demand for late/storage melons was judged generally to be very high, but were harvested prematurely by Central Asian standards (early September as opposed to late October to mid November) because the vines were beginning to collapse in early September due to disease pressure.

For peppers, a premium was realized at the beginning of the season (August 12) of 134% (Table 5). This price advantage diminished slowly but progressively until, by mid-September, little or no wholesale price premium was evident. A comparison of the average wholesale prices for the season showed a 33% premium for Central Asian versus commodity peppers (Table 5). Feedback from retail market buyers indicated that the Central Asian peppers were excellent, but not substantially differentiated from similar products in the myriad of other emerging categories, for example Italian frying types, and that customers were more price- than category-driven. This applied particularly in periods of over-supply, conditions that were present in much of the latter portion of the season.

With regard to the Central Asian tomatoes, however, sustained wholesale premium prices of up to 212% were realized over the course of the entire production season, despite the perceived quality issues voiced by buyers (size disparity within lots, blemishes, misshapen fruit). The average premium realized over the season was 74% (Table 5). This is clearly indicative of the acceptance of “Old World” products by recent immigrants.

Table 4. Mean separations for symptoms of foliar necrosis and vine collapse, diagnosed as downy mildew, 2001 USA field experiments

<table>
<thead>
<tr>
<th>Variety</th>
<th>Disease rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khorezimskay × Athena</td>
<td>3.75 a</td>
</tr>
<tr>
<td>Oltin vadii × Athena</td>
<td>4.00 ab</td>
</tr>
<tr>
<td>Shakar pilak × Saticoy</td>
<td>4.25 abc</td>
</tr>
<tr>
<td>Mirzachulskay × Athena</td>
<td>4.50 a-d</td>
</tr>
<tr>
<td>Athena × Buri kally</td>
<td>4.75 a-e</td>
</tr>
<tr>
<td>Shirali × Athena</td>
<td>5.25 a-f</td>
</tr>
<tr>
<td>Tashlak</td>
<td>5.25 a-f</td>
</tr>
<tr>
<td>Mirzachulskay × Athena²</td>
<td>5.50 a-f</td>
</tr>
<tr>
<td>Oltin vadii 1</td>
<td>6.00 a-f</td>
</tr>
<tr>
<td>Shirali × Savor²</td>
<td>6.00 a-f</td>
</tr>
<tr>
<td>Oltin vadii × Athena²</td>
<td>6.50 a-g</td>
</tr>
<tr>
<td>Shakar pilak uzbekistana</td>
<td>6.50 a-g</td>
</tr>
<tr>
<td>Shakar pilak × Alienor</td>
<td>6.50 a-g</td>
</tr>
<tr>
<td>Suuncci × Alienor</td>
<td>6.75 b-g</td>
</tr>
<tr>
<td>Savor x Oltin vadii</td>
<td>7.00 c-g</td>
</tr>
<tr>
<td>Buri kally x Alienor</td>
<td>7.00 c-g</td>
</tr>
<tr>
<td>Tuena × Savor</td>
<td>7.25 c-g</td>
</tr>
<tr>
<td>Shirali</td>
<td>7.25 c-g</td>
</tr>
<tr>
<td>Suuncci × Savor</td>
<td>7.25 c-g</td>
</tr>
<tr>
<td>Buri kally</td>
<td>7.50 c-g</td>
</tr>
<tr>
<td>Suuncci</td>
<td>7.75 c-g</td>
</tr>
<tr>
<td>Alienor</td>
<td>8.25 d-g</td>
</tr>
<tr>
<td>Oltin vadii 2</td>
<td>8.50 d-g</td>
</tr>
<tr>
<td>Oltin tepa</td>
<td>8.50 d-g</td>
</tr>
<tr>
<td>Savor</td>
<td>8.50 d-g</td>
</tr>
<tr>
<td>Shakar pilak</td>
<td>9.00 efg</td>
</tr>
<tr>
<td>Z-52 × Alienor</td>
<td>9.75 fg</td>
</tr>
</tbody>
</table>

1 Mean disease rating 1–10, 10 most severe
2 Varieties where two or more replications exhibited clear evidence of genetic segregation for tolerance
they were harvested at earlier, more firm stages of maturity. Packouts increased from less than 50% to over 70% as the season progressed. Because plants set fruit late in the season, a substantial portion of the overall yield had to be abandoned due to the lack of labor. Early fruit harvests were regarded by the growers as “ugly, but with great flavor”, and one grower commented that stunting made it difficult to avoid fruit damage during initial harvests because fruit were lodged in the vines. This problem was exacerbated on plants that were staked. In the future, it should be possible to capture this additional yield by earlier planting and avoidance of any possible use of growth retardants. Single-layer packages were later tested with buyers, and were met with high enthusiasm.

A small survey of buyers and market owners was conducted at the conclusion of the 2002 season to gauge their opinions about the success of the project and what they would like to see more or less of in the future. They were overwhelmingly pleased with the quality and uniqueness of most of the products that were sampled. The tomatoes and late, elongated melons were particularly successful, while the peppers and storage melons were moderately popular. The early melons were not deemed by buyers to have any value-added potential. A larger survey was conducted in 2003 among a more broad range of outlets. The results of this survey indicated that Central Asian fresh vegetable products tend to perform best economically in upscale retail markets and high quality restaurants, and do not perform well where price is the primary choice criterion (Table 6).

**North American Varieties in Uzbekistan**

*Tomatoes*. Table 7 presents a comparison of key tomato performance parameters (means of data for field trials conducted in years 2001 and 2002). With regard to days from transplanting to first fruit ripening, the Uzbek check varieties ranged from 85 (‘Doni-200’) to 107 (‘Pridnestrovya’). North American tomato varieties ranged from 79 (‘Glamor’) to 104 (‘Affirm’) days, so the Uzbek varieties tended to be slightly later maturing. The
highest yield among Uzbek varieties was 59.5 t/ha (‘Doni-2000’), an unexpected result given that this variety was also the earliest. The variety ‘Bohodir’ exhibited significantly lower total yield than all other trial entries (27.1 t/ha), including North American varieties (Table 7). The USA varieties ranged from 39.7 to 62.1 t/ha. Fifteen of the 17 North American varieties exceeded the designated Uzbek check (‘TMK-22’) with regard to total yield. This is perhaps due to the fact that all of the USA varieties were genetically vigorous F₁ hybrids, while the Uzbek varieties were all open-pollinated.

Actual and estimated yields and packouts in the Uzbek trials were extremely high as compared to NJ production standards (6.65 t/ha for fresh market tomatoes in 2001; New Jersey Agriculture 2002 Annual Report – Agricultural Statistics). Yield and packout parameters are not at all comparable between USA and Uzbekistan due to disparate production methods and product specifications. First, Uzbek growers typically establish production fields at much higher densities than do counterparts in USA. Further, in contrast to market limitations faced by USA growers, Uzbek tomato growers produce a hand-graded multi-tiered crop for many potential markets: premier fresh, second grade fresh, multi-grade processed, and tertiary (feed). Uzbek markets are also much more accepting of superficial fruit quality problems such as cracks, blemishes, off colors, and mixed sizes/shapes.

