CGIAR REGIONAL PROGRAM FOR CENTRAL ASIA AND THE CAUCASUS

Annual Report 2012 - 2013

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ACRONYMS

ADB	Asian Development Bank
ARI	Advanced Research Institute
AVRDC	World Vegetable Centre (Asian Vegetable Research and Development Centre)
BMZ	The Federal Ministry for Economic Cooperation and Development (Germany)
CAC	Central Asia and the Caucasus
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	International Maize and Wheat Improvement Centre
CIP	International Potato Centre
CRP	CGIAR Research Program
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GIZ	The German International Cooperation Agency
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICBA	International Centre for Biosaline Agriculture
ICRISAT	International Crops Research Institute for Semi-Arid Tropics
IDB	Islamic Development Bank
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IPM	Integrated Pest Management
IWMI	International Water Management Institute
IWWIP	International Winter Wheat Improvement Program
KASIB	Kazakhstan-Siberian Network On Wheat Improvement
MSU	Michigan State University
NARS	National Agricultural Research System
NGO	Non-Governmental Organization
PFU	Program Facilitation Unit

PGR	Plant Genetic Resources
SDC	Swiss Agency for Development and Cooperation
SIC-ICWC	Scientific Information Centre of Interstate Commission for Water Coordination in Central Asia
SVTC	State Variety Testing Commission
TAAS	Tajik Academy of Agricultural Sciences
TPS	True Potato Seed
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WUA	Water Users Association
WUE	Water Use Efficiency

INTRODUCTION

This Annual Report provides an overview of the collaborative work carried out by the international agricultural research centers and their national partners from eight countries under the umbrella of the CGIAR Regional Program for Central Asia and the Caucasus (CAC). It covers the period of one year from mid-2012 to mid-2013.

The Program activities continue to build on many years of applied research that produces results for increasing the productivity of agricultural systems through germplasm enhancement, crop improvement and diversification, as well as natural resources management, underpinned by socioeconomic and public policy research. The Program and its partners work on the conservation, study and evaluation of genetic resources in the Region; breeding and development of improved crop varieties; development and introduction of soil and water management technologies and practices. All these areas have seen considerable progress over the past year, as the Annual Report describes in some detail.

In 2012-2013 researchers evaluated a number of improved breeding lines and out-scaled selected varieties of wheat, potato, vegetables, and food legumes. A number of new crop varieties were also released. For instance, chickpea variety 'Aragvi' and lentil variety 'Tsilkani' in Georgia, and chickpea varieties 'Karin', 'Sipan' and 'Arpi' in Armenia were released. Three winter wheat varieties 'Hazrati Bashir', 'Elomon' and 'Gozgon' were given the status of prospective varieties in Uzbekistan. Large-scale seed multiplication of these three varieties is under way. What is more, farmers are also involved in seed production of these varieties. Many high-yielding winter wheat lines with resistance to yellow rust were identified through collaborative research involving ICARDA, CIMMYT and the International Winter Wheat Improvement Program (IWWIP). Results of studies in 2013 at three sites in Uzbekistan showed that there were several yellow-rust-resistant lines that produced significantly higher grain yields than the local checks.

Researchers also continued efforts to conserve native horticultural crops and wild fruit species in Central Asia. As part of a conservation project, national partners in five countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) conducted household surveys of farmers to assess the impact of the project activities distribution and diversity level of target fruit crops and livelihoods. In total, 727 households were surveyed including 114 households in Kazakhstan, 89 in Kyrgyzstan, 216 in Tajikistan, 98 in Turkmenistan and 210 in Uzbekistan. A total of 132 promising forms of wild fruit and nut-bearing species were identified in the forests (*in situ*). Furthermore, 59 nurseries were established for multiplication of local varieties of target fruit crops and promising forms of wild fruit species in all partner countries. As a result, production of planting material in the Region increased by 2.8 times in 2012 in comparison with 2007.

Work also continued on introducing improved varieties of sorghum and pearl millet for crop diversification in Central Asia. To make the most of salt-affected and marginal lands in the Region, high-yielding, salinity-tolerant sorghum and pearl millet lines and cultivars, as well as crop management technologies for economic and sustainable crop-livestock production systems, are being developed and introduced. For example, after screening more than 52 improved lines of pearl millet through on-station and on-farm trials, some 12 varieties of pearl millet were identified as the most salt/drought-tolerant and highly productive varieties for food and forage production. Among sorghum varieties evaluated so far, eight were found to yield more than some local lines. All of these improved lines of sorghum produced about 30% higher dry fodder and 25% higher seed yield than the local varieties.

During this period, improvement and diversification of vegetable crops also received a boost. During regional varietal trials in 2012, a total of 78 accessions of six vegetable crops were introduced to eight countries of the Region. In addition, a total of 106 accessions of ten vegetable crops were introduced to research institutes of four countries based on specific requests. In 2013 some 89 accessions of five species were under evaluation in the Region.

To protect crops, ecologically-based Integrated Pest Management (IPM) packages are being developed and delivered in the Region. In Tajikistan in particular, a five-year (2009-2014) collaborative program is in full swing to develop and deliver ecologically-based IPM packages for key food security crops. The program aims to develop IPM packages for wheat and potato through collaborative research and access to new technologies. Three IPM applied research and demonstration sites were established for collaborative research, training and outreach to farmers. These pilot sites have been used as Farmer Field Schools (FFS) to disseminate research findings to local farmers.

The Program also continued capacity-building activities aimed at farmers and researchers. One of the major achievements, for instance, was a four-year project on value-added fiber supported by IFAD. It has increased employment opportunities and income options for poor rural populations, particularly vulnerable women, in Tajikistan and Kyrgyzstan. The initiative targeted specifically rural women artisans and small livestock breeders, and aimed to improve their livelihoods and income through improved production, processing and export of value-added fiber.

We would like to acknowledge the contributions of all our partners with whom we have worked in our efforts throughout the year, the guidance, support and encouragement received from the Program Steering Committee and from ICARDA as the host Center, and the highly dedicated team of scientists and support staff in Central Asia and the Caucasus.

GERMPLASM ENHANCEMENT IN WHEAT, BARLEY AND FOOD LEGUMES

Aims and scope of work

Every year ICARDA, CIMMYT and IWWIP in partnership with national wheat improvement programs in the CAC introduce and evaluate improved germplasm of winter and spring wheat to address the prevalent production constraints in the Region. Each year, more than 1,000 advanced breeding lines and improved germplasm of wheat received as international nurseries are tested for high yield potential, improved quality traits and tolerance to the prevalent abiotic and biotic stresses. Similarly, ICARDA in collaboration with national partners introduces and tests more than 1,000 advanced breeding lines of barley, chickpea, lentil, fababean and grasspea in the CAC Region every year to identify high-yielding varieties with tolerance to drought, heat, diseases and pests. Besides, basic genetic and breeding studies are conducted, primarily by involving postgraduate students and young researchers to complement capacity-building efforts in germplasm characterization and crop improvement. In order to develop improved varieties of cereals and food legumes accessible to rural farmers to improve their livelihoods, varietal adoption is promoted through seed multiplication and farmers' field demonstrations. ICARDA and CIMMYT give priority to capacity-building through short- and long-term training of young researchers, specialized research projects and opportunities for participation in international meetings and conferences.

General weather conditions during the 2012-2013 crop season

The winter crop season 2012-2013 was somewhat drier than average in most parts of the CAC Region. The autumn months in 2012 saw normal rainfall resulting in timely planting of winter crops. The winter was shorter and milder than normal, followed by long cool spring. Due to long cool spring conditions, severe infections of yellow rust were recorded in many parts of the CAC Region. Cereals and legumes production in 2013 is expected to be normal except in land pockets where wheat yellow rust epidemics prevailed for a long period.

Distribution of international nurseries

Evaluation of improved breeding lines and out-scaling of selected varieties of wheat, barley and chickpea were the major activities accomplished in the 2012-2013 crop season. More than 2,000 advanced breeding lines of wheat, barley, chickpea, lentil, fababean and grasspea were distributed among the national programs in the eight countries following their requests. The number of international nursery sets across the CAC Region included 48 winter wheat, 25 spring wheat, 30 durum wheat, 51 barley, 76 chickpea, 72 lentil, eight fababean and 14 grasspea.

New crop varieties

During the reporting period, food legumes varieties released in the CAC originating from ICARDA nurseries are 'Aragvi' chickpea and 'Tsilkani' lentil in Georgia and 'Karin', 'Sipan' and 'Arpi' chickpea in Armenia.

Three winter wheat varieties ('Hazrati Bashir', 'Elomon' and 'Gozgon') originating from germplasm provided by IWWIP which had been submitted to the SVTC of Uzbekistan by Kashkadarya Research Institute of Grain Breeding and Seed Production in collaboration with ICARDA in 2010 were given the status of prospective varieties. In this status, large-scale seed multiplication of these three varieties was undertaken. All seed of these three varieties harvested in 2013 will be planted for further multiplication in 2013-2014. Farmers are involved in seed production of these varieties.

High-yielding winter wheat germplasm distributed in the CAC Region

Many high-yielding winter wheat advanced lines with resistance to yellow rust were identified through collaborative research involving Kashkadarya Research Institute of Grain Breeding and Seed Production, the Uzbek Research Institute of Plant Industry, ICARDA and IWWIP. Seeds of 20 superior lines were distributed to wheat improvement programs in Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. Results from 2013 across three sites in Uzbekistan showed that there were several stripe rust resistant lines that produced significantly higher grain yields than the local checks. A number of these stripe rust resistant lines also possess early maturity, high 1,000-kernel weight, lodging tolerance, and preferred plant height and other agronomic traits. These lines could be useful for wheat improvement programs in Central Asia as new cultivars as well as improved parental sources of stripe rust resistance. Several of these lines are being considered as candidate cultivars in Uzbekistan.

Accelerated adoption of yellow rust resistant winter wheat varieties

Yellow rust is the most important disease constraint causing substantial grain yield reductions. If controlled by fungicide spray, as done in Uzbekistan, cost of cultivation increases, which reduces farmers' income. Through funding support from CRP WHEAT partners' grant scheme, seed multiplication was initiated in 2012-2013 using four yellow rust resistant varieties ('Hazrati Bashir', 'Elomon', 'Gozgon' and 'Yaksart') in Uzbekistan in an area of 65 ha and three varieties ('Ormon', 'Alex' and 'Chumon') in an area of 61 ha in Tajikistan. There are plans to continue seed multiplication in an area of 1,000 ha in Uzbekistan and 1,000 ha in Tajikistan.

IWWIP regional activities in Uzbekistan

Based on the recommendation of the regional Wheat Strategy meeting held in 2009, wheat yield trials from IWWIP continued to be evaluated in Uzbekistan with the aim of developing targeted winter wheat yield trials for the CAC Region under IWWIP. The nurseries under evaluation at two sites in Uzbekistan include five replicated yield trials (250 advanced breeding lines), three observation nurseries of facultative and winter wheat, and winter wheat screening nurseries for Ug99 stem rust and several other miscellaneous nurseries. Many superior lines of winter/facultative wheat were identified in the yield trials and observation nurseries were tested in the CAC Region in 2013, and superior lines were selected by the NARS partners for planting in 2013-2014.

Identifying salinity-tolerant winter/facultative wheat

ICARDA, in collaboration with the NARS partners in Uzbekistan, Kazakhstan and Turkmenistan started in 2010 a project titled 'Utilization of wild relatives of wheat in developing salinity tolerant winter wheat with improved quality for Central Asia', funded by BMZ/GIZ. Three sets of improved materials (more than 600 accessions) were tested under this project in Uzbekistan and Turkmenistan. Several lines possess tolerance to medium level soil salinity and produce over 25% higher yield than the local checks. The superior lines selected from this study will be further tested for identifying new cultivars for saline soils as well as for their use in crossing programs. In Turkmenistan, one salinity-tolerant winter wheat line is under consideration for submission to the State Variety Testing Commission.

Capacity building

During the reporting period ICARDA facilitated the participation of young scientists from the CAC Region in the following capacity-building activities:
One young researcher from Uzbekistan received four-month training on wheat improvement at CIMMYT, Mexico, in early 2013. A total of 17 young researchers participated in a two-week long training workshop on production and quality testing of wheat seed conducted by ICARDA, CIMMYT and Kashkadarya Research Institute of Grain Breeding and Seed Production in Uzbekistan. Ten young

researchers from Uzbekistan and Azerbaijan participated in a two-week training workshop on wheat breeding and genetics conducted by ICARDA in Uzbekistan. Twenty-three researchers and policymakers from the CAC participated in the International Winter Wheat Traveling Seminar organized in Uzbekistan from 20-25 May 2013. The participants learned about the collaborative work on wheat improvement in Uzbekistan with ICARDA, CIMMYT and IWWIP.

CRP Dryland Systems

The superior germplasm of cereals and food legumes identified through their evaluation in the Region will be tested in adaptive trials at CRP sites in Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan starting in the autumn 2013. Besides, recently released improved varieties will be promoted through demonstration trials and seed multiplication.

Centers: ICARDA, CIMMYT
Project period: ongoing
Donors: CRP Dryland Systems (Russian Federation); BMZ; CRP Wheat
Countries: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan

KAZAKHSTAN-SIBERIAN NETWORK ON WHEAT IMPROVEMENT

Aims and scope of work

KASIB was established by CIMMYT in 2000 as a result of cooperation between wheat breeding ARIs in northern Kazakhstan and western Siberia (Russia). The objective of KASIB is to improve the efficiency of spring wheat breeding in northern Kazakhstan and western Siberia through exchanging new varieties, breeding material, coordinated assessment of germplasm, exchanging information, meetings and discussions. At present, KASIB unites 19 breeding programs from Kazakhstan and Russia that have been conducting wheat breeding in the area of over 20 million ha. Regular exchanges are undertaken through nurseries of bread (KASIB-SBW) and durum (KASIB-SDW) wheat that are formed using best samples presented by the breeding programs. The criteria for evaluation of the material included biological and economically valuable traits that had been studied in different ecological conditions. The traits for varieties evaluation in KASIB are vegetation period, height of plants, top internode length, yield, 1,000 KW, test weight, disease resistance (leaf, stem and stripe rust, powdery mildew, septoriosis), lodging and shattering resistance.

The 13th KASIB nursery was studied in 2012 and consisted of 52 spring bread wheat and 21 spring durum wheat varieties. As part of a structural change of nursery along with the local varieties (early, mid-late and late), the 13th KASIB nursery included new commercial varieties such as 'Pamyaty Azieva', 'Tertsiya', 'Astana 2' and 'Omskaya 35'; historical check 'Saratovskaya 29' and three lines ('Fiton C 50', 'Line C 19' and 'Lutestsens 24') derived from the shuttle breeding program and entered into Yield Trial (YT). The statistical analysis of data obtained was made and the best cultivars were selected that demonstrated advantages compared with the other varieties. Among the bread wheat varieties, the following were notable: 'Line 241-00-4' (Kurganseed Company), 'Ekada 113' (Ekada spring wheat network), 'Lutestsens 151-03-85', '311-00-22-6' (Omsk ARI), 'Soltustyk' (Kazakh Institute of Grain Farming), 'Lutestsens 697' (Altay ARI), 'Lutestsens 4' (Karabalyk ARS). These varieties were 10-15% more high-yielding than average.

The screening of varieties to leaf and stem rust resistance was carried out in natural and artificial conditions. The most resistant genotypes ('Ekada 113', 'Lutestsens 151-03-85', 'Omskaya 41', 'Eritrospermum 23390') showed resistance to leaf rust. Varieties 'Fiton C 50', 'Lutestsens C 19', 'Stepnaya volna', 'Omskaya 41', 'Eritrospermum 23390' showed resistance to stem rust. The varieties were also selected based on the other biological and economically valuable traits.

Among the durum wheat varieties, the highest yield was produced by 'Line 653d-44', '688d-4' (Samara, Russia), 'Hordeiforme 677' (Altay, Russia), 'Omskiy izumrud', 'Hordeiforme 00-96-8' (Omsk, Russia), 'Kargala 1538' (Aktobe, Kazakhstan). The summarized and statistically processed results were distributed in the form of annual bulletin to all breeding programmes. About 25% of the studied KASIB varieties are being used by breeders for crossing in their own breeding programs.
Since 2012 CIMMYT-Kazakhstan has been doing research on 'Developing spring bread wheat varieties resistant to the most important abiotic and biotic stresses based on the Kazakhstan-Siberian Wheat Improvement Network (KASIB) and Shuttle Breeding Program 'Kazakhstan - Mexico' under the Kazakh Budget Program No 042 'Applied Research in Agriculture' (2012-2014). A total of 50 wheat varieties of KASIB 10-11 nurseries were studied. In total, 20 parameters of grain quality were tested including hardness, protein and gluten content, colour of flour, baking score, etc. Comparative assessment of grain quality analysis methods used in Kazakhstan was carried out. A statistical analysis of genotype-environment interactions of quality and productivity of wheat was performed.