_cucumbers_. The USA cucumber varieties tended to be later maturing and with a more narrow harvest window than the Uzbek checks (Table 8). While average yields were mostly comparable, the fruit size of Uzbek varieties was considerably smaller than

### Table 6. Summary of market acceptance feedback of Uzbek tomatoes by USA retailers, 2003 season

<table>
<thead>
<tr>
<th>Venue</th>
<th>Feedback</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small – medium Paterson, NJ retail produce markets (4)</td>
<td>Negative due to fruit quality issues. Product had to be repacked frequently due to fruit breakage and soft lesions. Customer base is mixed ethnicity but generally at a lower economic tier. Higher demand noticed among Asian customers.</td>
</tr>
<tr>
<td>Small – medium northern NJ direct markets (2)</td>
<td>Very negative due to fruit quality issues. Customer base mostly Caucasians at a high economic tier. Little or no premium quality was perceived by most of these customers. Premium prices (~15%) were obtained when fruit were labeled as ‘heirloom’.</td>
</tr>
<tr>
<td>Small – medium retail produce markets in Brighton Beach, NY (8)</td>
<td>Very positive due to the strong recognition of fruit - identification with native Russian cuisine. Premium wholesale prices obtained consistently, similar to results obtained in 2002.</td>
</tr>
<tr>
<td>High-end restaurants in NYC (3)</td>
<td>Very positive due to the high perception of flavor, appearance, uniqueness. Chefs were willing to pay up to 100% premium, but must have a consistent, reliable supply (did not in 2003).</td>
</tr>
</tbody>
</table>
Table 7. Characteristics of the USA and Uzbek tomato varieties, grown under Tashkent Province field conditions (average of 2001 and 2002 growing seasons)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Fruit shape</th>
<th>Days from transplant to maturity</th>
<th>Total yield (t/ha)</th>
<th>Avg fruit wt. (g)</th>
<th>Soluble solids (%)</th>
<th>Organoleptic quality¹</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Uzbek varieties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TMK-22</td>
<td>round</td>
<td>95</td>
<td>43.3</td>
<td>77.4</td>
<td>4.2</td>
<td>7.9</td>
</tr>
<tr>
<td>Novinka Pridnestrovya</td>
<td>plum</td>
<td>107</td>
<td>50.6</td>
<td>49.3</td>
<td>4.5</td>
<td>8.7</td>
</tr>
<tr>
<td>Doni-2000</td>
<td>plum</td>
<td>85</td>
<td>59.5</td>
<td>56.8</td>
<td>4.4</td>
<td>8.1</td>
</tr>
<tr>
<td>Bohodir</td>
<td>multi-loc</td>
<td>100</td>
<td>27.1</td>
<td>210.3</td>
<td>3.9</td>
<td>9.5</td>
</tr>
<tr>
<td><strong>USA varieties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mountain Spring F₁</td>
<td>round</td>
<td>93</td>
<td>48.8</td>
<td>146.9</td>
<td>4.1</td>
<td>9.5</td>
</tr>
<tr>
<td>Atomic</td>
<td>round</td>
<td>96</td>
<td>45.3</td>
<td>133.5</td>
<td>4.2</td>
<td>9.5</td>
</tr>
<tr>
<td>Affirm</td>
<td>round</td>
<td>104</td>
<td>46.3</td>
<td>129.2</td>
<td>4.2</td>
<td>9.4</td>
</tr>
<tr>
<td>Glamor</td>
<td>round</td>
<td>79</td>
<td>43.2</td>
<td>120.0</td>
<td>4.3</td>
<td>9.1</td>
</tr>
<tr>
<td>TSH-3</td>
<td>plum</td>
<td>85</td>
<td>39.7</td>
<td>48.2</td>
<td>4.7</td>
<td>8.1</td>
</tr>
<tr>
<td>Acclaim</td>
<td>round</td>
<td>95</td>
<td>46.3</td>
<td>126.7</td>
<td>4.2</td>
<td>8.6</td>
</tr>
<tr>
<td>H-9423</td>
<td>round</td>
<td>93</td>
<td>46.7</td>
<td>57.7</td>
<td>4.5</td>
<td>7.9</td>
</tr>
<tr>
<td>H-9314</td>
<td>plum</td>
<td>91</td>
<td>62.1</td>
<td>49.3</td>
<td>4.4</td>
<td>7.3</td>
</tr>
<tr>
<td>H-9422</td>
<td>round</td>
<td>96</td>
<td>48.7</td>
<td>50.9</td>
<td>4.2</td>
<td>7.2</td>
</tr>
<tr>
<td>OX-150</td>
<td>plum</td>
<td>89</td>
<td>55.0</td>
<td>49.2</td>
<td>4.1</td>
<td>7.9</td>
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<tr>
<td>Sun Leaper</td>
<td>plum</td>
<td>90</td>
<td>51.3</td>
<td>59.5</td>
<td>3.9</td>
<td>9.3</td>
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<tr>
<td>Mountain Fresh F₁</td>
<td>round</td>
<td>98</td>
<td>55.5</td>
<td>128.4</td>
<td>4.3</td>
<td>9.3</td>
</tr>
<tr>
<td>Sun 6347</td>
<td>plum</td>
<td>90</td>
<td>51.3</td>
<td>59.5</td>
<td>3.9</td>
<td>7.7</td>
</tr>
<tr>
<td>La Rossa</td>
<td>plum</td>
<td>80</td>
<td>44.8</td>
<td>71.6</td>
<td>4.2</td>
<td>7.5</td>
</tr>
<tr>
<td>AP-711</td>
<td>plum</td>
<td>97</td>
<td>52.1</td>
<td>82.0</td>
<td>3.9</td>
<td>7.8</td>
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<tr>
<td>TSH-2</td>
<td>elong. oval</td>
<td>93</td>
<td>46.1</td>
<td>54.4</td>
<td>4.4</td>
<td>8.3</td>
</tr>
<tr>
<td>AP-721</td>
<td>plum</td>
<td>84</td>
<td>57.3</td>
<td>77.2</td>
<td>4.0</td>
<td>7.7</td>
</tr>
<tr>
<td>CV (%)</td>
<td></td>
<td></td>
<td>13.6</td>
<td>7.8</td>
<td>13.8</td>
<td>10.2</td>
</tr>
<tr>
<td>LSD (0.05)²</td>
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<td></td>
<td>2.85</td>
<td>55.0</td>
<td>0.09</td>
<td>0.45</td>
</tr>
</tbody>
</table>

¹ Subjective taste/texture test according to Uzbek parameters 1–10 scale, 10 best
² Fisher’s protected least significant difference

that of almost all of the USA counterparts. Certain of the USA varieties were considered by Uzbek scientists to have flavor and textural qualities at or above their native types.

**Conclusions**

Much has been learned in the very short period of this collaboration. Many Central Asian varieties hold promise for economic success in the USA, particularly among affluent consumers and populations of residents that are familiar with the unique attributes they embody. These varieties have been adapted to the relatively arid climate of Uzbekistan, and are susceptible to diseases that are prevalent of the more humid and rainfed Mid-Atlantic coast region of the USA. Perhaps backcross breeding programs can be em-
Characteristics of the USA and Uzbek cucumber varieties, grown under Tashkent Province field conditions (average of 2001 and 2002 growing seasons)

<table>
<thead>
<tr>
<th>Variety</th>
<th>Days from transplant to maturity</th>
<th>Days Avg yield harvest window (t/ha)</th>
<th>Avg fruit wt. (g)</th>
<th>Organoleptic quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uzbek varieties</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Darad</td>
<td>43</td>
<td>44</td>
<td>17.6</td>
<td>112</td>
</tr>
<tr>
<td>Omad</td>
<td>43</td>
<td>42</td>
<td>31.9</td>
<td>130</td>
</tr>
<tr>
<td>Uzbekskiy 740</td>
<td>47</td>
<td>43</td>
<td>27.6</td>
<td>106</td>
</tr>
<tr>
<td>USA varieties</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fanfare F₁</td>
<td>46</td>
<td>43</td>
<td>28.3</td>
<td>151</td>
</tr>
<tr>
<td>Marketmore 76</td>
<td>52</td>
<td>36</td>
<td>24.4</td>
<td>184</td>
</tr>
<tr>
<td>Prince F₁</td>
<td>42</td>
<td>44</td>
<td>33.9</td>
<td>119</td>
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<tr>
<td>Slicing Lemon</td>
<td>51</td>
<td>35</td>
<td>28.6</td>
<td>197</td>
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<td>Slicing SMR-58</td>
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<td>125</td>
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<td>Space Master</td>
<td>46</td>
<td>39</td>
<td>27.6</td>
<td>157</td>
</tr>
<tr>
<td>Straight Eight</td>
<td>50</td>
<td>35</td>
<td>25.9</td>
<td>146</td>
</tr>
<tr>
<td>Sweet Slice</td>
<td>42</td>
<td>43</td>
<td>32.8</td>
<td>200</td>
</tr>
<tr>
<td>Tendergreen</td>
<td>50</td>
<td>35</td>
<td>24.5</td>
<td>169</td>
</tr>
</tbody>
</table>

¹Subjective taste/texture test according to Uzbek parameters 1–10 scale, 10 best

Employed to merge positive characteristics. Certain USA varieties also performed well in Uzbekistan, although acceptance by consumers there has not yet been tested. These varieties are generally more resistant to diseases and pests, so will reduce the management inputs required of growers.

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Opportunities for Research Collaboration with Institute of Vegetable and Ornamental Crops

D. Schwarz, R. Grosch, H.-P. Kläring, A. Krumbein, and E. George
Institute for Vegetable and Ornamental Crops, Theodor-Echtermeyer-Weg 1, 14979 Großbeeren, Germany

Introduction

Horticultural research serves as an important catalyst of horticultural development in Germany. German scientists are taking the lead in devising strategies and technologies to respond to the urgency of the needs in the horticultural sector. Research activities are carried out at various levels in the country. In essence, there are two types of horticultural research in Germany:

• Basic research is mission-oriented, aimed at understanding specific problems. Universities are responsible for this area of research. Germany has one university with faculty of horticulture and four other universities with smaller institutes or departments of horticulture.

• Applied research develops technological innovations by adapting basic research results to solve the growers’ field problems or to meet their specific needs. Much of this research is carried out at experiment stations in the specialized production regions of different states.

In addition to experiment stations and universities, a number of other institutions are also involved in both levels of horticultural research. The Institute of Vegetable and Ornamental Crops (IGZ) is one of them. IGZ (www.igzev.de) is a member of the Leibniz Association (www.wgl.de) and is funded by the federal government and state governments of Brandenburg and Thuringen. It is one of the largest publicly funded horticultural research institutes in Germany. IGZ is solving specific horticultural problems with a broad application over several disciplines. It seeks to develop methodologies and technologies to produce new knowledge, principles, and understanding for critical needs. Its programs strive to develop efficient and competitive production systems, healthy and affordable products, improved taste and quality of food, and environmentally friendly practices. Below are three areas of its core expertise that IGZ would like to collaborate with the potential partners in Central Asia and the Caucasus.

Model-based Decision Support Systems in Greenhouse Production

Computer-based decision support systems (DSSs) have a well-established tradition within agriculture. The DSS range from simple accounting-based systems to systems based on
detailed deterministic or stochastic models. Clearly, using different methods to model the same domain will produce different results. IGZ has developed DSS for managing greenhouse climate and crop fertilization and irrigation (fertigation) of tomato to improve yield, reduce environmental pollution, and save water, fertilizers and energy (Bar Yosef et al. 2003). It entails three modules:

- A generic, modular substrate-plant-climate model designed to predict crop response to varying climate conditions, fertigation management, water quality and substrate characteristics.

- A feedback control module that evaluates the quality of certain model predictions based on measurements inside the greenhouse.

- A management module that stores values on target dry matter and nitrogen accumulation, and compares them with simulated results from the model.

Figure 1 briefs the above three modules. The objective of this DSS is to derive optimal greenhouse management rules for maintaining growth close to the target value with minimal intervention by the grower. Tests of the DSS indicate that the system is well calibrated to tomato growth in greenhouses in central Germany and has the potential for simulating tomato growth in closed irrigation loop greenhouses under arid conditions. The modular structure of the DSS allows the simple replacement of any component by a more sophisticated one when justified. As most greenhouse crops are C_3 plants, it is likely that photosynthesis, transpiration, dry matter production (DMP) and nutrient and water uptake models can be adapted to crop-type by parameter modifications. The main differences among crops appear to be dry matter and nitrogen partitioning and root growth as a function of time (Feller and Fink 2002), which may need to be characterized before further refinement of the DMP components. Now the DSS for tomato is being modified for greenhouse production of lettuce and rose.

Disease Control

Management of soil-borne pathogens

To seek effective control measures with minimal use of fungicides, IGZ is developing alternative control measures to control soil-borne fungal pathogens. The methods include 1) use of resistant cultivars; 2) crop rotation to limit the pathogen population in the soil; 3) use of beneficial microorganisms to promote growth and defense against pathogens; and 4) use of antagonistic microorganisms to retard the infection or colonization of the pathogen in the rhizosphere. Currently, these measures target *Rhizoctonia solani*, *Pythium aphanidermatum*, *Aphanomyces euteiches*, and *Fusarium* spp. in both open field and greenhouse production systems.
Figure 1. Overview of the model based management system (Bar Yosef et al. 2003)
Characterization of pathogen

Characterization of the pathogen is a prerequisite to investigate its epidemiology and to develop control measures. Classical methods of characterization are tedious, whereas molecular methods are fast and accurate. Recently, detection of fungal pathogens with polymerase chain reaction (PCR) techniques has been used extensively.

*Rhizoctonia* species and groups are identified by characteristics of their hyphae and ability of hyphae to fuse with one another (known as anastomosis), which is the primary means of genetic recombination, because they often do not produce spores. Morphological or physiological characterizations of anastomosis groups (AGs) are time consuming (Grosch et al. 2004). A rapid technique for identification and detection of *R. solani* AG 1-IB, the causal agent of bottom rot of lettuce, has been developed using PCR. Amplification products obtained from random amplified polymorphic DNA (RAPD) reactions were cloned and sequenced, and two extended primer sets were designed from the resulting data that were used to detect sequence-characterized amplified regions (SCAR). These SCAR markers can be used to unambiguously detect the presence of AG 1-IB in infected plant tissue and in soil samples collected from lettuce fields (Grosch et al. 2005b). On the other hand, RAPD assays were used to determine formae specialis (f. sp.) and physiological races in pathogenic and antagonistic species of *Fusarium* spp.

The other molecular detection method involves the internal transcribed spacer (ITS) region of the ribosomal DNA. ITS contains two variable non-coding regions that are nested within the rDNA repeat between the highly conserved small subunit, 5.8S, and large subunit rRNA genes. Species-specific variation has been reported in ITS regions of the rDNA in a number of fungi. Thus, examination of the restriction fragment length polymorphisms of the amplified ITS region by PCR proved to be a powerful technique for the identification of fungi. This has been used to identify *Pythium aphanidermatum*, the causal agent of damping-off of cucumber, lettuce and tomato seedlings.