Shuttle breeding between Kazakhstan and CIMMYT-Mexico

Shuttle breeding was established by CIMMYT in 2000. The crossing program conducted in Mexico emphasizes Kazakh x Mexico crosses as well as top crosses with the relevant US and Canadian germplasm. The best entries of F5-F6 progenies are selected to make the Kazakh-Siberian Shuttle Breeding Nursery (KSBN). KSBN is distributed to all co-operators in Kazakhstan and Russia. The number of crosses and F4-F5 progenies developed in Mexico from crosses among CIMMYT and Kazakh/Siberian material for shuttle breeding during 2000-2012 is 5,885.
Since 2009, in order to enhance breeding efficiency and expand shuttle breeding network, multiplication and initial assessment of F5-F6ME6KAZ populations from Mexico have been undertaken at two locations, namely in Karabalyk (Kazakhstan) and Omsk (Russia). Kazakh Shuttle Breeding Nurseries (KSBN) and Russian Shuttle Breeding Nurseries (RSBN) compiled after the studies were distributed to Kazakh and Russian collaborators. The total number of program collaborators in 2012 was 14 institutions.
The new shuttle material 'F5-F6ME6KAZ' (800 entries) was planted and evaluated in the Republican Quarantine Nursery, Karabalyk Experimental Station (Kazakhstan) and Omsk Agrarian University (Russia). In order to compile the 12th KSBN the F5-F6 populations were selected.
The 11th KSBN comprising 183 entries were studied at six institutions of Kazakhstan, and the 11th RSBN of 127 entries at nine institutions of Russia. Data demonstrates high efficiency of the studies. Efficiency of selection from hybrid populations in a number of institutions (Pavlodar, Novosibirsk ARIs, Tyumen and Omsk SAUs) reached up to 95-100%. The most adaptive lines are those selected throughout more ecological locations. The adaptation of the shuttle germplasm to high latitude environment is gradually improved. Some of the advanced shuttle lines were entered into PYT and YT in different breeding programs: Fiton company, Karabalyk, Karaganda, and Chelyabinsk. The largest amount of shuttle advanced lines in YT was selected at Fiton breeding company. The total number of shuttle material in the breeding process increased significantly. Thus, the number of lines in the BN-1 for the last four years (2009-2012) increased by 4.4 times, in the BN-2 by three times. Most of the lines selected from the 3-5 KSBN were 8-14% more high-yielding than local check 'Akmola 2'. An annual bulletin of KASIB and KSBN results (82 pages) was published and distributed to the members of KASIB Network.

Winter wheat breeding

Winter wheat is cultivated in south, southeast and southwest Kazakhstan in an area of over 400,000 ha. Breeding of winter wheat is carried out through four breeding programs. Winter wheat breeding in the southern regions is undertaken both for irrigated and rainfed conditions, while in the north and east (Karabalyk, Ust-Kamenogorsk) for rainfed conditions. The limiting factors are extremely continental climate and harsh winters, which determine the breeding trend aimed at increasing wheat frost resistance. In 2012, 778 entries from nurseries '5th RWKLDN', 'MX103-04 MIYCSN', 'LSSN', '13 HRWYT', '16 HRWSN', '8 WON-SA', '8th HLWWC', '10th IWWYT-SA', '11th IWWYT-IR', '12 IWWYT-IR', '15 FAWWON-IR', '15 FAWWON-SA', '16 FAWWON-IR', '16 FAWWON-SA', '18th FAWWON-SA', '18th

FAWWON-IR', which were released from CIMMYT in previous years, were evaluated repeatedly in EYT 1-2. Assessment was undertaken for 350 entries identified from the environmental test under the breeding process. Yield of winter wheat varied from 1.06 to 7.56 t/ha. About 30% of entries surpassed the check varieties in yield capacity by 0.4-2.5 t/ha. Display of leaf diseases including SR, LR and YR under natural conditions were not observed. In addition, 531 entries of new nurseries ('19th FAWWON-IR', '19th FAWWON-SA', '14th IWWYT-SA', 'WWYRRN') received in 2011, were studied for the first time in four institutions.
Severe climate and cold winters of north Kazakhstan are usually unfavourable for winter wheat production. Nevertheless, the development of winter wheat varieties suitable for these conditions and appropriate agronomy practices based on no-till technologies with straw and stubble retention represents a good alternative option for crop production in a huge area of north Kazakhstan. Such approach may be of high importance because of the aggravation and frequency of drought summers during last decades; in case of a positive solution of winter wheat production in north Kazakhstan the farmers could avoid damaging effect of summer droughts on wheat yield. Testing of 265 entries of winter bread wheat was undertaken in Karabalyk. In addition to local material, the study involved genetic material from CIMMYT, Russia, Ukraine, Bulgaria, Canada etc. CIMMYT material was represented by the following nurseries: WWYRRN-FB, WWSRRN-FB, 12F2 TCI-COLD. The promising material was selected at all stages of breeding process. A total of 50 best lines, 18 of which were from Novosibirsk (NWWN), were studied in YT. The local check was outperformed by 15 lines: 'Lutestsens 397 II', 'Lutestsens 437 II', 'Lutestsens 372 II' and 'Lutestsens 635 II' showed the highest yield and surpassed the local check by 0.24-0.47 t/ha.
The following nurseries the 15th IWWYT-SA, 16th IWWYT-IR, 20th FAWWON-SA, 20th FAWWON-IR, were planted in 2012 in Kazakh ARI of Farming and Crop Production (southeast Kazakhstan), Karabalyk ARS (southwest Kazakhstan), east Kazakhstan ARI, Krasnovodopad ARS (south Kazakhstan). Ecological testing of winter triticale varieties was initiated to diversify crop production.

Biofortification of wheat by zinc and iron

During the reporting period, the results of 29 field experiments conducted in 2006-2012 by CIMMYT on biofortification research were summarized. To identify properties of flour available in retail sale the locally produced flour was analyzed. The flour samples represented the largest flour producing companies from key grain producing regions - Akmola, north Kazakhstan and Kostanay. Analysis of four high-grade and four grade one flour samples were performed at Sabanci University (Turkey). Analysis findings suggest that Fe concentration in the samples varied from 5.9 to 21.3 mg/kg. Zn concentration ranged from 5.4 to 13.0 mg/kg. Analyzed samples in general are characterized by low Zn and Fe concentration. Only one flour sample (OJSC Rozovskoye) was found to have 13.2 mg/kg of Fe and 13.0 mg/kg of Zn. In general, the Kazakh flour available on the local market is characterized by low micronutrient concentration. It was identified that the higher flour grade and less flour output the less micronutrients are present in the wheat flour. Fe and Zn in grade one flour on average were higher than those of high-grade flour by 1.7 and 1.2 times respectively.
Both breeding and agronomic approaches to increase the concentration of Zn and Fe micronutrients in wheat grain were applied. The level of Fe and Zn concentration in the grain of over 400 of commercial spring and winter wheat varieties, advanced lines and genetic recourses used in breeding programs in Kazakhstan was determined. The promising genotypes with high Fe and Zn concentrations in the grain were identified. In this study iron showed large variation among genotypes, ranging from 25 to 67 mg/kg. Similarly, zinc concentration varied among genotypes, ranging between 12 and 54 mg/kg.
An international Semi-Arid Micronutrient Yield Trial (SAMNYT) consisted of 20 entries, of which nine were synthetic wheat lines, was done in three locations: Shortandy, Karabalyk and Aktobe. The 3rd and 4th SAMNYT nurseries were planted with two treatments: (i) Application of 50 kg Zn prior to planting; (ii) Nil Zn application. Pre-sowing soil application of zinc increased zinc concentration in the grain by an average of 4-7 mg/kg or 17-25%, while maintaining the yield of varieties at the same level. Zinc application was found to increase both zinc and iron as shown by grain analysis findings. Fe and Zn increase was 1-7 mg/kg and 3-24 mg/kg respectively. It should be mentioned that not all genotypes responded equally to Zn application. For example, varieties 'Seri M 82' and 'Sonora 64' showed a 10%

increase, while varieties 'Incalab 91', 'Oasis F86', 'T.DIC.PI94625/AE.SQ.(372)//TUI/GLMS/3/*PASTOR' were characterized by more than a 40% increase. On the concentration of zinc in the grain the varieties of SAMNYT nursery on control plots exceeded the local varieties by 3-8 mg/kg. Under zinc application the best genotypes ('PBW343', 'CUCURPE S86', 'T.DICOCCON PI94625/AE.SQUARROSA (372)//TUI/GLMS/3/*PASTOR' etc.) exceeded the local varieties by up to 24 mg/kg.
The role of soil and/or leave-applied various doses of Zn fertilizers on wheat grain accumulation was investigated. The application was made at the following stages to determine the optimal plant growth stages: (i) tillering, (ii) tillering and booting, (iii) booting, (iv) heading, (v) heading and grain filling, (vi) grain filling. Off-root Zn application was under two treatments: (i) 50 kg/ha application into the soil; (ii) nil soil application.
The results of experiment indicate that the maximum effect was reported on the treatment with two applications at the heading and grain filling stages. The maximum rate was 68 mg/kg on that treatment. When combined with the off-root application into the soil, Zn concentration efficiency in wheat grain was even higher reaching 76 mg/kg or exceeding Zn concentration by 3.8 times compared with the check treatment with nil Zinc application. These results suggest that soil and foliar application of Zn fertilizers is very promising short-term approaches of rapid increase of Zn in seeds.
Environment, including meteorological conditions during the year, had significant effect on the extent of biofortification by both genotypes and agronomic approaches. Soil, foliar and combined soil & foliar Zn application as an agronomic strategy meets the criteria of biofortification and it alone or combined with elite genotypes in future could maximize the effect of biofortification for overcoming Zn malnutrition. Combination of breeding and agronomic approaches will be the most promising strategy for biofortification of wheat grain with Zn for overcoming Zn malnutrition.
The results obtained from this study can be very important for Kazakhstan’s wheat breeding programs, and are also useful since many Asian developing countries including Uzbekistan, Tajikistan, Kyrgyzstan etc import flour and grain from Kazakhstan.

Centers: CIMMYT
Donors: CRP Wheat; Kazakhstan State Budget Program No.042 'Applied Research in Agriculture'
Project period: 2012- 2014
Countries: Kazakhstan

GERMPLASM CONSERVATION AND ENHANCEMENT IN POTATO

Aims and scope of work

Several research studies were carried out on potato germplasm within the BMZ/GIZ project 'Enhanced food and income security in South-West and Central Asia (SWCA) through potato varieties with improved tolerance to abiotic stress', which was initiated in 2008 and completed in 2011. The project aimed at research of potato cultivars' response to water stress before releasing appropriate cultivars/varieties in regions experiencing such abiotic stress conditions. Imported potato varieties are not adapted to local conditions because they are selected usually in the northern European environment, and therefore, under agro-ecological conditions where water supply is not an issue, and heat and salinity are not constraints. In general, those varieties have been grown for the European farmers who can afford to pay high prices for the regular replenishment of seeds. In Uzbekistan, it was estimated that only large farmer households can purchase imported seeds of European varieties and plant them in 15-20% of the whole potato cultivated area.

Uzbekistan - PSTV infestation

Due to the positive result of tests conducted in Lima, the potato disease PSTV (Potato Spindle Tuber Viroid) was found in many samples of the CIP collection cultivated in the mid-elevation research site of Pskem. The unanimous decision was to eliminate the entire collection and seed potatoes harvested in

October 2012 - about 15 tons of seed - that were buried at about 1m depth and covered with lime. CIP's research work was consequently considerably delayed although the germplasm materials kept in-vitro were found disease-free. Furthermore, the research site was declared improper for research purposes for at least three years, on condition that the Institute of Vegetables, Melon and Potato would implement a protocol of rotations with wheat or barley, peas, as preferred crops. PSTV is an EPPO (European and Mediterranean Plant Protection Organization) A2 quarantine pest (OEPP/EPPO, 1978) and is also of quarantine significance for NAPPO (North American Plant Protection Organization). EPPO suggests that importation of seed potatoes may be prohibited from countries where PSTV occurs (OEPP/EPPO, 1990). In the country, PSTV is endemic, but unfortunately not considered as a quarantine disease. This will prevent Uzbekistan from becoming a seed potato exporter unless serious measures are taken by the government to eradicate the disease.

Some relevant results from the BMZ-funded project

Climate change and relative reduced water supply to potato growers in the downstream regions of the Aral Sea basin underline the importance of sustainable agricultural production systems. In this regard, two field experiments were conducted in Tashkent Region under the semi-arid and arid conditions of the first and second growing season of the double cropping system of the temperate lowlands, respectively, to test the response of some potato genotypes to water-saving techniques. Haulm killing was carried out at 90 days after planting in both trials and harvest conducted ten days later. In the first trial (28 March - 26 June) consisting of a RCB design the objective was to test variety 'Pskem' (CIP 390478.9) under three different irrigation methods: (i) conventional furrow irrigation according to local standards with water applied to every furrow; (ii) fixed partial root-zone drying technique (FPRI), where a fixed half of the root zone is always irrigated while the other half is always dried; (iii) the partial root-zone drying (PRD) irrigation technique consisting of water applied every two furrows, but in a reverse system with second and further irrigation applied to the furrows which were kept dry during the previous irrigation. Each plot had four rows, with 20 plants/row (14.0 m^2) at the planting distance of 0.7 x 0.25 m. The second trial (14 July - 12 October) consisted of a 2 (varieties: 'Sante' and 'Pskem' or CIP 390478.9) × 4 (irrigation treatments) factorial experiment in a randomized complete block design with three replications for a total of 2 × 4 × 3 = 24 plots. Each plot had four rows, with 20 plants/row at the planting distance of 0.7 x 0.25 m (14.0 m^2). The four treatments were as follows: (i) Standard irrigation practice (irrigation in every furrow) with no less than 42 m^3 of water which corresponds to 10,000 m^3 of water per ha; (ii) Deficit irrigation, with irrigation water applied to every furrow, and no less than 33.6 m^3 of water, which corresponds to 8,000 m^3 of water per ha; (iii) Partial root-zone drying or irrigation in every two furrows in a reverse system, with no less than 21.0 m^3 of water, which corresponds to 5,000 m^3 of water per ha; (iv) Mulching (with application of 10 cm deep wheat straw in each furrow) and irrigation in every two furrows in a reverse system and no less than 12.6 m^3 of water, which corresponds to 3,000 m^3 of water per ha.

In the WUE trial implemented in Tashkent Region during the first growing season, decreasing water supply to about one half resulted in significantly lower yields for the local variety 'Pskem' (33.1 to 24.7 and 25.8 t/ha) and lower specific gravity (1.077 vs. 1.067 and 1.069 respectively) with harvest at 90 days after planting, during the first growing season. Conversely, Water Use Efficiency (WUE) increased with the reduction of the amount of water supplied (2.65 vs. 4.1 and 3.72 kg/m^3). On the other hand under the higher temperatures of the second growing season, reducing the supplied water to about one half did not affect fresh tuber yield since the interaction Genotype x Irrigation method was not significant; whereas WUE was equally incremented for all the reduced water treatments. There was only a significant difference across genotypes (24.3 vs. 21.8 t/ha for varieties 'Sante' and 'Pskem', respectively, at 5% level of significance). During the second growing season the results showed that application of irrigation water per unit area can be reduced in relation to common practices in Uzbekistan, maintaining in the meantime the tuber yields currently obtained by local farmers. Under low precipitation, high temperatures and low water retention capacity (16% under the sandy clay loam conditions of the trial) the use of straw mulching can make the difference by maintaining a high yield while reducing the wasteful use of water resources. Furthermore, reduction in evaporative surface had an indirect positive effect on soil salinity as the periodic determination of soil electric conductivity all along crop development demonstrated.

Participatory varietal evaluation

Immediately after the project inception meeting in March 2012, a training course was organized with stakeholders, among them researchers, advisors and potato growers to present the rudiments of Participatory Varietal Evaluation. On that occasion a Russian-translated manual explaining the principles of Mother & Baby trials for potato was distributed to all the participants.
In July 2012, a Mother & Baby trial was implemented in Zangiota District of Tashkent Region, with the participation of the Institute of Vegetables, Melon and Potato, and 19 farmers. The mother trial was set up with twenty-two genotypes, among them varieties, advanced clones and F1C2 TPS families, in three replications, while each one of the nineteen farmers received a sample of 20 tubers per genotype. In the mother trial TPS family 998019 (25.1 t/ha) performed the best but the yield was not significantly higher than '998010' (23.9 t/ha), '388611.22' (23.2 t/ha) and other seven varieties/clones. A significant linear relationship was found between tuber yield and number of tubers per plant with the equation $y = 0.502044 + 3.031546x$ and a determination coefficient $R2 = 0.67$. The regression coefficient 3.031546 meant that in this model, the yield increased by 3 t/ha for each additional tuber unit increase per plant. In the baby trial conducted at farm level and where the 19 farmers were each considered as a replication, clones '392797.22' and '397077.16' (variety 'Sarnav') were the best to perform with a tuber yield of 23.0 and 21.0 t/ha respectively. A positive correlation ($r = 0.677$) was found between the two trials meaning that results were positively correlated.