Biology and epidemiology

*P. aphanidermatum* is the major pathogen of cucumber under the greenhouse-hydroponics system (Menzies et al. 1996). Its population reduction would be one of the effective means to prevent the spread of pathogen. Kyuchukova et al. (2004, 2005) showed that the pathogen density in the roots increased with inoculum density and temperature, and resulted in growth reduction of the cucumber plants. Clearly, low temperatures delayed the development of the disease in the plant, while high temperatures combined with high inoculum densities led to sudden death of some plants. On the other hand, Grosch and Kofoe (2003) found high temperatures favored hyphal growth of *R. solani* AG 1-IB. *R. solani* is a destructive pathogen in a wide range of vegetables in the world (Ogoshi 1987). (Its sexual stage with fruiting structure of teleomorph is known as *Thanatephorus cucumeris*.) The optimal hyphal growth under high temperatures is in parallel with high incidence of lettuce bottom rot under warm and wet climatic conditions in south Germany.
**Biological control**

Biological control methods based on antagonistic microorganisms are well documented. They are environmentally friendly to protect plants against soil-borne pathogens (Emmert and Handelsman 1999). A screening strategy was developed to assess the potential of plant-associated bacteria to control diseases caused by \textit{R. solani}. About 434 already characterized antagonistic bacterial strains isolated from diverse plant species and microenvironments were evaluated for biological control and plant growth promotion by a hierarchical combination of assays (Faltin et al. 2004). The strains were characterized by their antagonistic mechanisms in vitro (focusing on fungal cell wall-degrading chitinase, glucanase and protease) as well as their production of the plant growth hormone indole-3-acetic acid. Molecular fingerprints of isolates obtained by BOX-PCR were compared to save future investigation with genetically similar strains and to search for unique molecular fingerprints for quality control and patent licensing. According to this strategy, an assessment scheme was developed and several efficient biological control agents (BCA) identified (Grosch et al. 2005a). These BCAs could be candidates for developing commercial products against \textit{Rhizoctonia} diseases under field and greenhouse conditions.

**Basics of Quality Management**

Quality management is required to meet the quality preferences of customers. Production and distribution of vegetables can tremendously affect quality characteristics, such as taste, flavor, sensory quality, and health-promoting compounds. Quality management systems consist of quality planning (requirement and characterization) and quality control (effects of production and distribution on quality). The aim is the development of an integrated strategy for the production and assurance of customer-oriented quality of horticultural products.

The quality depends mainly on genotype, environmental factors and cultivation methods (Schonhof et al. 1999). Investigations in selected \textit{Brassica} vegetables (i.e., \textit{B. oleracea} var. \textit{alboglabra}, var. \textit{botrytis} and var. \textit{italica}) showed significant differences in the glucosinolate proportion as well as health-promoting and flavor-influencing R group (side chain) of glucosinolate among the cultivar groups (Schonhof et al. 2004). The study also showed that the species forms and cultivars diverged in their external and internal sensory attributes, for example, color; taste properties such as bitter and sweet; and flavors such as green/grassy, spicy, broccoli-like, cabbage-like, cauliflower-like, kohlrabi-like, leek-like and mouth-feel pungent. Differences in the sensory attributes led to different consumer acceptability based on first impressions judged on color, flavor and overall liking. Consumers preferred cultivars with bright color, low bitter tasting (i.e., low contents of alkenyl- and indole-glucosinolates) and higher sucrose content. There were significant correlations between glucosinolate concentrations, sensory properties and consumer preference. This indicates that there is a potential to optimize the taste to boost acceptability of any particular species or variety of vegetable.

Krumbein et al. (2001) showed that S-fertilization increased the content of alkyl
glucosinolate (glucoraphanin) and indole glucosinolate (glucobrassicin) in broccoli, and
alkenyl glucosinolate (glucoraphasatin) in radish. On the other hand, increased N-fertiliz-
eration resulted in 30% reduction of alkyl glucosinolates (glucoraphanin and glucoiberin)
in broccoli. Moreover, Schreiner (2005) demonstrated that certain management prac-
tices have the ability to achieve 10-fold increases in specific phytochemicals in broccoli
and cauliflower and two-fold increases in radish. These results highlight the importance
that management strategies have on a crop’s phytochemical profile. Some of these man-
agement and fertilization practices could be used to maximize nutraceutical values of
vegetables in the market.

As with fresh-market commodities, post-harvest treatment can precipitate a number
of changes in bioactive plants. In a post-harvest evaluation of tomatoes harvested red
ripe and stored in simulated retail store conditions, Krumbein et al. (2004) found hexanal,
(E)-2-heptenal, (E,E)-2,4-decadienal, 6-methyl-5-hepten-2-one, geranylacetone, 2-
isobutylthiazole, 1-nitro-2-phenylethane, geranial, methyl salicylate, (Z)-3-hexenal, 1-
penten-3-one, and (E)-2-hexenal are the most odor-active aroma volatiles in fresh toma-
toes and subject to change during the post-harvest phase. By applying principal compo-
nent analysis to the attributes of odor, flavor and aftertaste, as well as chemical com-
 pounds (14 aroma volatiles, titratable acid and reducing sugars), the first three compo-
nents explained 87.2% of the variance. The results indicate strong relations between
chemical compounds and sensory attributes.

It is apparent that the concentration of phytochemicals can be effectively controlled
in the plant by a variety of pre- and post-harvest conditions. Furthermore, it is possible to
alter the composition of plant-derived nutraceuticals during storage or processing, whether
by selecting the appropriate unit operation technology or by modifying processing condi-
tions. Regardless of the means, a valid question is: What is the recommended dosage of
nutrients or phytochemicals? The benefits of phytochemicals and plant-derived nutrients
are indisputable. With growing evidence in support of pre- and post-harvest methods for
increasing the level of certain phytochemicals in vegetable products, it is important to
remain cognizant of the effect of such increases on total dietary intake.

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Recent Developments of the Vegetable Production System in Turkey

Suat Yilmaz¹, Ahmet F. Fırat¹, Nedim Mütlü¹, and Nurten Surmeli²
¹West Mediterranean Agricultural Research Institute, Antalya, Turkey; ²Atatürk Horticultural Central Research Institute, Yalova, Turkey

Introduction

Turkey is located in the sub-tropics between 36–42° N latitude and 26–45° E longitude. Geographically Turkey is a land bridge between Europe and Asia. The total amount of arable land is about 27.6 million ha, 35% of the total land area of 78 million ha. Turkey’s great variety of microclimates and adequate rainfall permit a broad range of crops. The main farming systems are dry and irrigated farming. Crop farming is conducted throughout the country, although it is less common in the mountainous eastern regions. Agriculture is one of the most important sectors in Turkish economy. Thirty-five percent of its population of 71 million resides in rural areas. Agriculture employs 34% of the population, and contributes 15% of the total gross domestic product (Yılmaz et al. 2003).

Vegetable Production

Vegetables are one of the most important dietary supplements in Turkey. The annual per capita vegetable consumption is 102 kg, 123 kg and 210 kg in the world, European Union, and Turkey, respectively (Güclü 2003). The vegetable sector provides necessary food supply to the population, raw materials to the agricultural-based industry, creates additional employment, and contributes to national income and export (Güclü 2003, Anonymous 2004a, CIHEAM 2005).

Turkey has strong vegetable production potential due to its very special geographic location, accession to different market places, suitable climates and relatively cheap labor. Furthermore, it is either in center of origin or diversity for some vegetables or possesses similar climatic conditions to some centers (Anonymous 2003, Titiz, 2004). There about 50 different major species are grown in Turkey plus 20 native species, which usually are harvested from the wild. Of the total arable land in the country, 1.05 million ha or 3.8% are engaged in vegetable production (Anonymous 2004b).

Turkey’s total vegetable production was 24.1 million t in 2004, fourth largest among nations in the world, and accounted for 2.8% of the world’s production (FAOstat data 2006). Its 610,000 t of fresh vegetable exports amounted to US$218 million in 2004 (Turkish Fresh Fruit and Exporter Unions, unpublished data). Of the vegetables grown, fruit vegetables, leafy vegetables, root and tuber vegetables, and legumes account for 86%, 8%, 3%, and 3% shares, respectively (Anonymous 2002a, Anonymous 2002b, Anonymous 2003).
Vegetable Sector Development in the Past Three Decades

Turkey has a relative advantage over other countries in the region. These include a suitable climate and abundant water resources, easy accessibility to large and diverse markets (e.g., EU, Eastern Europe, Middle East), relatively cheap labor, and rich genetic resources for various species (Titiz 2003).

Developments in open-field vegetable systems

Vegetables can be grown in many parts of Turkey because of the favorable climate and soil conditions. The regions where vegetables are grown extensively are the Mediterranean, Aegean, and Marmara coasts. Among these regions, the Aegean region ranks first in terms of production, followed by the Mediterranean and Marmara regions. During the past two decades, vegetable cropped area expanded by 35%, production 88%, and yield 39% (Anonymous 2003; Anonymous 2004a). Of the total production, 87% are produced in open-field and the rest in protected cultivation (Anonymous 2004a).

The most important vegetables are tomato, watermelon, onion, melon, and cucumber and pepper. The share of tomato in the total vegetable production is 33%, and the shares of onion, cucumber, pepper are around 7%. The type of vegetables grown in the country has been diversified in the recent years. New crops include cherry tomato, fresh market tomato, capia pepper, Hungarian and American peppers, Chinese cabbage, Brussels sprout, pickling cucumber, and aromatic plants. Field-grown tomatoes are mainly used in paste production. Turkey is the fourth largest in the world in tomato paste production, two-thirds of which is exported and valued US$150 million annually (Anonymous 2004a).

Developments in protected vegetable systems

Protected vegetable production area covers around 46,000 ha (Titiz 2004). Of the total greenhouse area, 96% is used for vegetable production (Titiz 2004, Keskin and Cakaryildirim 2003). Tomato again is the leading crop in protected production followed by cucumber, watermelon, pepper, and eggplant (Anonymous 2003, Titiz 2003, Titiz 2004). About 90% of protected vegetable production is concentrated in the Mediterranean coast; within this region Antalya is the center for protected production with 30% of all protected area, 82% of all glasshouses, and 43% of all plastic greenhouses in Turkey. Other provinces, e.g., Adana, Mersin and Hatay, in the Mediterranean coast have also significant amounts of protected greenhouse area. Almost all vegetable production in the Aegean region is protected (96%) with Mugla, Aydin, and Izmir provinces occupying 56%, 24%, and 17%, respectively. Samsun has 74% of the protected areas in the Black Sea region (Keskin and Cakaryildirim 2003, Titiz 2003).

Because of its mild winter, greenhouses throughout the Mediterranean and Aegean coasts require less inputs and usually are not heated. Use of plastic cover is widespread in the Mediterranean countries. However, Turkey has more glasshouse area than other countries in Mediterranean, 20% over 12%. Of all the protected areas, 43% are low
tunnels, 34% plastic greenhouses, 12% glasshouses, and 11% high tunnels (Anonymous 2002b, Titiz 2004).

**Development of F₁ hybrid seeds and new varieties**

Turkey produced 992 t of vegetable seeds, and imported 764 t (valued about 70 million US$), mainly from Holland, France, USA and Israel in 2003. About 102 t of vegetable seeds produced in 2003 were exported. A total of 1,756 t of vegetable seeds were used in 2003. Among them, 435 t were hybrid seeds (TUGEM, unpublished data).

Greenhouse vegetable production began with the open-pollinated varieties that were used in field production. F₁ hybrid seeds for greenhouse vegetable production came into the market in the early 1980s, giving rise to increased yield, quality and profitability. Later, the government has promulgated policy of seed production and legal regulation on registration, quality control, certification and pricing of the seed. The main objective of the Turkish national seed policy is to be self-sufficient in seed production and supply of field, industrial, and vegetable crops and become a reliable seed exporter. National seed policy and regulations are conducive for private enterprise development. Today, the private sector produces almost all seed of vegetable crops (Batur 2002, Dellal and Giray 2002, Firat et al. 2002). Under the seed policy, the government has funded projects to encourage collaborative research between public and private sectors to develop F₁ hybrid varieties in order to reduce dependency on imported seeds. The project focuses on tomato, pepper, eggplant, cucumber, melon, watermelon, squash, and cabbage (Anonymous 2004a).

**Development of seedling industry**

The vegetable seedling industry has expanded rapidly in the last decade. Use of seedlings in Antalya reaches over 70%, and number of seedling companies in the country reaches to 40 (Titiz 2004). Growers have come to cherish the use of healthy, uniform, standard seedlings produced and distributed by professionals (Fidan 2003, Titiz 2004).

The use of grafted seedlings in production is increasing rapidly. In 2004, grafted tomato crops generated US$13.3 million (unpublished data). The technology involves grafting desirable varieties on rootstocks with strong root systems and resistance to soil-borne diseases. Grafted seedlings increase crop stand, yield and quality. The technology has been applied in tomato, watermelon, melon, eggplant and cucumber (Fidan 2003, Titiz 2004). In addition, the technology could facilitate the scheduled phase out of methyl bromide by 2007.

**Use of bumblebees in greenhouses**

Growth regulators have been used to stimulate fruit set in unheated greenhouse productions of tomato, eggplant, and squash (Yazici et al. 2004). However, they usually cause deformation in fruit shape and flavor that reduce its chance for export. In the domestic
market, consumers also shun away from crops with growth regulators. To cope with this
trend, bumblebees (*Bombus terrestris*) were introduced in the late 1990s to encourage
pollination in the greenhouse, especially during the cool season (Gürel 1997). At present,
there are three companies supplying about 42,000 hives of bumblebees annually. About
25% of protected tomato production use bumblebees.

**Development of soilless culture and drip irrigation**

Soilless culture was introduced in 1996 and has increased to 100 ha since then (Gül et al.
2003). Production requires higher input, know-how, and technology but it presents higher
return by higher yield and longer growing period (Titiz, 2004). The technology has been
used in the production of cluster tomato, cherry tomato, and sweet pepper, as well as
ornamental plants. Growth media used are perlite, torf peat, rockwool, cocopit, pomza
stone, volcanic tuff, and mixture of these materials (Gület al. 2003, Titiz 2004).

Israeli companies first introduced drip irrigation techniques to the protected produc-
tion of ornamentals. Later, the technology has been expanded to field production of vege-
tables. At present, 95% of protected cultivation and 5% of field production employ drip
irrigation. Number of farms with drip irrigation was 124,722 ha in 2003, a 14% increase
from the previous year (Anonymous 2004a). Some of the drip irrigation system are also
coupled with automated fertilization, which allow growers to adjust pH and EC (Erken

**Use of modern machineries and chemicals**

Turkish agriculture has experienced tremendous improvements in the use of modern
machineries and agricultural chemicals in the last three decades. Presently, about one
million tractors in the country (Anonymous 2004a) have contributed to the average num-
ber of one tractor per 28 ha of farmland area (Yilmaz 2004). In 2003, the total amounts
of pesticides (excluding cupper sulfide and sulfur) and fertilizers used were about 12,000
t and 5 million t, respectively. At present, 1 ha of farmland uses around 92 kg of fertilizer.
Vegetable production tends to use relatively more farm machineries, pesticides and fer-
tilizers compared to other crops (Velioglu et al. 2004, Yilmaz 2004).