Baseline data surveys

A baseline data survey based on irrigation and potato cultivation methods involved 28 farmers each in Fergana and Andijan Regions. It was carried out by two advisors of the respective Water Users' Associations in September 2012. Some differences were noticed between farmers living in Andijan compared to those located in Fergana. While in Andijan irrigation water is supplied when plants start wilting, in Fergana this is done when soil cracks appear. Weeds are a big problem everywhere and are heavily competing with potato plants for light, nutrients and water. Farmers are unable to quantify the cost for weeding although it takes a considerable part of their time that they could allocate to other activities. The majority of farmers prefer planting in one season of the double cropping system of the lowlands because their choice is dictated by the seed variety available. If it is an early variety, then planting is in February-March, while July planting is privileged only if medium or mid-late varieties are available. Farmers also prefer planting on ridges already formed at planting, while in many other areas of the country planting is done on the edge of furrows with ridges built up little by little after plant emergence. All the interviewed farmers confirmed that they start irrigation only when soil cracks appear because they do not have any means to measure soil-moisture levels. Water is normally applied up to half height of the ridge, but some of them wait till the water reaches the top of the ridge. The majority of farmers declared to be unaware of the moment when to apply fertilizers and the respective amount to be used per unit area. In general, they cultivate from 0.2 to 1.0 hectare of potatoes every year. Costs of production to produce one hectare of potato was also analyzed on 12 farms, six per region. The gross margins of the examined 12 potato farms vary from 750 to 11,900 USD. Such large gap is explained by farmers skills and knowledge on how to manage the crop and sell the product after harvest. Seed potatoes are the most costly item representing 43-52% of the total costs, without any guarantee that the seed purchased is of good quality since they are bought on the local market or saved from their own traditional selection that consists of a simple sorting of tubers at the end of winter time.

Building capacity for potato breeding in Central Asia

Building Central Asian capacities for breeding is continuing. In Tajikistan, the breeder of a local NGO called Tukhmiparvar plus specialists of the Horticulture Institute Bogparvar are the main beneficiaries, while in Uzbekistan capacity-building concerns the specialists of the local Institute of Vegetables, Melon and Potato plus those of the Bio-organic Chemistry Institute, both based in Tashkent. The genotypes supplied by CIP-Lima under the project are still under multiplication; therefore, it is too early to describe specific activities in breeding and selection with partners. It has to be added that all the products of crossings made in Uzbekistan were eliminated due to PSTV infection.

Tajikistan - True Potato Seed (TPS) technology

In order to provide resource-poor farmers living in the highlands of Central Asia with high-quality and cheap potato seed, CIP-Liaison office in Tashkent in collaboration with NGOs and private farmers disseminated TPS technology in the highlands of Tajikistan. A case study was carried out and looked at the production of TPS according to the direct seeding technique in nursery beds measuring approximately 580 m^2 set up by 35 smallholders in Garm District of the Rasht valley, Tajikistan. They produced 2 tons of seedling tubers F_1C_0 of TPS family '9943013', at the rate of 3.3 kg/m^2, and of an average weight of 19.3 g. Low standard deviation and coefficients of variation for plant height, seedling tuber fractions (%) and average seedling tuber weight indicated that the grouped data was stable and uniform respectively. In May 2013, the agronomist following this activity in Garm District included other farmers to reach a total of 56 smallholders. In order to render TPS technology self-sustainable the production of hybrid TPS (LT-8 x TS-15) was initiated in Jirgatol District of the Rasht valley. However, only 150 g of TPS were produced mainly due to the improper location of the enterprise (2,700 m asl) too much affected by frost in recent years and the consequent poor flowering of the parent materials.

Uzbekistan - positive selection

The low quality of seed potato is a major problem for small-scale potato producers in Uzbekistan. Interventions to tackle this problem have never reached smallholders and have mainly focused on large-scale state-owned farms, but the results have not been very positive and have never concerned the majority of potato producers, most of whom select seed potato for the next planting season from their own saved seed taken out of the cellar and sorted by size just before the planting season starts. A different approach has been introduced in the country, which consists of improving the quality of seed potato at farm level by improving the selection process in the field and providing a package of improved cultural practices to the farmers. The presence of an efficient extension system would facilitate the dissemination to farmers. Due to logistic reasons, a group of farmers have been selected and initiated to positive selection in Gazalkent District of Tashkent Region. After providing them with improved seed of CIP candidate varieties and showing them the main rudiments of positive selection, they were able to apply it in May-September 2012. The performance of selected seed issued from positive selection will be compared with the other seed obtained under traditional practices and their health tested with ELISA in 2013. At the same time, some field experiments were carried out at station level in order to investigate the best planting distance and fertilization to adopt for obtaining the best performance from the varieties utilized. The results of trials demonstrated that the highest proportion of seed sized tubers between 25 and 55 mm is obtained when a planting distance of 70 x 15 cm is adopted, while a fertilization formula of $90N:180P_2O_5:120K_2O$ is advisable in order to obtain a larger proportion of seed-sized tubers in case of early varieties.

Centers: CIP
Donors: CRP Potato and Tubers; BMZ/GIZ funded project 'Enhanced food and income security in SWCA through potato varieties with improved tolerance to abiotic stress'
Project period: ongoing
Countries: Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan

SORGHUM AND PEARL MILLET FOR CROP DIVERSIFICATION IN CENTRAL ASIA

Aims and scope of work

ICBA/ICARDA/ICRISAT are implementing a joint project on 'Sorghum and Pearl Millet for Crop Diversification, Improved Crop-Livestock Productivity and Farmers Livelihood in Central Asia'. The main goal of the three-year project launched in 2011 is to contribute to the improvement of livelihoods of farmers in salinity-affected and marginal environments of Central Asia through the development and dissemination of high-yielding, salinity-tolerant sorghum and pearl millet lines and cultivars, as well as crop management technologies for economic and sustainable crop-livestock production systems in the three countries. During the first year of the project, 12 accessions of sorghum and seven improved lines of pearl millet derived from ICBA/ICRISAT germplasm were evaluated in multi-location and on-farm trials in Central Asia. Local varieties were used as a control check during the trials. Research conducted in 2011 till summer 2012 allowed to assess the high-yielding and salt-tolerant accessions and improved lines of sorghum and pearl millet in saline and waterlogged soils; and to establish nurseries for the collection and selection of variety trials. The most adapted high-yielding accessions and improved genotypes (in terms of green biomass and quality of seed crop) were selected. Based on these accessions and genotypes, further breeding work and evaluation of productivity and profitability for forage and grain production are being conducted during the remaining years of the project; to identify high-yielding varieties of sorghum and millet as the second alternate crops after wheat harvest in Uzbekistan and Tajikistan, rice harvest in Kazakhstan, suitable for use by farmers; and to develop and recommend common criteria for primary seed multiplication at farm level.

Combating land and water degradation, and increasing agricultural productivity of marginal lands have been key issues in agricultural research for development. Every year tens of thousands of hectares of agricultural land in the Aral Sea basin become unsuitable for farming and livestock production and move into the category of marginal (low productive). There are a number of causes, including negative consequences of the Aral Sea desiccation, climate change and irrational use of natural resources for intensive agricultural production.

There are strong indications that secondary salinization, waterlogging, soil erosion, loss of organic carbon, and reduced biodiversity are resulting in yield losses, and declining soil fertility is leading to higher production costs. Together with limited water resources and high soil salinity, these are the major constraints to crop-livestock production in the Aral Sea basin. Adoption of crop species adapted to salinity, drought and hot environments, and further enhancement of their yield potential and grain quality is regarded as a cost-effective and sustainable solution to meet food, feed and fodder needs of rural households and farmers in the Region. Salt-tolerant trees and shrubs, crops and halophytes (plants adapted to saline conditions) for agro-forestry, biofuel and forage for grazing livestock are some of the solutions that ICBA in collaboration with NARS is exploring to manage salinity. Halophytes, low-cost biosaline technologies, and alley-cropping systems, such as dual-purpose food-feed crops and shrub-tree crops adapted to poor quality water, are proven to enhance the productivity of saline soils and rangeland grazing. These could transform saline areas in Central Asian countries into multi-use crop-tree systems.

Germplasm conservation and enhancement in sorghum and pearl millet

In an effort to introduce non-conventional salt-tolerant crops such as pearl millet and sorghum, the international centers together with national partners continue to assess ways and benefits of integrating pearl millet and sorghum into local crop-livestock feeding and farming production systems in diverse agro-ecological zones. Both crops have high water consumption efficiency, and are highly tolerant to drought, heat and soil salinity. These features make sorghum and pearl millet especially suitable for crop diversification and crop-livestock productivity enhancement in saline and drought-prone areas.

Screening of more than 52 improved lines of pearl millet through on-station and farmer-participatory on-farm trials under different field management practices identified 'Sudan Pop III', 'Guerinian-4', 'IP 6104', 'IP 6112', 'IP 19586', 'HHVBC Tall', 'ICMS 7704', 'IP Sudan Pop1', 'JBV3', 'ICMV 155', 'MC 94 C_2 ' and 'Raj 171' as the most salt/drought-tolerant and highly productive varieties for food and forage production. Among sorghum varieties evaluated so far, 'ICSV 93046', 'ICSSH 58', 'SPV 1411', 'ICSR 93034', 'ICSV 25280', 'S35', 'Sugar Graze', 'Pioneer 858' at a plant height of 204-262 cm exceeded the standard 'Korabosh' variety in 14.32-23.66 kg/plot of green matter and 1.85-4.01 kg/plot of dry matter. All of these improved lines of sorghum have demonstrated about 30% higher dry fodder and 25% higher seed yield than the local varieties.

Evaluation of sorghum and pearl millet performance in farmer-participatory trials

These two crops sowed with 30 cm inter-rows space significantly increase the plant density and, consequently the fresh forage production at the end of harvesting of sorghum and pearl millet from the fields. Sorghum varieties maturing in 110-140 days can be taken only as a main crop as frost starts early in this area. The early term seed bedding (middle of March at soil temperature +5-10 C) as was demonstrated in a trial in Kyzylkesek (central Kyzylkum) allowed to obtain three cuts (7, 8-9.1 kg/plot green forage) until late October. The seven pearl millet cultivars received from ICBA and ICRISAT, and planted in the Kyzylkum desert, Uzbekistan, produced between 38 and 96 t/ha of green biomass, of which the cultivars 'Raj 171' (90.0 t/ha), 'IP 19586' (91.6 t/ha), 'IP 1607' (93,4 t/ha) and 'IP 22269' (96.7 t/ha) performed best. If these cultivars are grown near the watering points in the vicinity of the herds (size of 2,000 units) in 10 ha area, the survival ratio could easily be doubled from 2 kg to 4 kg/day per animal during the severe winter season. Trials identified also promising dual-purpose varieties that produce grain for food or feed for poultry, as well as feed for livestock. These dual-purpose varieties could fill gaps in the crop-livestock systems in the three countries. 'Hashaki-1' locally released early maturing , multi-cutting variety performed particularly well on medium saline soils, which makes it possible to adopt this variety for wider cultivation both as a main crop in early spring or as a second crop after wheat harvest.

Research in 2012-2013 also demonstrated that, when alley-cropped sorghum and pearl millet with triticale and alfalfa, are grown together, they yielded 20% higher green biomass than barley alone in the traditional barley-fallow system. Growing salt-tolerant, high-yielding legumes in combination with cereals, alternated by strips of aboriginal halophytes, such as *Atriplex undulata, A. nitens, Ceratoides ewersmanniana, Clmacoptera lanata, Kochia scoparia, Salsola orientalis* and *Halothamnus subaphylla,* was found to have great potential for producing more of highly nutritional fodder (both fresh and as hay).

Licorice (*Glycyrrhiza glabra*) and *Alhagi pseudoalhagi,* both forage species from the family Fabaceae, can be planted together with multi-cutting sorghum and pearl millet varieties in mixed plantation or in alley-cropping strips on salt-affected and degraded rangelands for soil bio-remediation and creation of high palatable pure or multi-component pastures by increasing its productivity by 2.5 times compared with degraded overgrazed pastoral lands. The planting of mixed halophytes with these two valuable forage cereals is encouraged to be done along the saline water bodies, like artificial ponds and freely flowing artesian wells. Even during the remediation period, they have potential to generate income for farmers, since their biomass can be used as high quality forage additive for livestock. Their root material is well known to have very high marketability in many industries, especially in pharmaceuticals. *Alhagi peseudoalhagi* young stems, leaves and fruits are considered fattening feed for all kinds of animals and can be stored as hay/feed blocs/or sillage for winter feed. It is extensively collected by pastoralists during flowering stage. Measures should be taken for the domestication of these plants for pastures improvement. The studies are being continued. This material is still available at Kyzylkesek site (central Kyzylkum desert), but many are on the verge of disappearance due to grazing abuse and may become an irreversible loss of biodiversity resources.

Promising results were shown for using fast-growing pearl millet 'IP 19586' as broadcasting in growing mung bean after wheat harvesting on Bayavut farm, Syrdarya Region. Minimum tillage and field preparation was used. It was concluded that the evaluation and genetic enhancement of sorghum and pearl should continue, but seed production should be limited for the identified entries for each country.

Seed production should be carried at good quality lands to economize the seed production and increase the seed availability in the Region. ICRISAT will continue to provide appropriate germlasm for testing in the Region.

Development of sorghum and pearl millet varieties resistant to abiotic stress, especially to soil salinity

Monitoring of irrigation water, ground water and soil salinity level (at different soil depth profile - 15, 30, 45 cm) by using EC meter (Direct Soil EC meter) during sorghum and pearl millet vegetation season on Bayavut and Kyzylkesek farms (Uzbekistan), as wells as on Shortanbay farm (Karakalpakstan), showing the trend (ecological raw) of increasing of salt tolerance among investigated non-conventional germplasm from ICRISAT compared with local varieties. Average threshold salinity levels for examined pearl millet varieties ranged from 2.60 to 8.5 dS/m ; and from 2.4 up to 4.6 dS/m for sorghum entries respectively. New released variety 'Hashaki 1' has an intermediate position, while the lowest plant density (467 plants/ha) was observed for 'Raj171'. The new local variety is resistant to moderate soil salinity and low quality water with grain yield 2.96 t/ha. Thus, sorghum and pearl millet varieties derived from ICRISAT and ICBA germplasm normally can be classified as moderately salt-tolerant crops. Thus, sorghum was more sensitive than pearl millet to soil and water salinity under shallow (0. 5-1. 8 m) and saline water table (1.5-3.8 dS/m) as it was demonstrated in a trial on Shortanbay farm in Karakalpakstan. Sensors to measure soil water content and salinity near-continuously and in near real-time are powerful tools for improving irrigation management. Advances in instrumentation and communication can now provide agricultural producers, especially farmers with the information they need when they need it, and also enable automatic monitoring and feedback control of irrigation. Therefore during 2012-2013 vegetation season under sorghum and pearl millet fields ICBA officers installed moisture, temperatures and salinity sensors for managing irrigation under sorghum and pearl millet fields on Bayavut farm, Syrdarya Region. This pilot developing system is based on supervisory control and data acquisition to demonstrate the technical feasibility of using real-time measurements of soil moisture and salinity to manage irrigation in loamy clay medium saline soils. The sensors provide information on soil water content, soil salinity level, conductivity, temperature, crop water use, and the movement of water within and below the root zone including fluctuation of ground water all year round. Control systems that combine up-to-date weather information and data from moisture and salinity sensors can improve irrigation management and conserve water.

Seed multiplication trials (on-farm) to identify seed production facilities on sentinel sites

On- farm seed multiplication trials (an area of about 0.5 ha) and identification of seed production facilities on sentinel sites with participatory work of farmers to meet seed demand were established. Specialized on-farm seed multiplication trials for four promising sorghum 'ICSV 93046', 'SPV 1411' sorghum, three pearl millet ('HHVBC Tall', 'IP 19586', 'MC94C_2') from ICRISAT along with local newly released 'Hashaki 1' variety were conducted during the last two seasons on Kyzylkesek and Zangiota sites in Uzbekistan; Abay farm in southern Kazakhstan and Gafurov farm in Tajikistan. Selected farmers are producing the seed under fish nets and/or by using selfing bags to protect from bird damage. In Tajikistan 28 farmers were identified and invited to form a social network for pearl millet seed production. Seeds are produced by separate or cluster farmers of nearby villages on a remunerative price to recover the cost of seed production, plus 30-50% profit. A social network of 30 farmers from five specialized farms in northern Tajikistan on seed production was set up at district/village level. Laboratory standard analytical methods and field performance were analyzed to quantify seed quality (germination rate; energy of germination; seed viability) of sorghum and pearl millet seed, produced by farmers. Variety purity and seeds maintained by farmers were also assessed for different seed sources. Seed producing farmers will make some benefit in producing the seed for an incentive, and hence can ensure adequate and timely supply of quality seeds. The international centers and national institutions in the target area of seed production are providing technical guidance for quality seed production.

Capacity building

To show the advantages of sorghum and pearl millet crops to local farmers and researchers, a Field Day was held on 19 July 2013 on Shortanbay farm in Karakalpakstan (northern Uzbekistan). At the event the results of experimental trials of sorghum and pearl millet varieties were presented to 24 participants, including farmers and researchers from the Karakalpakstan branch of the Uzbek Rice Research Institute (KBURRI); the Nukus branch of Tashkent State Agrarian University; Karakalpakstan Institute of Crop Husbandry; government officials and non-governmental organization including women leaders. The participants heard that despite an exceptionally dry season and lack of water for irrigation (sorghum and pearl millet fields were irrigated only once in July 2013) this year, 13 entries of pearl millet had reached panicle emergence and flowering stages. 'Hashaki-1' locally released early maturing , multi-cutting variety performed particularly well on medium saline soils, which makes it possible to adopt this variety for wider cultivation both as a main crop in early spring or as a second crop after wheat harvest. Officials and farmers from different districts of Karakalpakstan noted that a major challenge to wider cultivation is ensuring the availability of seeds of improved lines of non-conventional salt-tolerant crops. However, efforts are under way to establish specialized farms for multiplication of good quality seed of this high-yielding variety in Uzbekistan. Participants agreed that large-scale seed multiplication of high-yielding varieties of sorghum, pearl millet and alfalfa, which shown good performance on salt affected lands on Shortanbay farm should start to meet the growing demand of farmers.
Under the project a regional travelling workshop for farmers and experts on 'Participatory evaluation of trials and identification of productive cultivars and appropriate crop management practices' was conducted between 26-30 August 2013 in Uzbekistan and Tajikistan in close collaboration with the national research partners. Around 60 participants attended this seminar in both countries.

Centers: ICBA, ICARDA and ICRISAT
Donor: Islamic Development Bank
Project period: 2011-2014
Countries: Uzbekistan, Tajikistan and Kazakhstan

Utilization of low quality water for halophytic forage and renewable energy production

Aims and scope of work

The main goal of this project is to identify the benefits of cultivation of halophytes to improve economic utility of marginal lands and water. During the period of 2012-2013 the main focus was on:

- Studying soil and water quality in areas under investigation (Shurkul Koshkopir lake, Khorezm Region and Kyzylkesek, Kyzylkum desert);
- Examining feasibility of use of non-conventional water sources (hot artesian saline ground water, saline lake water) to irrigate halophytic crops on marginal soils;
- Investigating halophyte cultivation on marginal soils to produce biomass for bioenergy or fodder;
- Assessing livestock forage potential of halophytes and salt-tolerant crops, including the protein, lipids/fat and hydrocarbon content;
- Evaluating potential of some local halophytes for biogas production.

Analysis of soil and water

Analysis of soil samples from the pilot sites to determine the type and extent of salinity and soil fertility was accomplished. Investigated parameters are: pH, conductivity, carbonates (alkalinity), chloride, sulfate, calcium, magnesium, sodium, dry residue, nutrients (potassium, phosphorus, nitrogen), humus, soil organic carbon (TOC). It was revealed that soils in the pilot area Shurkul have medium and strongly chloride-sulphate type of salinity. On the top layer of soil chloride content varies 0.065-2.340% and sulfates 0.100-0.860%. Humus content in the upper layer ranges 0.317-1.709%. Soils in the pilot area Kyzylkesek have medium sulphate-chloride type of salinity, strong soil salinity was observed only in a solonchak area. On the top layer of soil chloride content varies 0.007-0.626% and sulfates 0.022-3.004%. Humus content in the upper layer ranges 0.169-0.992%. Soil salinity survey with EM38 for Kyzylkesek site showed that most of the biotopes surveyed in Kyzylkum desert have low salinity levels (on average less than 40 mS/m).

Analysis of water samples from the lake, artesian wells and irrigation canal from Shurkul-Koshkupur site and pilot area Kyzylkesek was done to determine the suitability of water for irrigation of cultivated plants. Investigated parameters are: pH, hardness, ammonia, nitrite, nitrate, phosphate, total phosphorus, hydrogen, chloride, sulfate, sodium, potassium, calcium, magnesium. Mineralization of Shurkul lake water was 3.3 g/l (September) - 3.5 g/l (November), and salinity of the channel - 0.7 and 0. 85 g/l respectively. The mineralization of thermal artesian water and irrigation water on Kyzylkesek site was 2.4 - 2.5 g/l. Monitoring of groundwater salinity on Koshkupur site based on electric conductivity (EC water) and assessment of groundwater suitability for leaching showed that groundwater salinity is very high (above 10 dS/m) and did not decrease after several hours of pumping. Organization of alternative water supply for leaching purposes, use of motor pump and irrigation hoses to deliver water from the nearby lake with EC water in the range of 4-6 dS/m. Mineralization (total dissolved solids) of thermal artesian water and irrigation water on Kizilkesek site in February was 2.35 - 2.75 g/l, mineralization of drainage water was 8.44 g/l in February and 8.99 g/l in March.

Planting of salt-tolerant plants on marginal lands

Field experiments to study planting of salt-tolerant plants on marginal lands were conducted. Four types of halophytes (*Atriplex nitens, Climacoptera lanata, Salsola slerantha, Kochia scoparia*) were planted in pure stands. Intercropping of four types of halophytes (*Atriplex nitens, Climacoptera lanata, Salsola slerantha, Kochia scoparia*) with salt-tolerant crops (sorghum, millet, artichoke, licorice) was tested. Since field operations were completed earlier in 2012, in coordination with ICBA expertise it was decided to test salinity-resistant alfalfa on Shurkul lake site. Alfalfa was planted in late summer of 2012 in the low saline part of the experimental area. However, results show that seedling establishment of alfalfa in such saline environment was not possible. Planned sowing activities of halophytes in pure stands were completed in late February 2013. In consultation with ICBA it was decided to replicate trials of Kyzylkesek site with the help of ICBA field assistant. Kyzylkesek site was established earlier and is successfully running. As of the time of the report, there was no seed germination on Shurkul lake site.

Nutritional value

Nutritional value of halophyte's biomasses (20 species) was assessed. Contents of protein, lipids and hydrocarbons were measured for assessment of livestock forage potential of some halophytes. Considerable content of proteins (up to 17.6%) and soluble carbohydrates (up to 24.6%) was revealed in biomasses under investigation. It means that many salt-tolerant (and halophytic) plants can be considered as value forage for livestock. Mineral content, organic matter and cation/anion content of halophitic biomass was measured as well. It was detected that investigated plants contain from 10 to 49% of ash in DM (dry matter). Significant amounts of mineral compounds were found in biomass of *Salicornia europaea* (48.6%), the least salt accumulation was demonstrated by *Karelinia caspia* (it was about 14% DM). The most organic fractions were in *Suaeda paradoxa, Atriplex nitens and Karelinia caspia*. It was about 750-900 mg organics per 1 g of dry matter.

Biogas production

Biogas production of halophyte's biomass (seven wild species) was assessed. It was found that at least 200-400 ml biogas can be produced in result of anaerobic digestion 1 g DM of halophytic biomass. *Suaeda paradoxa*, *Atriplex nitens* and *Karelinia caspia* can be recognized as the most productive plant species for biogas production. It was shown that 70-90% organic fractions can be converted into biogas. The highest yield of biogas is demonstrated in lab experiments on anaerobic digestion by *Atriplex nitens, Karelinia caspia* and *Suaeda paradoxa*. It was calculated that from 1 t DM of these halophytes 360-380

m^3 of biogas can be produced. Potential biogas production (m^3/ha/year) was calculated for all plants under the study taking into consideration their biomass yield in Central Asia and biogas production measured in laboratory. Taking into consideration that only one halophyte from investigated plants - *Karelinia caspia* - is used for nothing by local people (it is very poor fodder and it is eaten by animals very little), it was concluded that biomass of *Karelinia* is the most promising renewable source for biogas production in desert areas of Central Asia. It could be recommended to use wild associations of above mentioned perennial halophyte or try to plant it in abandoned saline arid lands.

Evaluation of economic feasibility

Evaluation of economic feasibility of the use of halophytes as a livestock feed and biogas production was done:

- The questionnaire on socioeconomic analysis was developed;
- Training of the personnel to conduct socioeconomic survey was done;
- Test survey on Kyzylkesek site was conducted;
- Initial findings were documented on community infrastructure and natural resources mapping, community needs assessment, informal institutional arrangements, income sources.

Finally, a manual on halophytes in Central Asia was developed. The manual contains data on more than 78 halophytes species that grow under desert and semi-desert conditions. The manual includes information on the biology, seed morphology and germination along with fodder and pastoral value of halophytes. Each species is illustrated with a general view of the plant, morphology of seed and fruit including data on ecology of seed germination that is very important for creation of industrial plantation of halophytes. This is the first monograph on halophytes of Uzbekistan.

Centers: ICBA and Nevada University (USA)
Donor: USAID- National Science Fund (NSF)
Project period: 2012-2014
Countries: Uzbekistan

Web-based platforms of water quality of Zarafshan River basin
Aims and scope of work

To promote and adopt innovative biosaline agriculture technologies for sustainable development and conservation of agro-ecosystem and scarce water resources, a new initiative was launched by ICBA, Uzbek Research Institute of Karakul Sheep Breeding and Desert Ecology and Samarkand State University on 'Web-based platforms of water quality of Zarafshan River basin integrated with promotion of technologies of marginal resources as part of a climate change adaptation strategy' funded from a grant of the Government of Uzbekistan for the period of 2012-2015.
During the period of 2012-2013 main activities were focused on water quality monitoring of the main streams, irrigation canals, collector-drainage system of Zarafshan River basin and adjoining areas of Kyzylkum desert in Uzbekistan and on developing a web-based platform for efficient data management and sharing of water quality and hydrological datasets. The water quality analysis of 74 sampling sites along the river course throughout the upper stream, middle stream and downstream basin areas and collected water samples, hydrological, meteorological and economic data indicate that generally water in the downstream part of the basin was of significantly low quality. Three field expeditions were organized for field data collection. The water contains high concentration of salts and heavy metals that could be dangerous for plant growing and people's livelihoods. The database, which started to be developed, integrates quantitative and qualitative datasets into spatially-explicit maps, which help intuitive data handling and easy sharing for collaboration work. A web-based information platform (Zarafshan River basin as a case study) based on open-source solutions at no cost for installation and usage was developed. The platform facilitates data storage, searching within the storage, simple visualization of the collected data, and collaborative work with data to improve the productivity and outcomes of research activities. Platform serves to improve user and data interaction and simplify

action on sorting, accessing and managing collected data, providing solutions for small communities or group of project based researchers in addition to hydrological functionality. The web-platform is based on the processed dataset of HydroSHEDS and Hydro1K by a simple up-scaling algorithm to preserve the high resolution properties of topography throughout variable scales. This function helps to define area of interest and limit searching or adding the data within the basin. Platform is coupled with the Rainfall-Runoff Inundation model to provide automatic processed hydrological data inputs on global scale for different catchments. The application can generate input dataset of Digital Elevation Model, stream flow direction, flow accumulation and land use cover for the chosen catchments. Client-server architecture used in this study with the communication through internet gives opportunity to pass server all big calculations and management regulation, where user side works as visual information presenter. We are interested in integration with the numerical models to upgrade usage of the platform, not only as a tool for data management but also for decision-makers or data mining application. Efficient searching systems allow hydrologists to concentrate on data analysis by minimizing the previously time-consuming tasks of locating, collating and manually organizing data. This study resulted in several publications (Toderich et al, 2013; Khujanazarov et al, 2012, 2013).

Centers: ICBA
Donor: State Committee for Science and Technology of the Republic of Uzbekistan and Kyoto University, Japan
Project period: 2012-2015
Countries: Uzbekistan

IMPROVEMENT AND DIVERSIFICATION OF VEGETABLE CROPS

Aims and scope of work

In 2011, the Regional Variety Trials supported by the World Vegetable Center - AVRDC were conducted in different soil and climatic conditions in all eight countries of the CAC Region: Armenia (Research Center of Vegetable, Melon and Industrial Crops), Azerbaijan (Azerbaijan Research Institute of Vegetable Growing), Georgia (Research Institute of Crop Husbandry), Kazakhstan (Kazakh Research Institute of Potato and Vegetable Crops), Kyrgyzstan (Research Institute of Crop Husbandry), Tajikistan (Research Institute of Horticulture and Vegetable Growing), Turkmenistan (Research Institute of Crop Husbandry) and Uzbekistan (Uzbek Research Institute of Plant Industry).
In 2012-2013 AVRDC activities within Regional Network for Vegetable Systems Research and Development (CACVEG) concentrated on the following core activities: collaborative research with partner institutes on providing new germplasm from AVRDC genebank and breeding units, regional varietal trial, study and development of new vegetable crop varieties, consumption, tomato grafting technology adoption, promotional events (workshops, training and Farmers' Days), capacity building, publications, information exchange, collection and establishment of baseline data on vegetables.
In 2012, the AVRDC Regional Variety Trial was conducted in all eight countries in Central Asia and the Caucasus. A total of 78 accessions (germplasm from AVRDC's genebank and improved germplasm from breeding units) of six vegetable crops were introduced from AVRDC to eight countries of the CAC Region. In addition, a total of 106 accessions of 10 vegetable crops were introduced to research institutes of four countries based on specific requests.
In 2013, a total of 89 accessions of five species were under evaluation in CAC. All accessions were evaluated on biological, morphological and marketability traits under different soil and climatic conditions. Promising accessions (early-maturing, high-yielding, resistant to diseases, good fruit quality, etc) were selected in each country and seeds were multiplied for further research work.

CAC Regional Variety Trial

In 2012-2013, the Regional Variety Trial was conducted in different soil and climatic conditions in eight countries of Central Asia and the Caucasus, including Armenia (Research Center of Vegetable, Melon and Industrial Crops), Azerbaijan (Azerbaijan Research Institute of Vegetable Growing), Georgia (Research Institute of Crop Husbandry), Kazakhstan (Kazakh Research Institute of Potato and Vegetable Growing), Kyrgyzstan (Research Institute of Crop Husbandry), Tajikistan (Research Institute of Horticulture and Vegetable Growing), Turkmenistan (Research Institute of Crop Husbandry) and Uzbekistan (Uzbek Research Institute of Plant Industry and Uzbek Research Institute of Vegetable, Melon Crops and Potato).
As a result, promising lines were identified, including tomato line 'CLN3241B' and sweet pepper lines 'PP0126-18', 'PP0937-7040Bk' in Armenia and Tajikistan; hot pepper line 'PP0937-7627' in Armenia and Georgia; pisum pea accessions 'VI034084' and 'VI046188' in Armenia, Kazakhstan and Uzbekistan; custard squash accession 'VIO56234' in Kazakhstan and Uzbekistan.
In 2012, eight new varieties of five crops were released, including tomato varieties 'Rubina' (CLN 1558B) in Armenia; hot pepper varieties 'Punj' (CO1803) in Armenia and 'Erekshe' (0337-7069) in Kazakhstan; sweet pepper varieties 'Mili' (PBC271) in Armenia and 'Kozy-Korpesh' (0237-7011) in Kazakhstan; soybean variety 'Inju' (AGS437) in Kazakhstan; mung bean varieties 'Zhasyl Dan' (VC6492-59) in Kazakhstan and 'Turon' (VC6153B-20G) in Uzbekistan.
The seed multiplication of released varieties was conducted to provide farmers with high-quality seeds for vegetable production. Farmers started to grow new varieties enthusiastically and earn income. Smallholders also grow new varieties in home gardens. Released varieties have a high potential impact to increase the production of nutritious vegetables, diversify the diet, increase farmers' income and open the export potential of fresh and processed vegetables.

Released new varieties in CAC countries in 2012.

Crop	**From AVRDC acc./line**	**Variety name**	**Country**	**Certificates for release variety since 2012**	**Released year**
Tomato	CLN 1558B	Rubina	Armenia	Patent №68 issued 22 Dec. 2011	2012
Tomato	CLN2545A	Alsou	Azerbaijan	Certificate issued 2012	2012
Hot pepper	CO1803	Punj	Armenia	Patent №70 issued 22 Dec. 2011	2012
Hot pepper	0337-7069	Erekshe	Kazakhstan	Certificate № 419 issued 23 April 2012	2012
Sweet pepper	PBC271	Mili	Armenia	Patent №69 issued 22 Dec. 2011	2012
Sweet pepper	0237-7011	Kozy-Korpesh	Kazakhstan	Certificate №435 issued 23 April 2012	2012
Soybean	AGS437	Inju	Kazakhstan	Certificate №421 issued 23 April 2012	2012
Mung bean	VC6492-59	Zhasyl Dan	Kazakhstan	Certificate № 420 issued 23 April 2012	2012
Mung bean	VC6153B-20G	Turon	Uzbekistan	Certificate№ 353issued 14 August 2012	2012
Released in 2013					
Sweet pepper	PP0437- 7031 (Bell, LYO-Y)	Sabo	Uzbekistan	Certificate№	2013
Eggplant	germplasm From genebank	Firuz	Uzbekistan	Certificate№	2013

As of 2013, a total of 38 new varieties of 12 species are under state variety trials in eight countries, including tomato - four, sweet pepper - seven, hot pepper - eight, cucumber - two, eggplant - five, mung bean - three, soybean - three, basil - one, bean - one, marrow squash - two, lettuce - one, scallop - one. Through the described collaborative work, 35 new varieties of eight vegetable crops including tomato, sweet and hot pepper, eggplant, vegetable soybean, mung bean, yard-long bean and cabbage have been released in the CAC countries.