**Development of post-harvest technologies**

The vegetable processing industry has grown significantly in recent years. About 65% of
tomato production is for paste production, which ranks fourth in the world (Anonymous
2004a, Anonymous 2004b). Canned and pickling vegetables are also fast growing enter-
pises during the last decade. Of all the vegetables produced in Turkey, 7–8 million t are
processed and 16–17 million t consumed fresh (Anonymous 2002b). Most of the fresh
vegetables are sold at open markets locally while the ones destined for export and/or
urban centers are sorted and packaged. However, at the present, the amount of pack-
aged vegetables is only around 5%.
Good Agricultural Practices (EurepGAP)

EurepGAP was developed by the Euro-Retailer Produce Working Group (EUREP) to enforce/promote internationally accepted Good Agricultural Practices (GAP) in the production of horticultural crops. European retailers who control 70 to 80% of European Union (EU) market put together EurepGAP protocol in 1999, which aims to reduce the risk of hazardous residues in fresh vegetables to their consumers. With this protocol, retailers request assurance from wholesalers and producers that their products would not harm their customers. The protocol is to assure the production procedure complies with GAP and is not harmful to the people, other living organisms and the overall environment, and the product does not contain any harmful chemicals and microbes. EurepGAP is focused on: 1) preventing risks; 2) using appropriate technology; 3) using integrated crop and pest management strategies; and 4) integrating with the Hazard Analysis Critical Control Points (HACCP). The minimum standards that registered producers are to follow include traceability, recordkeeping, varieties and rootstocks, site history and management, soil and substrate management, fertilizer usage, irrigation, crop protection methods, harvesting methods, post-harvest treatments, waste and pollution management, recycling and reuse, worker health safety and welfare, and environmental issues (EurepGAP 2006). Turkey introduced EurepGAP in 2002, and the number of growers who adopt this protocol are increasing significantly because of the profitability of their products in Europe.

Vegetable Research System in Turkey

Several research institutions under the Ministry of Agriculture, Forestry and Rural Affairs (MAFRA) are involved in vegetable research and development, specifically in the areas of variety improvement, crop and soil management, plant protection, production technologies, post-harvest technologies, marketing, etc. Research efforts in the universities focus on basic and strategic research. In recent years, over 40 private enterprises have gained licenses for agricultural research mainly on crop improvement and seed production of high-value crops. Public and private seed production organizations as well as multinationals are active in vegetable seed production. The Variety Registration and Certification Centre of MAFRA is responsible for the registration of the improved varieties developed by the public or private research institutions. Those institutions, after the registration of their varieties, are responsible to produce elite and basic seeds of their varieties. The certified seeds are produced by the State Farms or private sector to supply seed to the farmers. For research funding, the National Science of Foundation of Turkey (TUBA) and the Scientific and Technical Research Council of Turkey (TUBITAK) have increased their funding on research in the last few years. European Union also provides grants and funding on competitive bases within Frame Work 6 (FP6) and upcoming FP7.
Challenges and Opportunities for the Vegetable Sector in Turkey

Turkey is facing a number of challenges in improving market-oriented vegetable production. For example, small farm size, expensive energy, weak farmers’ organizations, lack of grower-industry collaboration, dependency on foreign technologies and materials, price fluctuations, poor traceability from farm to fork, and inadequate agricultural insurance have deterred vegetable systems development (Titiz 2004, Yilmaz et al. 2003). On the other hand, the country possesses a great potential to overcome these challenges. It possesses favorable climatic conditions, abundance of arable land, high quality irrigation water resources, rich crop diversity, well-developed agriculture-related infrastructures and industries, cheap but experienced labor, well-conversed technical personnel, proximity to European and Middle East markets, and a large domestic market (Titiz 2004, Yilmaz et al. 2003). With all these factors placed in the proper place, Turkey carries the potential to triple or quadruple its vegetable production in the next decade.

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List of Participants

Afghanistan

Mr. Abdul Ahad Khan  
S/O Abdul Shakoor Khan  
ARRP Horticulture Manager  
Mercy Corps Afghanistan  
CPO Box 1992, House 558, St.5  
Qala-e-fatullah District 10, Kabul  
Afghanistan  
E-mail: xavhagen@yahoo.com

Mr. Attiqullah  
S/O Akhter Mohammad  
ARRP Manager  
Mercy Corps Afghanistan  
CPO Box 1992, House 558, St.5  
Qala-e-fatullah District 10, Kabul  
Afghanistan  
E-mail: obaidullah@mercycorpssirld.org

Armenia

Dr. Ashot Oganesyan  
Head  
Department of Science  
Ministry of Agriculture  
48 Nalbandian Str., Yerevan 375010  
Armenia  
Tel: +374-1-524834  
Fax: +374-1-523793

Dr. Agwan Saakyan  
Director  
Scientific Center of Agrobiotechnology  
Darakert, Masis district, Ararat region 378372  
Armenia  
Tel: +374-1-451373

Dr. Galust Aslanyan  
Director  
Scientific Center of Vegetable, Melons & Industrial Crops  
Darakert, Masis district, Ararat region 378372  
Armenia  
Tel: +374-36-40892, +374-1-581371 (h)  
E-mail: aslanyan_galust@yahoo.com

Dr. Rubik Shakhhasisyan  
Deputy Director, Scientific Center of Vegetable, Melons & Industrial Crops  
Darakert, Masis district, Ararat region 378372  
Armenia  
Tel: 374-36-40892

Azerbaijan

Dr. Eldar Kosayev  
Deputy Director  
Agrarian Scientific Center  
Room 1049, 10 floor, Government House,  
40, Gadjibekov St., Baku 1001  
Azerbaijan  
Tel: +994-12-4933186, +994-12-4982114  
E-mail: YGuliyev@agroagency.gov.az

Dr. Lalazar Sadikhova  
Head of Department  
Azerbaijan Research Institute of Vegetable Growing  
Sov. No. 2, pos. Pirshagi, Baku 1098  
Azerbaijan  
Tel: +994-12-4972136, +994-12-4516091

Dr. Alisoltan Babayev  
Head of Department  
Azerbaijan Research Institute of Vegetable Growing  
Sov. No. 2, pos. Pirshagi, Baku 1098  
Azerbaijan  
Tel: +994-12-4972136, +994-12-4516091
Dr. Brilyant Mammadzada  
Deputy Director  
Azerbaijan Research Institute of Vegetable Growing  
Sov. No. 2, pos. Pirshagi, Baku, 1098 Azerbaijan  
Tel: +994-12-4972136

Dr. Bakhtiyar Baghirov  
Head Specialist  
Non governmental organization "EMA",  
Gorodskoe shosse, Box. Sabunchu, Baku 1034 Azerbaijan  
Tel: +994-12-4503417  
Fax: +994-12-4504053

Georgia

Dr. Zurab Dzhindzhihadze  
Deputy Director  
Research Institute of Crop Husbandry  
126, I, Abanidze St., Tbilisi 380000 Georgia  
Tel: +995-32-935509

Dr. Guram Gurgenidze  
Head  
Department of Economics, Institute of Economics & Agro-Industrial Complex Management  
82, Chavchavadze St., Tbilisi 380062 Georgia  
Tel: +995-32-226636

Dr. Natalya Kakabadze  
Senior Researcher  
Research Institute of Crop Husbandry  
126, I, Abanidze St., Tbilisi 380000 Georgia  
Tel: +995-32-261306

Dr. Tinatin Kuprashvili  
Senior Researcher  
Research Institute of Plant Protection  
82, Chavchavadze St., Tbilisi 380062 Georgia  
Tel: +995-32-230388

Germany

Prof. Wilfried Hermann Schnitzler  
Chair  
Vegetable Sciences-Quality of Vegetable Foodstuff  
Technical University Munich  
Center of Life Sciences  
Weihenstephan, Dürnast II, D-85350 Freising Germany  
Tel: +0049-8161-713427 / +0151-1165-7081  
Fax: +0040-8161-714491  
E-mail: whs@wzw.tum.de