Capacity building

Two students continued PhD research on AVRDC vegetable soybean and hot pepper germplasm in Uzbekistan in 2012-2013. One Master's student defended his thesis on tomato and one PhD student completed a doctoral thesis on leafy cabbage in Uzbekistan in 2012. One Master's student conducted research on tomato grafting in 2013. A grafting method evaluation for *Fusarium* control and tomato cultivation in an open field is being studied at Tashkent State Agrarian University, Uzbekistan, by Master's student Mr Otabek Majlimov. A total of 19 tomato lines were used as rootstocks for grafting of local variety 'Dustlik'. For the first time tomato grafting technology was applied on a farm in Armenia. The report on results at both sites will be presented after a vegetation period finishing in the beginning of November 2013.
Within the Project 'Development and Delivery of Ecologically-Based IPM Packages for Field and Vegetable Crop Systems in Central Asia' (see below section), research on tomato grafting in winter-spring in greenhouses was finalized at Tashkent State Agrarian University, Uzbekistan and a Master's thesis was defended by Mr Bakhtiyor Karimov in June 2012. As a result, four promising tomato lines were identified for use as rootstocks and recommended for use in production. Using this environmentally friendly biological method will allow farmers to increase productivity and quality of tomato production.
Following training courses for agricultural colleage students in Bostanlyk (Uzbekistan) during 2012, the Education, Research and Production Integration Center was established by AVRDC, ICARDA, the National University and the Women Community at Bostanlyk Agricultural College. The aim of the Center is to join common efforts on vegetable production development, in order to diversify daily diet, increase income and welfare of the population living in the area.

AVRDC-CAC provided financial support to two young specialists working on vegetable research in Uzbekistan and one specialist in Kyrgyzstan to participate in English language courses in their countries in 2012.
Three training courses on tomato grafting were organized within various events conducted in Tashkent, Uzbekistan during 2012, including a special session on tomato grafting technology during The Fifth Steering Committee Meeting of CAC Network, 13 December 2012. A total of 52 people were trained, including postgraduate students, researchers, research workers and farmers.
Training in sunflower varieties trial was conducted jointly with the Uzbek Research Institute of Plant Industry on 15-18 August 2012 in Namangan, Uzbekistan. A total 10 farmers were trained and received certificates. This training will allow conducting further field trial by local trained staff in a girasol planting area in Uzbekistan.
The Fifth Steering Committee Meeting on Central Asia and the Caucasus Vegetable System Research and Development Network (CACVEG) was held in Tashkent, Uzbekistan on 11-13 December 2012. Thirty-five participants, including the national coordinators on vegetable system research and development, and specialists from eight CAC countries participated in this workshop.
A number of other seminars, workshops and training courses were also organized during the reporting period.

Center: AVRDC - The World Vegetable Center
Donors: AVRDC - The World Vegetable Center
Project period: ongoing
Countries: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

DEVELOPMENT AND DELIVERY OF ECOLOGICALLY-BASED IPM PACKAGES IN TAJIKISTAN

Aims and scope of work

Building on the strong foundation and the regional network established during Phase I of the project, MSU with the USAID support launched Phase II, a five-year (2009-2014) collaborative program to develop and deliver ecologically-based IPM packages for key food security crops for Tajikistan. The project took an integrated and applied approach to develop and deliver ecologically-based IPM packages for wheat and potato cropping systems in Tajikistan.

The objectives of Phase II of the Tajikistan IPM CRSP Project are:

- Develop ecologically-based IPM packages for wheat and potato through collaborative research and access to new technologies;
- Disseminate IPM packages to farmers and end-users through technology transfer and outreach programs in collaboration with local NGOs and government institutions;
- Build institutional capacity through education, training and human resource development;
- Enhance communication, networking and linkages among local institutions and with US institutions, international agricultural research centers, and IPM CRSP Regional and global theme programs;
- Create a 'Central Asia IPM Knowledge Network' encompassing a cadre of trained IPM specialists, trainers, IPM packages, information base, and institutional linkages.

Ecologically-based IPM packages are being developed through integrating existing pest management practices with new technologies developed through collaborative research with appropriate links with IPM CSRP global theme and regional programs. In Tajikistan for wheat, three IPM applied research and demonstration sites have been established for collaborative research, training and outreach to farmers. These pilot sites have been used as Farmer Field Schools (FFS) to disseminate findings to local farmers. As part of the training and capacity-building strategy, over the four-year period, the project has trained around 15 local graduate students, and provided opportunities to more than 50 IPM professionals from Tajikistan to attend various training programs, workshops, seminars and short courses with due consideration of gender balance.

To harness the resources and expertise of global theme projects of IPM CRSP, the project has developed collaborative links to four cross-cutting areas including pest diagnostics, virus disease management, impact assessment, and gender issues. Through regional and global partnerships, the project has helped to create the 'Central Asia IPM Knowledge Network' which encompasses a cadre of 21 trained IPM specialists, nine master trainers, and two IPM packages for wheat and potato crops with an extensive information base in local languages and strong institutional linkages to sustain this network. The project has placed strong emphasis on scholarship, publication and dissemination of research results through both electronic and print media including enhancing its existing website at http://www.ipm.msu.edu/central-asia.htm.

IPM applied research and demonstration site for wheat

Starting in 2010, a total of three applied research and demonstration sites were set up for wheat in Tajikistan. One of these three sites was located on a farm named after its founder Ilhom Boimatov in Spitamen District of Sughd Region of Tajikistan. At this demonstration site, the focus was on management of the Sunn pest (*Eurygaster integriceps)* and diseases including the wheat rusts: yellow rust (*Puccinia striiformis*) and brown rust (*Puccinia recondite*). The key weeds in wheat in this region include oat grass (*Avenafatua*), *s*hepherd's purse (*Capsella bursa-pastoris),* pigweed or lambsquarters (*Chenopodium album)* and bermuda grass (*Cynodondactylon*).

The following IPM package components were compared to local farmers' practices in the same area:

- Plots of 10 x 10 m planted with 'Ormon' variety resistant to yellow and brown rusts, four replications;
- Two strips of flowering plants including coriander *(Coriandrum sativum L.)*, dill *(Anethum graveolens L.),* sweet basil *(Ocimum basilicum L.),* ziziphora *(Ziziphora interrupta*Juz.), marigold *(Calendula officinalis L.)* and winter cress (*Barbarea vulgaris)* alongside the wheat plots to enhance Sunn pest egg parasitoids;
- Best cultural practices (planting date, seed rate, fertilizer application, and weed control);
- Hand collection of Sunn pest adults during 2-3 weeks beginning at the time of migration to wheat fields.

Local farmers participated in the establishment of the trial and in the final yield evaluation. At harvest, we measured: number of seeds in 1 ear of wheat, weight of seeds, thousand-kernel weight, and overall yield of wheat from plots. During the growing season, it was observed that the wheat rust diseases infestation rate in farmer practice plots with 'Starshina' variety was 40% in contrast with 5% in IPM demo plot with 'Ormon' variety. In general during the monitoring and assessment of insect pests with farmers in 1 m^2 plots, the numbers of Sunn pest adult and larvae numbers in farmer practice plots were 24 to 28 in contrast with 4 - 5 in IPM demo plots.

The results of 'Farmer Practice' Plots and IPM Package on Wheat Yield Components

	Thousand-kernel weight (gram)	Yield of wheat from plots (kilogram)
Farmer practice	31.2 $\pm$ 0.74 a	29.6$\pm$ 0.56 a
IPM package	51.1 $\pm$ 0.40 b	49.9 $\pm$ 0.48 b

Values within the same column followed by different letters are significantly different at the $P \leq 0.001$ level, T-test.

In contrast to the 'Farmer Practice' plots, each of the yield components were higher in the IPM Wheat package plots resulting in a 41% increase in final yield (from 29.6 to 49.9 kg/plot) in the IPM Package plots. The farmers that participated in the evaluation were very impressed with the rust resistance they observed and requested access to ' Ormon' variety in the future. The results were presented to the farmers through the Institute of Farming and were shared at various meetings and programs with local farmers.

Farmers Field Schools (FFS): One of the important objectives of the IPM CRSP project is to transfer IPM knowledge and demonstrate existing and new IPM technologies to local farmers through the establishment of FFS in collaboration with agriculture ministries, local NGOs, and local universities. During 2010-2013, the Tajikistan IPM CRSP project conducted various training programs and workshops for local farmers. More than 500 farmers attended these programs with 30% participation of women farmers.

Farmer awareness on wheat pest control: One of the main objectives of IPM CRSP program in Tajikistan is to support local farmers on effective control of wheat pest. For enhancing farmers' knowledge on Sunn pest control, the IPM CRSP program distributed a leaflet on Sunn pest control to 500 local farmers in the local Tajik language and 1,000 brochures on 'Wheat pest and diseases and methods of their control' and 'Weeds in cereal crops and methods of their management' published by the IPM CRSP team members: N. Saidov, A. U. Jalilov, D. Landis, M. Kennelly**,** M. Bouhssini (2011 and 2012).

Student Field School on IPM in wheat: The project objective on IPM outreach and education focused on both academic and non-academic stakeholders through student field schools (SFS) and farmers field schools (FFS). A student field school was conducted on wheat IPM for 12 students (five female and seven male) of year 3 in the Biological faculty of Tajik National University. The SFS program curriculum consisted of 22 hours of classroom/theoretical presentations and 16 hours of IPM practical/field research work.

Long-term training: Under Phase II of the Central Asia IPM CRSP Project, one student from Tajikistan is receiving long-term training at Michigan State University focusing on biological control aspects of wheat IPM.

Centers: Michigan State University, ICARDA
Donors: IPM CRSP, USAID
Project period: 2009-2014
Countries: Kyrgyzstan, Tajikistan, Uzbekistan

IN SITU/ON FARM CONSERVATION AND USE OF AGRICULTURAL BIODIVERSITY IN CENTRAL ASIA

Aims and scope of work

The Bioversity International/UNEP-GEF project '*In Situ*/On Farm Conservation and Use of Agricultural Biodiversity (Horticultural Crops and Wild Fruit Species) in Central Asia' brings together five countries to address issues of conservation and sustainable use of local fruit crops and genetic diversity of wild fruit species. Local varieties of horticultural crops and wild fruit species are conserved *in situ*/on farm through enhanced capacity of stakeholder groups including policymakers, researchers, agricultural extension workers, farmers and their associations, local communities, and NGOs. Knowledge about levels and distribution of fruit species genetic diversity, and the value of this diversity for sustainable agriculture and ecosystem health are used to strengthen policy and legislation. The project produces and distributes proven participatory management models that contribute to the conservation of this important global resource within and outside the five target countries. Key project objectives are: (i) to provide options to policymakers for strengthening legal and policy frameworks for conservation and use of fruit genetic resources; (ii) to assess, document, and manage local varieties of horticultural crops and wild fruit species in a sustainable way; (iii) to promote broad stakeholder participation, representative decision-making, and strong partnerships among them; and (iv) to strengthen the capacity to implement all aspects of fruit genetic diversity conservation at local, national and regional levels.

Conservation

In the reporting period, national partners in the five countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) involved in the project conducted household surveys of farmers to assess the impact of the project activities distribution and diversity level of target fruit crops and livelihoods. In total, 727 households were surveyed including 114 households in Kazakhstan, 89 in Kyrgyzstan, 216 in Tajikistan, 98 in Turkmenistan and 210 in Uzbekistan. The diversity of target fruit crops is represented by 239 local varieties and forms of apple, 221 of apricot, 158 of grapevine, 59 of pear, 18 walnut, 35 of pomegranate, 14 of almond, eight of cherry plum, seven of fig, eight of food mulberry, four of pistachio, seven of currant, and three of peach. Distribution of local fruit crop diversity varies among the countries in the Region. The richest diversity of apple is available in Kazakhstan (86 local varieties and forms), of apricot in Tajikistan and Uzbekistan (92 varieties in each country), grapevine diversity is rich in all countries. A total of 132 promising forms of wild fruit and nut-bearing species are identified in the forests (*in situ*) while 19 forms grow in Kazakhstan, 31 in Kyrgyzstan, 15 in Tajikistan, 29 in Turkmenistan and 38 in Uzbekistan. The most intra-specific diversity is available in walnut populations (22 forms), pistachio (44 forms), almond (17 forms) and apple (17 forms). Many of these varieties and forms possess useful traits such as drought and frost tolerance, resistance to pests and diseases, high yield and good taste quality. A total of 72 demonstration plots/matrix orchards were established in five partner countries in all agro-ecological zones comprising: 14 in Kazakhstan (total area 29.57 ha); seven in Kyrgyzstan (total area 15.4 ha); 18 in Tajikistan (total area 32.38 ha); 11 in Turkmenistan (total area 8.1 ha); and 22 in Uzbekistan (total area 18.4 ha). Twelve of these demonstration plots/matrix orchards are established in forest sites to conserve *in situ* wild relatives of target species. A total of 436 local varieties of target fruit crops and 117 promising forms of wild nut-bearing and fruit species are maintained *in situ* and on farm at these sites. Furthermore, 59 nurseries were established for multiplication local varieties of target fruit crops and promising forms of wild fruit species in all partner countries (14 in Kazakhstan, seven in Kyrgyzstan, 11 in Tajikistan, 10 in Turkmenistan and 17 in Uzbekistan). Every year, more than

1,500,000 samplings of local varieties of target fruit crops and 91,500 saplings of promising forms of wild fruit and nut-bearing species are being produced in these nurseries. In all partner countries, production of planting material of local varieties of target crops has been increased and more than 6,000,000 saplings of fruit trees have been grown and distributed among the farmers during the project lifespan. In 2012, production of planting material increased by 2.8 times in comparison with 2007.
The central database established during the project was launched at the International Workshop Launching of Central Database and Web-Portal organized on 12 June 2013 at Bioversity's HQ in Maccarese, Italy. The database is hosted by Bioversity International according to the signed agreement with national partners on access and information sharing. It contains data on morphological characterization of local varieties of target fruit crops, their geographical location, information about farmers, holders of these varieties and related socioeconomic data on the households. National partners are provided with access to the database according to the terms of agreement on access and information exchange through the project's web portal: http://centralasia.bioversity.asia/

Enabling legislation

National partners continued working on proposals for strengthening legislative frameworks in support of *in situ*/on farm conservation of fruit crops diversity in their countries. A publication 'Conservation of fruit trees diversity in Central Asia: policy options and challenges' including national reports on legislation and policy analysis and regional synthesis paper was prepared in Russian and English. The publication provides an overview of the current legislative and policy framework in Central Asian countries on agro-biodiversity conservation in protected areas, supporting development of farming enterprises and conservation of local crop diversity, protection of farmers' rights to access to land, water resources, seed and planting material, markets, education and financial support. It also includes countries' proposals on creating a favorable legislative environment for encouraging farmers and local communities to maintain unique local diversity of crops.
Analyses carried out by the national project teams in the partner countries allowed the national authorities to review relevant national legislation on farm enterprise development, protection of breeding achievements, biodiversity conservation etc from a new 'genetically diverse' perspective, identify gaps in existing legislation and elaborate normative proposals. The main initiatives of national partners were focused on modification of different aspects of agriculture development which are linked to fruit crop diversity conservation: proposals on dehkan (farming) enterprise legislation to promote long-term lease land, land tax exemption if land is dedicated to cultivation of local or old varieties of fruit crops and grapevine, economic subsidies to support local landraces, farmer responsibility for conservation.

Dissemination

In total, 55 scientific guidelines on various aspects of fruit trees diversity management, including traditional knowledge were published within the project and disseminated among stakeholders.
National rosters of local varieties of fruit, nut-bearing crops and grapevine maintained *in situ* and on farm were produced in the partner countries.
In total, 19 interviews on the importance of conservation of local diversity of fruit crops and their wild relatives were given in the reporting period by the national partners in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, comprising 14 interviews to television channels and five to radio channels. All partner countries developed booklets on the regional and national training centers established within the project to disseminate information on services provided by the centers. The booklets contain information on the facilities available and expertise of the centers to provide training courses and qualified consultancy on specific issues related to agricultural biodiversity management.
In total, 27 video films were produced within the project by the national partners comprising seven in Kazakhstan, seven in Kyrgyzstan, six in Tajikistan, three in Turkmenistan and four in Uzbekistan.
In Uzbekistan a national workshop devoted to the International Day to Combat Desertification and Drought was organized on 18 April 2013 at Tashkent State Agrarian University. Issues on the role of fruit trees in reforestation, technologies for their cultivation, organization of training courses for farmers and

forest dwellers were discussed at the workshop attended by 60 representatives of local authorities; members of the Agrarian Committee of Oliy Majlis (the Parliament) of Uzbekistan, MSc and PhD students and the scientists from national research institutes and universities.

Capacity building

Bioversity International organized a number of training workshops, scientific and practical conferences at regional and national levels for policymakers, researches, students, farmers, forest dwellers and local communities. Participation of national partners at significant international events dedicated to conservation of agricultural biodiversity was also supported. Special attention was paid to training young scientists on agro-biodiversity study and conservation , and use of information resources for their scientific research. More than 60 MSc and PhD students and university tutors of Tashkent State Agrarian University and Samarkand State University were trained to use information resources for scientific research in workshops organized in March 2013 in Tashkent and Samarkand, respectively. Research catalogues available over the internet such as Mendeley, Scirus and Google Scholar were presented to the participants in order to help them gain full access to research papers and manage the gathered information. A total of 45 bachelor students from Tashkent State Agrarian University in Uzbekistan were trained on 'Wild relatives of fruit crops and a need for their conservation' at Bruchmulla forest enterprise and Chatkal Forestry Experimental Station in May-June 2013.

Centers: Bioversity International
Donors: UNEP/GEF
Project period: 2006-2013
Countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan

CONSERVATION AGRICULTURE FOR IRRIGATED AND RAINFED CROPPING SYSTEMS OF SOUTH KAZAKHSTAN

Aims and scope of work

Kazakhstan is characterized by a rich diversity of climatic conditions and soil types. The existing crop production systems in terms of cereals include the following:

- Rainfed agriculture dominated by spring cereals (northern and central parts of the country);
- Rainfed agriculture dominated by winter cereals (southern and southeastern parts);
- Irrigated agriculture (mostly in the southern part of the country).

In the beginning of 2000 CIMMYT, in cooperation with NARS and Ministry of Agriculture of Kazakhstan initiated large-scale conservation agriculture activities in the rainfed area of north and central Kazakhstan. Due to these efforts, the area under CA-based practices increased from virtually none to an estimated area of 1,850,000 ha in 2012, with continued rapid increases in area. The utilization of CA-based technologies has become an official state policy in agriculture in Kazakhstan. Since 2008, the government of Kazakhstan has been subsidizing farmers who are adopting CA-based technologies. With this, Kazakhstan is now among the top 10 countries with the largest areas under no-tillage in the world.

The agricultural system of south Kazakhstan differs from that of north Kazakhstan. CA adoption is more challenging in south Kazakhstan. Since 2002 CIMMYT activities in south Kazakhstan have focused mainly on furrow irrigation and raised bed wheat planting showing high efficiency for seed multiplication and wheat production in comparison with traditional ways. In 2008 CIMMYT started large-scale CA/no-till activities in south Kazakhstan (direct seeding on permanent beds in irrigated areas and no-till in rainfed fields). Due to these activities and efforts, areas under CA in south Kazakhstan was increased from 7,400 ha in 2008 to 41,500 in 2009; 68,800 ha in 2010; and around 90,000 ha in 2012, In total, CA areas increased more than 10 times over the last five years.

The results demonstrated advantages of the CA technologies, including tillage cost reduction, better residue management, weed control, improved irrigation conditions, reduced seed rate, economic efficiency of the crops production. If the distance between beds is acceptable for other crops in the rotation, use of permanent beds can significantly reduce the time between harvesting the previous crop and sowing the next one (obtaining two crops in one year is the most important objective and challenge for the region).
The data of the assessment of winter wheat CA trials in Almaty Region, southeast Kazakhstan, demonstrates gradual increases in the 'CA wheat' yield in comparison with conventional technologies both in irrigated and rainfed fields. Taking into consideration that the inputs (labor, fuel, etc) in case of CA were rather lower in comparison with conventional methods the data obtained confirm economic efficiency of conservation agriculture technologies in south Kazakhstan.

Introduction of high-yielding and drought-resistant crops and advanced technologies for large-scale feed and biofuel production

As part of CA and crop diversification activities in the country, CIMMYT-Kazakhstan and KazAgroInnovation JSC initiated introduction of sorghum into crop rotation systems, the plant known as one of the most drought-resistant, high-yielding and low-input crops in the world. Sorghum could help in short time to create sustainable bases for intensive livestock and biofuel productions - important components of the national food and energy security. Sorghum, as a crop with high content of sugar, also could replace traditionally used for sugar production sugar beet - a crop requires too much water and is complicated for cultivation, and presently due to water scarcity and climate change is becoming low-profitable.
A total of 50 varieties and lines of sorghum kindly provided by ICARDA, ICRISAT, ICBA and the Russian Academy of Agricultural Sciences were tested in Almaty Region, south Kazakhstan under conventional and CA technologies. The trial demonstrated high productivity of sorghum varieties both in irrigated and rainfed fields. The best 2012 genotypes ('Uzbekistan 18', 'Oranzhevoyo 160', and 'Kazakhstanskoyo 20') yielded 70 t/ha of green biomass with sugar content of up to 20%.

Assessment of CA/no-till area, advancement and impact of CA/no-till technology adoption in Kazakhstan

According to an assessment done by CIMMYT in 2012, which updates an estimation made in 2008, no-till in Kazakhstan is practiced in an area of at least 1.85 million ha. A remarkable 200% increase in five years (Figure 1). To ascertain the actual no-till area CIMMYT surveyed and interviewed more than 150 farms in Kazakhstan, consulted with officials of Ministry of Agriculture (MoA), local government and territorial agricultural departments, research institutes, financing institutions, agricultural machinery companies, the Union of Farmers of Kazakhstan, and a wide range of other stakeholders. The collected data was analyzed by CIMMYT, FAO and World Bank experts and a special report 'Advancement and impact of Conservation Agriculture/no-till technology adoption in Kazakhstan' was prepared. As a result of this assessment, Kazakhstan can be ranked as the ninth country in the world in terms of acreage with CA/no-till technology. Together with China, Kazakhstan appears to have been the fastest in terms of adoption rates.
The latest MoA estimate on net wheat production in 2012 was 10.7m tons from a reported 13.5m ha of sown areas. At the same time, in 2012 the no-till area (considering only 80% of the overall updated no-till area assumed under this crop) would have produced an estimated 1.8m tons of wheat. The incremental wheat production only because of no-till area is hence projected to be 0.72m tons, equivalent to around 220m USD (average FOB prices). (Figure 2).
The adoption of CA/no-till technology in Kazakhstan has increased wheat production by almost 2m tons, equivalent to about 580m USD incremental income over the last three years (2010-2012). Importantly, in food security terms this incremental production is on average able to satisfy the annual cereal requirements of some 5 million people (130 kg/per capita/year). In terms of climate change mitigation, Kazakhstan would contribute to the carbon sequestration of about 1.8m tons of carbon dioxide (1 ton/ha). (Figures 3 and 4).
In addition to these economic, social and environmental benefits, the adoption of no-till in Kazakhstan is also reducing production costs for the concerned farmers that are calculated at around 15 USD/ha and would now be standing at about 30m USD per year (less fuel, less seed, and over time less herbicide use). In

this regard, it is estimated that farmers in northern Kazakhstan have invested about 200m USD to equip their farms with no-till machinery (100-120 USD/ha).

Centers: CIMMYT
Donors: Ministry of Agriculture of Kazakhstan, National Budget Program No 042 'Applied Research in Agriculture', Project 'Improvement of Crops' Genetic Yield Potential and Agricultural Technologies for Different Agro-ecological Zones of Kazakhstan'
Project period: 2012- 2014
Countries: Kazakhstan

CONSERVATION AGRICULTURE IN IRRIGATED AREAS OF AZERBAIJAN, KAZAKHSTAN AND UZBEKISTAN

Aims and scope of work

The expected long-term impact of the project launched in 2011 is to improve rural livelihoods and food security through increased productivity of irrigated farming systems in Kazakhstan, Uzbekistan and Azerbaijan, using the principles and practices of conservation agriculture. It is expected that at the end of the project, improved water and soil conservation techniques will be sufficiently validated by a core group of farmers and an expanded program will be prepared for farmers in a broader geographic area.

Improved crop production and management within demonstration sites through accelerated adoption of conservation agriculture practices

Conservation agriculture practices were tested at three demonstration sites covering all three respective project countries. Minimum tillage by disking, minimum tillage by chiseling and no-till technologies were tested along with conventional practices in the irrigated conditions. No-till maize, in Azerbaijan and Kazakhstan, under irrigated agriculture provided yields comparable to those obtained through full tillage and minimum tillage. Winter wheat yield was higher in the treatment with no-till method compared to the other treatments in Azerbaijan.
Mung bean was seeded into wheat stubble in Uzbekistan by no-till planter and grain yield was slightly higher than tilled mung bean. Direct seeding of double cropped crops supervised across the project countries and obtained data is statistically analyzed.

Raised-bed planter and land levelling technology
Bed planting method tested in Azerbaijan, Kazakhstan as well as in Uzbekistan reduced seed rates by almost half and provided higher winter wheat yields. The highest winter wheat grain yield, with bed planting, was recorded (5.10 t/ha) in farmer 1, while the lowest grain yield was recorded (2.23 t/ha) in farmer 2 with traditional planting in Azerbaijan.
Wheat was planted at Sayram site in Kazakhstan, using the bed-planter at seeding rates 100, 120, 140 kg/ha, while in the broadcasting method the seeding rate was 200 kg/ha. The best sowing rate with regard to grain yield across planting methods was bed planting at 120 kg/ha and had the highest (4.54 t/ha) grain yield compared to control treatment. Laser land leveling was done in an area of 4 ha in Azerbaijan which is the basis for improved irrigation practices. Less and more efficient water use for the new crop rotations was introduced. Water use efficiency was significantly higher with the bed planting (2.36 and 2.11 kg/ m^3) compared with conventional planting (1.67 and 1.85 kg/ m^3). The best improved irrigation technology and crop rotations will be identified and will be recommended for adoption in the project countries.

Crop rotations diversified with crops suitable for CA

Crop diversification practices were tested at three demonstration sites in Azerbaijan, Kazakhstan and Uzbekistan. Field trials in Azerbaijan included testing of food legumes (soybean and kidney bean), small grains (winter wheat, winter barley, buckwheat, pearl millet and millet).
In Kazakhstan maize, mung bean, soybean and kidney bean were studied as compared to summer fallow after winter wheat harvest. Mung bean was studied under irrigated wheat-cotton rotation in Uzbekistan for double cropping after the harvest of winter wheat. It was found that food legumes are the best crops for diversification under conservation agriculture in the irrigated conditions. It is a good starting point for conservation agriculture in cotton-wheat cropping system. All the above mentioned crops were planted by using Brazilian no-till drill.

Economics

Growing conditions of crops on selected farms (demonstration and control plots) are being monitored. All work on testing new technologies was done in a farmers' participatory method during field days which helped to disseminate technologies in a wider area. The highest net benefits (745 USD/ha) were obtained with bed planting while the conventional method achieved the lowest net benefits (495 USD/ha) in Azerbaijan. The profitability was 139% for bed planting. Socioeconomic survey instrument was pre-tested and fine-tuned. The sampling methodology was developed and sample sizes were determined. Farmer perceptions and preferences are being monitored. The economic impact of the traditional and bed planting technologies are being analyzed.

Farmer-oriented brochures and guidelines

Draft guidelines on improved land, water and crop management through CA technologies are being prepared and a brochure on conservation agriculture practices in Kazakhstan was published in Russian. A leaflet on specifications of zero till planter was published in Uzbekistan. A poster on conservation agriculture in Azerbaijan was published. A poster entitled 'Conservation agriculture for irrigated areas in Azerbaijan, Kazakhstan, and Uzbekistan' was prepared and presented in European Regional Conference (ERC) of FAO in 2012: 'Save and Grow' and promotion of Conservation Agriculture, Baku, Azerbaijan. Also scientists produced and published five scientific papers based on the results achieved under the project. National TV covered the Field Days and interviewed Drs Asad Musaev, Zokhidjon Ziyadullaev and Dossymbek Sydyk in Azerbaijan, Kazakhstan and Uzbekistan respectively.

Field Days

Three Field Days, involving about 70 farmers and representatives of local authorities in Azerbaijan, 50 in Kazakhstan and 70 in Uzbekistan were organized. During these Field Days, improved technologies of irrigation, conservation agriculture and crop diversification were demonstrated by the scientists and collaborating farmers. The capability of the no-till seeder to seed maize (Azerbaijan and Kazakhstan) and mung bean (Uzbekistan) directly behind the combining of wheat was demonstrated during the Field Days which were conducted in 2012.

Training courses

A series of training courses on conservation agriculture practices were conducted in Azerbaijan, Kazakhstan and Uzbekistan. In all, 221 participants (Azerbaijan 58, Kazakhstan 72 and Uzbekistan 81) attended the courses, including policymakers, officials from Ministry of Agriculture, researchers, national consultants of the project, and farmers. The main objectives of the courses were to train the scientists and farmers in the required skills and tools to be used in better targeting of conservation agricultural research in order to increase adoption of these technologies in the respective countries. Demonstration and research activities were carried out in at least one selected benchmark site of 25 ha in each country. In addition to the demonstration sites in each country, thanks to project on 'Conservation agriculture for irrigated areas in Azerbaijan, Kazakhstan and Uzbekistan' area under conservation agriculture in neighboring farmers' fields reached 1,246.1 ha in Azerbaijan, 869.3 ha in Kazakhstan and 923 ha in Uzbekistan in 2012 under irrigated conditions. The results of this project convinced policymakers to start adoption of conservation agriculture in the irrigated areas in the respective project countries.

Center: ICARDA
Donors: FAO in the framework of the FAO-Turkey Partnership Program
Project period: 2011-2013
Countries: Azerbaijan, Kazakhstan, Uzbekistan

INTEGRATED WATER RESOURCES MANAGEMENT IN FERGANA VALLEY

Aims and scope of work

The main goal of the 'Integrated Water Resources Management in the Fergana Valley' project is to contribute to the security of livelihoods, increase environmental sustainability and social harmony through improving the effectiveness of water resources management in the Fergana Valley.

Specific objectives for Phase 6 were:

- Preservation of acquired technical and operational competencies, including its documentation at the level of an editorially agreed standard;
- The average capacity of WUAs in the project zone should be enhanced in terms of financial viability and efficient provision of water services. For that a limited number of well-performing WUAs in the project areas will be provided with computers, simple software and pertinent IT training;
- Continuation of ongoing transboundary consultations process for two pilot STTs (IWMI);
- To complete all project activities for logical termination of the existing contractual arrangements with SDC related to Phase 5 of the 'IWRM-Fergana' Project.

Project Purpose:

To sustain IWRM capacities/achievements created during 2001-2011 with the support from SDC, and to preserve basic local human potential for future wider IWRM dissemination, and prepare the ground for planning SDC's next roll-out phase.

Completing the consultation process in two small transboundary tributaries (STTs)

Regarding completing the consultation process on joint water governance in the two selected small transboundary tributaries (STTs) of Khojabakirgansai and Shahimardansai, the major thrust by the project throughout 2012 was on finalizing and facilitating the elaboration, operationalization and internalization of joint river-wide water governance arrangements and processes on each STT. The long term objective was to prepare the ground and blueprints for future inter-governmental agreements between respective riparian countries. This was achieved through joint action planning by respective riparian sides of two STTs. Consequential implementation of such joint action plans was aimed at strengthening and boosting the overall water cooperative spirit between co-riparians. Furthermore, by facilitating jointly developed processes, we established foundational mechanisms for more systematic and regular cross-border dialogue.
Capacity-building efforts were aimed at key institutions and persons on each STT who were considered capable and had authority to make sure that the project achievements were properly anchored, maintained and further promoted beyond the project implementation time. As a result, a number of

applicable tools and skills have been developed, coordinated, introduced and put in place jointly with the key local stakeholders to facilitate ongoing water communication. Thematic scope of the dialogue processes was oriented at daily routine operations, emergency situations as well as for self-monitoring and strategic decision-making.

The key points on both sides of the two project STTs were equipped with full PC sets (3 per each riparian side and 12 in total) as well as additionally provided with means of communication (a total of 10 phones for 2 STTs). The respective personnel and institutions on each STT have been trained in a range of IT skills from basic Word and Excel processing to more advanced uses of Internet, email and Skype conferencing. To boost cooperation, an Excel and later a web-based STT Basin-wide Water Cooperation Database was developed for each STT. This will help the co-riparians to regularly maintain, update, monitor and audit ongoing cooperation. It is an Excel-based application comprising a set of practical thematic data worksheets logically structured and linked with each other to form a holistic and user-friendly river-wide database. This was designed to store and keep track of all sorts of data that will be generated in the course of two-side water cooperation. All key actors on both STTs assured that the joint database will be maintained and kept up-to-date serving the basis for longer term sustainability of the working cross-border relations and possible donor funding.

However, it should be acknowledged that to fully capitalize on the project's ground level accomplishments on both selected STTs, an intergovernmental framework agreement between the countries has yet to be negotiated and put in place. This is a longer-term process and clearly was not part of the current phase. The major steps as to how to achieve this were closely discussed and endorsed during national level consultations held in 2012. The sessions were attended by the National Coordination and Support Groups. In this respect it is worth noting that one STT – Khojabakirgansai - at this point is much better-off due to current facilitation of an inter-governmental agreement process by the GIZ project. As for the Shahimardansai STT, a separate intergovernmental negotiation process is yet to be initiated. To lead this process, formation of MAWR-led inter-ministerial working groups is necessary. This hopefully would be possible in future and under a different project or projects.