Dr. Dietmar Schwarz  
Group Leader  
Institute for Vegetable and Ornamental Crops  
Theodor Echtermeyer, Weg 1, D-14979, Grobbeeren Germany  
Tel: +49 33701 78206 / +49 33701 55391  
E-mail: schwarz@igzev.de

Kazakhstan

Dr. Serik Kenenbayev  
Director  
Scientific – Production Center of Crop Husbandry & Plant Industry  
1, Erlipesov St., Almalivak pos., Karasaiskii district, Almatinskaya region 483133 Kazakhstan  
Tel: +8-3272-983608  
Fax: +8-3272-983608

Acad. Abay Sagitov  
Director  
Research Institute of Plant Protection  
Rakhe Karasay district, Almaty region 33117 Kazakhstan  
Tel: +8-3272-295622  
Fax: +8-3272-295609
Dr. Temirjan Aytbayev
Director
Research Institute of Potato & Vegetable Farming
1, Institutskaya St., Karasarayskii district
Almatinskaya region 483123
Kazakhstan
Tel: +8-3272-983706
Fax: +8-3272-983706

Dr. Serik Djantasov
Deputy Director
Research Institute of Potato & Vegetable Farming
1, Institutskaya St., Karasarayskii district
Almatinskaya region 483123
Kazakhstan
Tel: +8-3272-983706
Fax: +8-3272-983706

Dr. Berdibek Bulashev
Associate Professor
Kazakh State Agrotechnical University
56/3, Birjansaly St. Astana 473000
Kazakhstan
Tel: +8-3172-382814

Mr. Toni Rogger
Economist
CYMMYT-DED-GTZ
P.O. Box 374, Almaty, 480000
Kazakhstan
Tel: +7-3272-284947 / +7-3272-282551
E-mail: arogger@nets.kz,
a.rogger@magnet.cl

Dr. Dae-Geun Oh
Director
Horticultural Biotechnology Division
National Horticultural Research Institute
Rural Development Administration
475, Imok-Dong, Jangan-gu
Suwon, 440-310
Korea
E-mail: daegeun@rda.go.kr

Kyrgyzstan

Mr. Akbaraly Abdivasiev
Head Specialist
Ministry of Agriculture, Water Management & Processing Manufacture
96a. Kievskaya St., Bishkek 720040
Kyrgyzstan
Tel: +996-312-623630
Fax: +996-312-623632
E-mail: mawr@bishkek.gov.kg

Dr. Sharshenbek Ismailov
Head of Department
Center of Agrarian Science & Extension Services, 354a, Lenin pr., s.
Lebedinovka, Alamedin district, 722160
Kyrgyzstan
Tel: +996-312-631342
Fax: +996-312-630487
E-mail: caniks@elcat.kg

Acad. Djamin Akimaliev
Director General
Research Institute of Crop Husbandry
73/1, Timur Frunze St., Bishkek 20027
Kyrgyzstan
Tel: +996-312-647154
Fax: +996-312-647907
E-mail: krif@mail.kg

Dr. Yuriy Levchenko
Head of Department
Research Institute of Crop Husbandry
73/1, Timur Frunze St., Bishkek 720027
Kyrgyzstan
Tel: +996-312-647154
Fax: +996-312-647907
E-mail: krif@mail.kg

Dr. Kurmanjan Osmonalieva
Head of Cathedra
The Kyrgyz Agrarian University
68, Mederov St., Bishkek 720027
Kyrgyzstan
Tel:/Fax +996-312-540445
E-mail: datkakurmanjan@rambler.ru

Korea

Dr. Sharshenbek Ismailov
Head of Department
Center of Agrarian Science & Extension Services, 354a, Lenin pr., s.
Lebedinovka, Alamedin district, 722160
Kyrgyzstan
Tel: +996-312-631342
Fax: +996-312-630487
E-mail: caniks@elcat.kg

Acad. Djamin Akimaliev
Director General
Research Institute of Crop Husbandry
73/1, Timur Frunze St., Bishkek 20027
Kyrgyzstan
Tel: +996-312-647154
Fax: +996-312-647907
E-mail: krif@mail.kg

Dr. Yuriy Levchenko
Head of Department
Research Institute of Crop Husbandry
73/1, Timur Frunze St., Bishkek 720027
Kyrgyzstan
Tel: +996-312-647154
Fax: +996-312-647907
E-mail: krif@mail.kg

Dr. Kurmanjan Osmonalieva
Head of Cathedra
The Kyrgyz Agrarian University
68, Mederov St., Bishkek 720027
Kyrgyzstan
Tel:/Fax +996-312-540445
E-mail: datkakurmanjan@rambler.ru
Mr. Azamat Kasymov  
Group Development Specialist  
German Agency for Technical Cooperation (GTZ)  
305/13, Lenin Street, Osh 14000  
Kyrgyzstan  
Tel: +996-3222-20380 / +996-5022-84403  
Fax: +996-3222-72930  
E-mail: cacosight2@knet.kg, azainfo@yahoo.com

Mr. Christoph Arndt  
Advisor to the Manager  
TES-Center (Agricultural Training and Extension)  
5, Say Boyu, Osh, 714018  
Kyrgyzstan  
Tel: +996-3222-57343  
Fax: +996-3222-56385  
E-mail: arndt@ktnet.kg, tes_centre@ktnet.kg

Mr. Myles Kevin Parker  
Crop Protection Specialist  
TES-Center  
5, Say Boyu Street, Osh, 714018  
Kyrgyzstan  
Tel: +996-3222-57343  
Fax: +996-3222-56285  
E-mail: mrparker@pmbx.net

Mr. Jumaboy Sodirovich Sodirov  
Agronomist, TES-Center  
5, Say Boyu Street, Osh, 714018  
Kyrgyzstan  
Tel: +996-3222-57743  
Fax: +996-3222-56385  
E-mail: tes_centre@knet.kg

Mongolia  

Mr. Khanimkhan Ivirai  
Deputy Director  
Department SPPD, Ministry of Food and Agriculture  
Government Building  
#9, Enktasian Ave., 16A  
Ulaanbaatar, 210349  
Mongolia  
Tel: +976-11-262953 / 976 99 11 4591  
Fax: +976 11 450140 / 262853  
E-mail: ikhanimkhan@yahoo.com

Philippines  

Mr. Willy Uy Co  
President  
The Asia & Pacific Seed Association  
c/o Allied Botanical Corporation  
Allied Agro Company  
21st Avenue, Tagumpay, Cubao, Quezon City, 1109  
Philippines  
Tel: +63-2-911-0836 / +63-2-917810187  
Fax: +63-2-911-0159  
E-mail: wco@alliedbotanical.com

Dr. Tumurdavaa Bayarsaihan  
Senior Agriculture Specialist  
Asian Development Bank  
6 ADB Avenue, Mandaluyong, Metro Manila  
Philippines  
Tel: +632-632-5966  
Fax: +632-636-2409  
E-mail: tbayarsaihan@abd.org

Taiwan  

Dr. Thomas A. Lumpkin  
Director General  
AVRDC – The World Vegetable Center  
P.O. Box 42, Tainan 74199  
Taiwan  
Tel: +886-6-5837801 / +886-6-5831962  
Fax: +866-6-5830009  
E-mail: lumpkin@avrdc.org
Dr. George Kuo
Director
International Cooperation Office
AVRDC – The World Vegetable Center
P.O. Box 42, Tainan 74199
Taiwan
Tel: +886-6-5837801 / +886-6-5831962
Fax: +886-6-5830009
E-mail: gkuo@avrdc.org