Firstly, the riparian parties at each STT following their initial action planning exercise jointly developed and agreed on their yearly action plan to regularly meet and cooperate on matters of common interest. These are water allocation (coordination of water rotation and ensuring the supply to the end tail parts of the system) in critical periods, joint actions during extreme events, limited assistance (cleaning the sections of transboundary canals, providing necessary equipment and machinery and labour support) in maintaining the transboundary infrastructure (mud flow control dams, section of the canals and head structures), sharing key water data and flow information for key diversion points. To this end both sides also jointly agreed on the frequency and dates when joint meetings were most important as well as the issues and information of common interest and concern that they were willing to discuss and share with each other. As initially agreed each riparian side hosted every other joint event. In addition, each riparian side appointed one of their key water professionals as a focal point to team up with the counterpart from the other side of a river and facilitate 2-side communication process - a prototype technical body/secretariat that can be formalized once a proper legal framework agreement is in place between both respective STT countries. Each time when joint meetings were held, it was the hosting side that chaired and took notes of the event.

Overall the process of cross-border cooperation upon full completion of Phase VI suggests that it was well accepted, smooth and fairly open in terms of both parties willing to discuss and share information of mutual interest and concern. However, the sustainability of the project achievements is yet to be seen beyond the project implementation period. Overall, the STT stakeholders consider the project facilitation process as a positive institutional building experience.

Centers: IWMI
Donors: Swiss Agency for Development and Cooperation
Project period: Phase 6: 03/2012 – 12/2012
Countries: Kyrgyzstan, Tajikistan, Uzbekistan

COMPREHENSIVE REVIEW OF WUA DEVELOPMENT IN UZBEKISTAN

Aims and scope of work

This desk study aims to improve management of water in Uzbekistan by consolidating the local Irrigation Management Transfer (IMT) reform through rigorously searching, selecting and studying all the printed, published or documented evidence available regarding different approaches and models to WUA establishment in this country based on the methodology of a systematic review using mostly qualitative methods of inquiry. It is a type of literature review based on a clear, transparent and replicable search protocol for available evidence aiming at mapping the available evidence base both quantitative and qualitative in an as unbiased way as possible and synthesizing it for some policy conclusions. A whole variety of documentary sources collected to date suggest at least 18 such projects funded by nine different donors since the late 1990's. These are spread across every Region of the country. Some of them have been completed while some are still ongoing. Currently there are a total of 1487 WUAs in Uzbekistan of which 25% were or are still being supported by one or more of these projects.

Accomplishments to date

The following are the major project accomplishments to date since started. Activities against the tasks as set for the project are in progress as planned. Particularly the following has been accomplished to date:

- Additional web and hand literature search has been conducted to complete the documentary source base of formally published and grey materials on all known WUA projects in Uzbekistan for further analysis;
- Categorization of all collected documentary sources was made and organized by the following categories: project implementation reports - inception reports, progress reports, completion reports; project evaluation reports - internal reports, external reports; training reports; journal publications/articles;
- The criteria for the quality and relevance of all collected documentary sources by each category and inclusion into analysis have been refined;
- The content analysis of collected documentary sources by each category is underway and will be completed and written up into a report as planned by the end of this year.

Preliminary findings to date

Using the criterion of project maturity for learning lessons, nine projects aged at more than three years old were short-listed for this study for in-depth analysis. Geographically these nine projects are scattered across 27 administrative districts in 13 Regions of Uzbekistan. The level of treatment in all these projects is WUA with the impacts aimed at farmer's level. The total number of WUAs treated in a number of different ways is 212. They cumulatively occupy over 500,000 ha of irrigated farmland or 12% of the total irrigated area of Uzbekistan. The total number of individual farmers within all such treated areas amounts to over 6,500. Besides, almost identical irrigated area in Uzbekistan has been also undergoing donor-led interventions in the framework of other at least nine WUA projects that were excluded from the short list as not sufficiently mature for impacts to emerge being less than three years old.

The nine WUA projects short-listed as mature are funded by four different donors. Seven of them were or are still being implemented by the Ministry of Agriculture and Water Resources, one by an international NGO and one by a partnership of regional and international research organizations. Initial analysis of project documents allowed categorizing the short-listed WUA approaches into the following eight different specific reform treatments:

A - setting up WUAs along the boundaries of former collective farms

B - setting up WUAs along the boundaries of entire administrative districts
C - setting up WUAs along the hydrologic boundaries
D - building local capacities for proper WUA organization, operations and governance
E - rehabilitating irrigation and drainage infrastructure of WUAs, and
F - providing WUAs with infrastructure maintenance machinery
G – setting up WUAs with separation of governance and management functions
H - setting up WUAs without separating governance and management functions

Based on a combination of the above specific treatments all the short-listed projects were further categorized into five broader project cluster groups as set out below:
- Treatment mix AH: 1 entire Region without a project
- Treatment mix CDG: 1 project with a total of 40 treated WUAs funded by 1 donor
- Treatment mix DEG: 3 projects with a total of 44 WUAs funded by 2 donors
- Treatment mix DEFG: 3 projects with 92 WUAs funded by 3 donors
- Treatment mix CDEFG: 2 projects with 36 WUAs funded by 3 donors

The content analysis of collected documentary sources by each category and project treatment group is underway and scheduled to be completed and written up into a full report until the end of the current year.

Centers: IWMI
Donor: CRP Water, Land and Ecosystems
Project period: January-December 2013
Countries: Uzbekistan

REVITALIZATION OF CANAL IRRIGATION IN CENTRAL ASIA

Aims and scope of work

Agricultural activities in vast areas of Central Asia heavily rely on surface water irrigation from the Syrdarya River and Amudarya River and their tributaries. However, mismanagement of the water resources and in some places unfavourable natural conditions have caused land degradation in the form of salinization and waterlogging in more than 50 % of the agricultural areas. Irrigation water contained salts, which were added to the agricultural land and also triggered dilution and mobilization of the fossil salts from deeper soil horizons, while rising groundwater brought about reappearing salinity build-up within the root zone of plants.
Soil salinization significantly reduces land productivity and crop yields and thus, negatively impacts livelihoods of rural population in Central Asian countries, particularly in Uzbekistan. Moreover, uncertainty of the freshwater supplies in terms of amounts and timing as induced by the global climate change may render agricultural activities unsustainable. In such conditions, inexpensive but sound interventions are urgently required to sustain agriculture, environmental and socioeconomic stability in the region.
The overall goal of this project is to contribute to socioeconomic and environmental sustainability of the irrigated agriculture in Central Asia (on the example of Dostlik Canal command area, Uzbekistan and Kazakhstan). The specific objective of the project is to test alternative drainage system.

The project tasks are to:

- Compile water and salt budgets for the pilot site on Novbahor farm, Syrdarya Region, Uzbekistan;
- Modelling soil and groundwater salinity dynamics.

This project is under implementation in cooperation with Gulistan State University.

Anticipated activities and progress

The project started in June 2013. During the inception workshop organized in August 2013, the scope of work and preliminary work plan, methodologies, activities and outputs were discussed and defined. The research site (30-ha typical agricultural field) was identified and fieldwork activities and data collection started immediately. Eighteen groundwater monitoring wells were installed with data collection period of five days, open drain, closed at both ends was deepened and widened, and soil samples were collected.

Centers: IWMI
Donor: CRP Water, Land and Ecosystems
Project period: 01.06.2013 – 31.12.2014
Country: Uzbekistan, Kazakhstan

IMPROVING WATER MANAGEMENT IN THE LIFT IRRIGATION AREAS OF THE SYRDARYA AND AMUDARYA BASINS

Aims and scope of work

This report targets water and energy productivity in the lift irrigation areas in the midstream of the Syrdarya River and the Amudarya River basins. The objective of the report is to estimate water and energy productivity of agricultural water use under lift canal and groundwater irrigation. Water and energy productivity are analyzed for lift irrigated areas of northern Tajikistan, located midstream of the Syrdarya River, and Kashkadarya Region, located in the midstream of the Amudarya River.

Lift irrigation in northern Tajikistan

The studies indicated high energy expenses for water lift from the Syrdarya River to highlands and foothills of the northern Tajikistan. In the Samgar lift irrigation zone the energy expenses for water delivery vary from 0.42 KWh/m^3 for the first lift zone to 0.57 KWh/m^3 for the second lift zone and to 0.82 KWh/m^3 for the third lift zone respectively. Efficiency of energy use for water lift for different pump stations is estimated in the range of 0.44 - 0.82. These data show the scope for reducing energy consumption through renovation of pump stations and rehabilitation of lift canals. At the same time, the power consumption for groundwater abstraction in the Kushatov Farm Union averaged 0.26 KWh/m^3, ie even after renovation of the lift irrigation system the energy expenses will be still twice that at the third lift and 44% higher at the second lift compared to groundwater abstraction for irrigation purposes. This data indicates the potential for conjunctive use of canal water and groundwater to reduce energy losses. Collected data show that farmers located in the first lift zone (the head part) have an excessive water supply with almost no interruptions to the access of water. Water supply exceeds irrigation requirements of main crops. Farmers widely practise inter-cropping and double cropping. A different picture occurs in the third lift zone. Starting from June to September there are often interruptions in water supply. Under such conditions farmers irrigate main crops only. Farmers using groundwater for irrigation apply a different strategy. The farmers using groundwater had uniform non-interruptable water supply except for a few days with the interruptions of power. The water supply meets crop water requirements during the whole crop vegetation season, except in mid-summer when farmers look for additional water from neighbouring farms.
The farmers from the head part of the lift canal had access to extra water – the total of irrigation applications was 15,000 m^3/ha. A different picture is observed in the third lift zone. Water supply was unreliable and the total irrigation applications was 7,500 m^3/ha. The amount of water supplied was close to the irrigation requirements of the crops at seasonal level but not on a monthly basis. For example, water supply was higher in April/May compared to July/August while crop water requirements have an opposite regime.

Lift irrigation in Kashkadarya Region

There are two primary sources causing soil salinization in the Karshi steppe: they are salt load associated with high concentration of salts in the Amudarya River in the midstream and soluble solids in the deposits of the zone watered by the groundwater table rise. The total dissolved solids in water of the Amudarya River in the midstream vary from 572 to 1,120 mg/l. Salt balance of the irrigated zone of the Karshi steppe indicates the mobilization of naturally originating salts within the Karshi steppe. While inflow exceeds outflow by 1,500 - 2,500 Mm^3/year, salt outflow exceeds salt inflow by 3,000,000 - 8,000,000 mg/year. This study aims at reducing the mobilization of primary salts by managed aquifer recharge and applying drip irrigation.

Centers: IWMI
Donor: CRP Water, Land and Ecosystems
Project period: 1 June 2012 – 31 December 2013
Country: Tajikistan and Uzbekistan

SUSTAINABLE GROUNDWATER IRRIGATION TECHNOLOGIES FOR SMALL FARMS OF CENTRAL ASIA

Aims and scope of work

The Syrdarya River basin in Central Asia has a catchment area of 219,000 km^2 and generates about one-third of the total flow that is used to feed the Aral Sea. Irrigated agriculture, based on the natural flow of the river, has been practiced in the basin from ancient times. But it was the massive scale of flow regulation in the second half of the twentieth century, and subsequent geopolitical change in the 1990s with the formation of the newly independent states that dramatically changed the hydrology of the river and complicated overall basin water management. Under current conditions, the midstream and the downstream of the Syrdarya basin face severe seasonal water shortage for agriculture and environment, caused, primarily, by three factors:
Non-uniform distribution of limited water. The midstream and downstream of the basin generate only 10.9 km^3 of flow (29% of the long-term mean annual flow [MAF] of the entire basin), while the needs of the downstream agriculture and environment are at least twice higher (Abdullaev et al. 2007). With increasing demand for water, the midstream and downstream water users become more dependable on the upstream inflow.
Growing competition for water between hydropower located upstream, and agriculture and environment demand downstream. The shift of the upstream reservoir on the Naryn River from irrigation to hydropower generation mode in the beginning of 1993 and the associated increase in winter discharges and reduced summer flow have caused an estimated shortage of 3 km^3 of water annually for the midstream and downstream agriculture (Mustafaev et al. 2006). There is not enough free storage in the midstream and downstream reservoirs in winter to accumulate the releases from the upstream reservoir for summer use.
Global climate change and its impact on water resources. Over the last 70 years, the air temperature has increased by 0.029 ^oC per year followed by high fluctuations in precipitation. According to the Hydrometeorology Service of Uzbekistan, by 2050, the reduction of the Syrdarya River flow can be around 6-10%, with an increased frequency of extreme flows, which will require more storage (Agaltsceva and Pak, 2007).
This short summary describes main advantages and limitations of groundwater development for irrigation in small farms of Central Asia as an approach to meet growing shortage of water for agriculture. The studies cover two main irrigation zones in the Syrdarya River basin, namely Fergana Valley and southern Kazakhstan. The studies in the Fergana Valley cover the grapevine production farm in the Shahimardan River downstream, Uzbekistan and Kushatov Farm Union in Bobojon Gafurov

district, northern Tajikistan. The studies in southern Kazakhstan were carried out in the Turon Farm Union, located in the Arys Turkestan Canal command zone. Water productivity at these sites is estimated for different crops affected by groundwater irrigation, intensive farming practices and adoption of water saving technologies.

Groundwater irrigation studies in the Shahimardan River basin

A dense system of canals supplies irrigation water for cultivation of cotton and winter wheat on fertile soils of the Fergana Valley. The land released for production of other crops, such as orchards, grapevines, vegetables, melons and fodders, is limited in the main canal commands. Farmers having a shortage of free land cultivate vegetables and fodders after the winter wheat harvesting from mid June to October if irrigation water is available. Another option is cultivation of crops in the upstream of small rivers with unregulated flow. Inconsistency between the natural flow of the rivers and crop water requirements causes irrigation water shortage in April-May and affects yields of agricultural crops in these areas. Under such conditions extracting groundwater, as an additional, or the main, source of irrigation water may provide a reliable water supply for crops. The studies on irrigation of grapevines using groundwater were carried out in 2011-2012 in the Shahimardan River downstream, which belongs to Altyaryk district of Fergana Region, Uzbekistan. The results of the studies at the Shahimardan River downstream suggest that, when intensive farming practices of grapevine production are applied, water productivity can increase from 0.5 to 1.5-1.6 kg/m^3. Anyway the farmers face water shortages and financial difficulties in the first years of grapevine cultivation. The farmers can generate an additional income by growing melons, vegetables or legumes between rows of young grapevine beds. They also may grow high-value drought-tolerant crops, such as pistachio on part of their land.

Increasing water and power productivity by groundwater development in lift irrigation areas of northern Tajikistan

The studies in northern Tajikistan focus on lift irrigation in areas which are most vulnerable to shortage of water and energy resources. The power requirements for operation of pump stations that lift water from the river to the foothills are much higher than the requirements for the traditional gravity system. Therefore, several mitigation measures were considered to increase the resources. These measures are increasing water and power productivity and groundwater development for irrigation purposes. Detailed analyses carried out at the Kushatov Farm Union located in the Samgar zone, one of the lift irrigation areas of northern Tajikistan, showed that power productivity is reduced from the first lift to the third lift canal irrigated area. Low power productivity is associated with high expenses for power per cubic meter of water lift and high losses of water in the delivery system and the irrigated fields amounting to about 40% of the water intake. The results of the study suggest that water and power productivity can be improved by recovering the water losses. Favorable hydro-geological conditions allow exploitation of wells to recover the groundwater for irrigation within the lift irrigation area. The studies found that groundwater irrigation creates conditions for more uniform water supply and higher water productivity than canal irrigation. Power consumption per cubic meter of water pumped by wells is less than the related consumption by pump stations lifting water to the same areas. The studies indicated that farmers from the lift irrigation areas have already realized advantages of the groundwater irrigation. Farmers, facing water shortage, install their own wells. Over 100 wells have been installed in the Samgar zone since 1991.

Drip irrigation using groundwater in the Arys-Turkestan canal zone

Growing water shortage can be met by adoption of water saving technologies such as drip irrigation. Currently, over 5,000 ha of the irrigated land in southern Kazakhstan and over 1,000 ha of land in Uzbekstan are under drip irrigation. Farmers apply drip irrigation using groundwater in a few sites in the region including the Turon Farm Union in southern Kazakhstan. The union has 1,145 ha of irrigated land in the Arys-Turkestan canal command, of which 290 ha are under drip irrigation. The results of the

studies indicate that there is increased water productivity under water-short conditions under drip irrigation than under furrow irrigation.
Impact of climate change on crop transpiration and evaporation was studied for conditions of the Shahimardan River downstream. With the use of projections for 2050 and 2080 for two climatic scenarios, A2 and B2, the impact of climate change on agricultural water use and groundwater recharge was estimated. The results of the modeling studies indicate that changes in temperature and precipitation will have significant effects on potential crop transpiration; however, actual transpiration change is expected to be minor due to conventional irrigation practices. This study suggests the needs for improving irrigation practices to gain from the increased potential for crop transpiration. The indicated reduction of groundwater recharge can be compensated for by managed aquifer recharge.
Studies on groundwater irrigation in different socio-ecological conditions of the Syrdarya River basin indicated there are several ways to achieve competing demands for food and water. To achieve this, the investments should focus on water and energy productivity, which can be increased by adoption of intensive farming practices, improved irrigation technologies and groundwater development to recover water losses for irrigation purposes. Groundwater development, if not regulated, may gradually lower the water table and deplete groundwater resources. Studies on climate change in the Fergana Valley suggest that the change of river flow due to global warming depletes glaciers and may deplete groundwater storages in future. The results obtained emphasize the need for managing aquifer recharge to improve water management in the Syrdarya River basin.