Dr. Liwayway M. Engle
Geneticist and Head
Genetic Resources and Seed Unit
AVRDC – The World Vegetable Center
P.O. Box 42, Tainan 74199
Taiwan
Tel: +886-6-5837801 / +886-6-5831962
Fax: +886-6-5830009
E-mail: lmengle@avrdc.org

Dr. Mubarik Ali
Agricultural Economist
AVRDC – The World Vegetable Center
P.O. Box 42, Tainan 74199
Taiwan
Tel: +886-6-5837801 / +886-6-5831962
Fax: +886-6-5830009
E-mail: mubarik@avrdc.org

Dr. Do-Ham Pae
Plant Breeder
AVRDC – The World Vegetable Center
P.O. Box 42, Tainan 74199
Taiwan
Tel: +886-6-5837801 / +886-6-5831962
Fax: +886-6-5830009
E-mail: pdoham@avrdc.org

Dr. Gwo-Chen Li
Executive Secretary
National Science and Technology
Program for Agricultural Biotechnology
Academia Sinica, Nankeng, Taipei 115
Taiwan
E-mail: gcli@tactri.gov.tw

Mr. Jinn-Jong Lin
Adviser
International Cooperation and Development Fund (ICDF)
2 Kaitakelan Blvd., Taipei
Taiwan
Tel: +886-2-23482852 / 0910-185560
Fax: +8862-23899694
E-mail: chclin@mofa.gov.tw

Tajikistan

Acad. Tolib Nabiev
President
Academy of Agricultural Science
44, Rudaki pr., Dushanbe, 734712
Tajikistan
Tel: +992-372-217004, +992-372-213680
Fax: +992-372-213757
E-mail: agroacad@tajik.net

Dr. Tursun Akhmedov
Director
Scientific-Production, Association “Bogparvar”
17, Giprozemgorodok, Dushambe, 734000
Tajikistan
Tel: +992-372-313747, +992-372-31538

Dr. Domulo Boboev
Director
Sogda Branch named after I. Michurin,
17, Giprozemgorodok, Dushambe, 734000
Tajikistan
Tel: +992-372-313747

Dr. Bakhrom Sanginov
Head of Department
Scientific-Production Association “Bogparvar”
17, Giprozemgorodok, Dushambe, 734000
Tajikistan
Tel: +992-372-313747, +992-372-311538
Dr. Geldi Goshayev
Director
Research Institute of Crop Husbandry
63, Azadi St., Ashgabat, 744000
Turkmenistan
Tel: +993-13-724840
Fax: +993-12-354348
E-mail: msvhtm@online.tm

Dr. Orazmirat Palvanmiradov
Head Researcher
Department of Vegetable Crops
Research Institute of Crop Husbandry
63, Azadi St., Ashgabat, 744000
Turkmenistan
Tel: +993-13-724840
Fax: +993-12-354348
E-mail: msvhtm@online.tm

Dr. Omerguly Akhmedov
Senior Researcher
Department of Vegetable Crops
Scientific-Production Experimental Center
Sayat Region, Lebap Province, 744000
Turkmenistan
Tel: +993-44-735356
Fax: +993-12-354348
E-mail: msvhtm@online.tm

Ms. Daniela Schwarz
International Adviser, DED/ Care Int’l
25, Bekhoz Street, Dushanbe
734013
Turkmenistan
Tel: +992-372-210091
Fax: +992-372-211778
E-mail: daniela@care.tajnet.com

Uzbekistan

Prof. Vladimir Zuev
Professor
Tashkent State Agrarian University
Universitetskaya St., Tashkent, 00140
Uzbekistan
Tel: +998-71-2639629, +998-71-2603852
Fax: +998-71-2637500

Prof. Odil Olimjanov
Head
Department of Analyses & Prognoesis in Agriculture, Ministry of Agriculture & Water Management
4, Navoi St., Tashkent, 700000
Uzbekistan
Tel: 998-71-1440920
Fax: 998-71-1391403

Prof. Batir Azimov
Head
Department of Plant Industry
Uzbek Scientific-Production Center for Agriculture
1, Usman Yusupov St., Tashkent, 700000
Uzbekistan
Tel: 998-71-1449152
Fax: 998-71-2418421

Prof. Abdushukur Khonazarov
Deputy Minister of Agriculture and Water Management
Director General of Uzbek Scientific Production Center
1, Usman Yusupov Str. Tashkent, 700000
Uzbekistan
Tel.: +998 712 1449152
Fax: +998 71-1394993

Prof. Toshtemir Astanokulov
Head
Department of Vegetable Growing
Samarkand Agricultural Institute
77, Ulugbek St., Samarkand, 704000
Uzbekistan
Tel: +998 71-331743, +998 71-381743
Mr. Lawrence Leahy
STCU Coordinator in Uzbekistan
Science and Technology Center in Ukraine
70, Y.Gulomov St., Tashkent, 700047
Uzbekistan
Tel: +998-71-1339544
Fax: +998-71-1320966
E-mail: lawrence.leahy@stcu.int

Mr. Alexey Kim
Project Coordinator Administrative Asst.
Science and Technology Center in Ukraine
70, Y. Gulomov St, Tashkent, 700047
Uzbekistan
Tel: +998 71 1206028
Fax: +998 71 1320966
E-mail: alexey.kim@stcu.int

Dr. Saidmurat Baboev
Consultant
Project GTZ-CIMMYT in Uzbekistan
354, Buyuk Ipak, Yuli, Tashkent
Uzbekistan
Tel: +998-71-1621892 / +998-71-1714891
Fax: +998-71-1621892 / +998-71-642230
E-mail: sai-baboev@yandex.ru

Dr. Galina Vladislavovna Stulina
Project Manager
Scientific Informational Centre of Interstate Coordination Water Farming Commission (SIC ICWC)
11, Massiv Karasu-4, Tashkent, 700187
Uzbekistan
Tel: +998-712-651658
Fax: +998-712-653969
E-mail: galina_stulina@mail.ru
Photo Gallery: Workshop Activities
Photo Gallery: Vegetable Research and Production

Shown above: 1) cabbage field in Uzbekistan; 2) pepper and tomato seedlings in shelter protected against cold in Uzbekistan; 3) hybrid tomato trial in Kazakhstan; 4) carrot root planting for seed production in Kazakhstan; 5) snap bean trial in Azerbaijan; 6) peri-urban carrot-apple intercropping in Uzbekistan; 7) checking on cabbage diseases in Kazakhstan; and 8) peri-urban greenhouses in Uzbekistan
Shown above: 9) cucumbers in heated greenhouse in Uzbekistan; 10) greenhouse tomato growers in Uzbekistan; 11) diversity of melons in Kazakhstan; 12) harvesting tomato in Turkmenistan; 13) transport of onion in Uzbekistan; 14) carrot underground storage in Kazakhstan; 15) Uzbek kimchi; 16) pepper products; 17) carrot seed production in Kazakhstan; and 18) Brassica seed production in Uzbekistan
INCREASING MARKET-ORIENTED VEGETABLE PRODUCTION IN CAC

Shown above: 19) onion seed production in Kazakhstan; 20) local seed vendor in Uzbekistan; 21) imported seed vendor in Uzbekistan; 22) vegetable lecture room in Uzbekistan; 23) rearing of beneficial insects in Uzbekistan; 24) genebank seed storage in Uzbekistan; and 25) research output display in Kazakhstan
Photo Gallery: Vegetables at the Market
INCREASING MARKET-ORIENTED VEGETABLE PRODUCTION IN CAC