Centers: IWMI
Donor: OPEC Fund for International Development
Project period: 1 January – 31 December 2012
Country: Tajikistan and Uzbekistan

WATER PRODUCTIVITY IMPROVEMENT AT PLOT LEVEL

Aims and scope of work

The overall goal of improving water management at plot level is to contribute to more secure livelihoods, increased environmental stability, reducing water related conflicts and thus to greater social harmony, through improved effectiveness of water resources management.

The innovation cycle

2012 was the last year of Phase III of the project and Phase III was the last phase of WPI-PL project. The Water Productivity Improvement at Plot Level Project (WPI-PL) contributed to enhancing water productivity, crop yields and yield stability at plot level through improved on-farm water management. The project strengthened the capacity (in terms of knowledge generation and dissemination) of the different actors in the agricultural innovation system through strategic partnerships for dissemination of sound and adapted extension messages relating to water productivity improvement at plot level to farmers. The project developed strategic alliances with national partners in the three countries that are interested in generating, translating and disseminating agro-technical and hydro-technical knowledge and experience from the IWRM and other development projects. Project activities followed the different steps of the innovation cycle for developing and disseminating relevant technologies, by constantly improving and adapting technologies and extension materials according to the systematically collected feedback from the end-users, the farmers.
In all three countries, the project has established a mechanism for operative assessment of the situation in irrigated agriculture and transfer of innovative solutions through the relationship of different institutions. The project was successful in attracting the interest of water users to apply these innovations, which laid the basis for the economic benefit of water users. Due to the efforts of the project, a basis was created for the design and development of the mechanism of interaction between

the water users and the WUA, attracting the WUA key specialists as consultants. The system based on continuous monitoring makes the use of specialists efficient not only to farmers, by eliminating their shortcomings and mistakes through the consultations, but also for the WUA by adjusting the water supply schedules.

The outcome analysis in 2012

The outcome analysis in 2012 showed that advisory work carried out with farmers does bring good results. If at the beginning of the project the interest of farmers to water issues was only about 10-15% , then by 2012 farmers' interest in water issues ranged from 70 to 80%, 20-25% of the issues are on farming techniques, and 5% relates to the legal and economic issues. In the water issues, farmers' greatest interests are often the irrigation regime, water measuring and technological irrigation scheme. In Uzbekistan and Tajikistan, farmers support the involvement of experienced and recognized agronomists in the WUA staff. In Tajikistan, farmers realized that in order to increase profitability it is necessary to introduce volumetric water charges for irrigation water used and 25 farms announced the installation of the WFM; farmers began to trust the recommended agro- and hydro-technologies and trainers' advice. In Kyrgyzstan, the partners noted the high interest of farmers in the mechanism of management of irrigation water within small areas and payment based on the volumetric water used. As a result of this method implementation, farmers started to pay more attention to the duration of irrigation, the technological irrigation scheme, the possibility of reducing water consumption, irrigation period and the number of irrigation applications. Independent consultant survey results indicated that all farmers in the project area reported that water productivity increased in intervention zones.
Within the scientific part of the project, the partners additionally looked for their research, design and advisory materials available and in other organizations. In Kyrgyzstan, Kyrgyz Research Institute for Irrigation sought for and selected materials that met farmer's needs in the field of irrigation water use. The collected material helped to develop additional 10 recommendations by the end of 2012. In Tajikistan, Tajikgiprovodkhoz, taking into account farmers needs and demands, prepared 14 additional materials with the use of its own resources and passed them to SOF in the form of brochures meant for distribution. In Uzbekistan, in SANIIIRI archives they found more than 50 materials on efficient use of irrigation water, irrigation techniques and their parameters.

Main outputs

In WPI-PL project for the first time in the practice of implementation of international projects, new concept and strategy proposed by SDC and based on the innovation cycle was adopted. The project created a system of interaction between the various organizations whose activities correspond to the three main areas of the project: research organizations, information centers and consulting services (disseminators) – where all levels are equally involved. The implemented innovation cycle operates independently in each country and is adjusted under existing conditions. All participating subjects of the innovation cycle have complete understanding of their roles, and they immediately respond to requests from other partners and support each other if required. The mechanism of the innovation cycle has proved its effectiveness and dynamism.
The project systematized the needs and problems that directly or indirectly influence efficiency of irrigation water use and that can be ranged into institutional, technological, financial-economical and legal. In order to solve problems identified, the project identified a set of technologies that meet local conditions of agricultural production. Based on the three-year activities, 14 main recommendations and technologies were identified that can be used for wider dissemination among farmers on a permanent basis.
The project introduced a new system of water allocation based on the organization of water accounting for groups of farmers with small areas. This system allowed to eliminate conflicts between farmers, ensure fair payment for the amount of irrigation water actually used by each farmer, and use of irrigation water effectively and rationally. The project organized a system of water accounting for each farm allowed to shift from the per hectare payment to calculation of the payment based on the volume of water actually used, reduced the cost of charges for water by 40-50%, and, accordingly reduced the

amount of water used for irrigation. The proposed system of key personnel in WUA (hydro-technician and agronomist) allowed disciplining the system of water use at farm level; standardizing the use of irrigation water; increasing knowledge of farmers through a system of regular monitoring and advice of key experts - agronomist and hydro-technician in WUA.

Centers: IWMI jointly with SIC-ICWC
Donor: SDC
Project period: end of phase III of WPI-PL project in December 2012
Country: Fergana Valley: Kyrgyzstan, Tajikistan and Uzbekistan

IMPROVED POTATO VARIETIES AND WATER MANAGEMENT TECHNOLOGIES FOR SMALLHOLDER FARMS

Aims and scope of work

The overall goal of this project is to increase potato productivity and yield stability, competitiveness, and family income of resource-poor farmers in water stress-prone areas in Central Asia. The objective is to investigate and validate cost-efficient alternative irrigation regimes for the potato crop under different agro-ecological conditions, with recommendations for improving current irrigation practices.
Two field sites were selected in Uzbekistan's part of the Fergana Valley: on Sarkor farm, Fergana Region and Baht Taronasi farm, Andijan Region. Both fields are close to the meteorological station located in Fergana city. At each site two different trials were conducted: Trial 1 and Trial 2. Within each trial, two potato varieties were tested: one CIP developed hybrid variety called 'Sarnav' and local variety used by farmers. 'Arnova' was the 'local' variety in Andijan, whereas 'Arinda' was the 'local' variety in Fergana. At each location, the 'local' variety under farmer's irrigation practices was used as the control.

Trial 1- Evaluate the effect of different levels of moisture stress on crop yield under furrow irrigation
Four different levels of soil-moisture stress on yield were evaluated under this trial. The four treatments were: (1) soil-moisture stress and yields were monitored under farmer's irrigation practices; (2) irrigating when 35% of the available soil-water was depleted (under irrigation scheduling); (3) no irrigation until tuber initiation stage (roughly 40 days after planting) followed by full irrigation and 35% depletion irrigation applications thereafter until the end of the season; and (4) no irrigation until tuber initiation stage followed by only one full irrigation application. Treatment 1 was the control treatment for this trial. Under this trial the 'local' variety and a CIP developed variety 'Sarnav' were evaluated.

Trial 2 - Compare the performance of high frequency furrow, partial root-zone drying (PRD), and drip irrigation on crop yield

Under this trial, three different methods of irrigation were compared: (1) high-frequency furrow irrigation (irrigating when 20% of the total available soil-water within the crop root-zone is depleted); (2) partial root-zone drying (PRD) method; and (3) drip irrigation. Drip irrigation systems were designed to apply small quantities of water (ie irrigated when the soil-moisture depletion reached 20%). The drip irrigation system was installed by a local agronomist. There was no separate control treatment in this trial. Therefore, treatment 2 under Trial 1 was considered as the control treatment for Trial 2.

Results

Results of the field trials are presented separately for the two locations - Andijan (Baht Taronasi farm) and Fergana (Sarkor farm).

Andijan

Trial 1: Under this trial the highest yield of 22.1 t/ha was obtained under normal irrigation with irrigation scheduling (NIS), followed by a yield of 20.8 t/ha under normal irrigation following farmer's practices (NIF). However, the amount of water used by the farmer was 8,544 m^3/ha as opposed to only 5,730 m^3/ha under NIS. Under the treatments of DI-1 and DI-2, the crop yields were significantly less than under NIF and NIS, but at the same time, the amount of water used by the crop under these two treatments was considerably less - only 1,773 m^3/ha and 1,203 m^3/ha.
Trial 2: Under this trial, advanced irrigation treatments DrI, PRD, and HFI are compared with normal furrow irrigation treatment with scheduling (NIS). The highest yield of 26.9 t/ha was obtained under HFI as opposed to only 22.1 t/ha under NIS, in spite of the fact that the amount of irrigation water applied was only 3398 m^3/ha under HFI as compared to 5,730 m^3/ha under NIS. The amount of water applied under DrI was only 2,130 m^3/ha which is less than the amount under HFI, indicating that not enough water was applied under drip irrigation. The yield of potato was only 18.3 t/ha under DrI as against a yield of 26.9 t/ha under HFI. However, because of this stress, the water productivity under DrI is slightly higher than under HFI. For PRD treatment, crop yield was 20.2 t/ha and the amount of water applied was 5,029 m^3/ha.

Fergana

In general, the yields from Sarkor farm in Fergana are lower than in Andijon because of two reasons: the fields in Fergana were affected by a widespread disease, and the farmer's field was infested by weeds (*Cyperus rotundus* or nutgrass).
Trial 1: Under this Trial the highest yield of 20.4 t/ha was obtained under farmer's management conditions (NIF), followed by a yield of 12.7 t/ha under normal irrigation with scheduling (NIS). However, the amount of water used by the farmer was 6,999 m^3/ha as opposed to only 4,198 m^3/ha under NIS. Under the treatments of DI-1 and DI-2, the crop yields were significantly less than under NIF and NIS, but at the same time, the amount of water used by the crop under these two treatments was considerably less - only 3,243 m^3/ha and 2,470 m^3/ha.
Trial 2: Under this trial, advanced irrigation treatments DrI, PRD and HFI are compared with normal furrow irrigation treatment with scheduling (NIS) of Trial-1. The highest yield of 19.6 t/ha was obtained under HFI as opposed to only 12.7 t/ha under NIS, in spite of the fact that the amount of irrigation water applied was only 3,082 m^3/ha under HFI as compared to 4,198 m^3/ha under NIS. The amount of water applied under DrI was only 1,762 m^3/ha which is less than the amount under HFI, indicating that not enough water was applied under DrI. The yield of potato was only 13.3 t/ha under DrI as against a yield of 19.6 t/ha under HFI. For PRD treatment, crop yield was 17.6 t/ha and the amount of water applied was 4688 m^3/ha.

Centers: IWMI and CIP
Donor: BMZ/GIZ
Project period: 2012-2015
Country: Uzbekistan, Kazakhstan

MODEL-BASED ASSESSMENT OF CLIMATE CHANGE IMPACTS

Aims and scope of work

Climate change (CC) is a major threat to food production in the dry areas of the world. Regional studies of the impacts of climate change on dry areas, such as the semi-arid regions of Central Asia are sparse, and those available rely on crude assumptions on the biophysical characteristics of crops, soils and climate as well as the agronomic management practices in these regions. The results of the ICARDA/IFPRI project 'Adaptation to Climate Change in Central Asia and People's Republic of China' funded by ADB showed that the main factor which can affect winter wheat productivity in Central Asia in view of climate change is an increase in air temperature in spring and corresponding heat stress during flowering leading to flower sterility.

In this context, ICARDA in close collaboration with Kashkadarya Research Institute of Grain Breeding and Seed Production of Cereal Crops (KRIGBSPCC) started a new project 'Testing of selected facultative wheat varieties for tolerance to heat stress during flowering' within CRP7 Activity 1.2.1 'Model-based assessment of the impacts of climate change and the effects of adaptation technologies on crop water availability and productivity and farmer's livelihood'.

Testing of selected facultative wheat varieties for tolerance to heat stress during flowering

The project involves field experiments along with the soil and crop laboratory analyses to assess the potential of crop management practices (best sowing time) along with screening of improved heat tolerant winter (facultative) wheat germplasm to escape or cope with heat stress during flowering and to assess yield losses associated with heat stress during flowering. Research activities involve collaboration of ICARDA with Kashkadarya Research Institute of Grain Breeding and Seed Production of Cereal Crops, chemical laboratories of Research Institute of Irrigation and Water Problems and Uzbek Cotton Research Institute. The project is currently implemented at an experimental site of Kashkadarya Research Institute of Grain Breeding and Seed Production of Cereal Crops (KRIGBSPCC) in Kovchin village of Karshi district, Kashkadarya Region, Uzbekistan.
Pre-sowing soil sampling and analysis were carried out in mid-September 2012. Eight varieties of facultative wheat (‘Hazrati Bashir’, ‘Bunyodkor’, ‘Gozgon’, ‘Jaihun’, ‘Elomon’, ‘Humo’, ‘Sanzar 4’, ‘Saidaziz’) were planted in different time windows, 21 October 2012 (optimal planting), 14 November 2012 (late planting) and 15 February 2013 (spring planting). During whole vegetation period (September 2012 - July 2013) data on soil physical properties and chemical composition, soil moisture and soil salinity, as well as meteorological data and data on crop phenology and management data were successfully collected for further calibration of CropSyst model. Additionally greenness and NDVI were measured simultaneously during the whole of the growing season. Significant positive correlation was observed at the stem elongation (r=0.79**) and 'dough' (r=0.69**) growth stages. Among the tested early planted wheat varieties the following entries demonstrated better productivity (grain yield of 7.6 t/ha - 9.2 t/ha): ‘Gozgon’, ‘Elomon’, ‘Humo’ and ‘Bunyodkor’. Among the tested late planted wheat entries the best varieties in terms of yield (6.3 t/ha - 7.0 t/ha) were ‘Gozgon’, ‘Hazrati Bashir’, ‘Jaihun’, ‘Elomon’. Among the tested spring planted wheat entries the best varieties were ‘Hazrati Bashir’, ‘Saidaziz’, ‘Sanzar 4’ and ‘Jaihun’ (3.2-3.7 t/ha). Thus, on the basis of the first year experiment results we can make preliminary conclusion on heat-tolerant winter (facultative) wheat varieties which can be used to escape or cope with heat stress during flowering, however continuation of the experiment is necessary to make a scientifically substantiated conclusion.
At the same time work on assessment of climate change impact on crop productivity in Central Asia is continued. In order to access the biophysical impact of climate change on cotton production and productivity, in the beginning of 2013 ICARDA scientists in collaboration with NARS partners launched collection of data from strategic cotton production sites within different agro-ecological zones in the four Central Asian countries (Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan). Historic production data from these sites are used for a site/region-specific calibration of the crop-simulation model CropSyst.

Capacity building

As part of the CRP 7 Activity 1.2.1 'Model-based assessment of the impacts of climate change and the effects of adaptation technologies on crop water availability and productivity and farmer's livelihood' a training course on 'Crop Modeling Using CropSyst' was held on 17-21 December 2012 in Tashkent, Uzbekistan. The training course was attended by 19 participants from nine institutions, including Kazakh Research Institute of Soil Science (Kazakhstan), Kyrgyz Research Institute of Husbandry (Kyrgyzstan), Horticulture and Vegetables Institute of TAAS (Tajikistan), Centre of Genetic Resources of TAAS (Tajikistan), Husbandry Research Institute of TAAS (Tajikistan), Research Institute of Irrigation and Water Problems (Uzbekistan), Uzbek Cotton Research Institute (Uzbekistan), Kashkadarya Scientific Research Institute for Breeding and Seed Production of Cereal Crops (Uzbekistan), and ICBA.
Centers: ICARDA
Donors: CRP Climate Change in Agriculture

Project period: 2012-2015
Countries: Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan

IMPROVING LIVELIHOODS OF SMALL FARMERS AND RURAL WOMEN THROUGH VALUE-ADDED PROCESSING AND EXPORT OF CASHMERE, WOOL AND MOHAIR

Aims and scope of work

IFAD/ICARDA project entitled 'Improving Livelihoods of Smallholders and Rural Women through Value-Added Processing and Export of Cashmere, Wool and Mohair' has been implemented on the pilot sites in Kyrgyzstan, Tajikistan, and Iran. The overall goal of the project is to enhance living standards of small-scale livestock producers and rural women through improved production, processing and export of value-added fiber. Hence, the project aims at setting up value chains focused on fiber production, processing and marketing at the project sites. The project continued to build capacities of sheep and goat producers and women's groups in fiber production, processing and marketing.

Breeding activities

In northern Tajikistan, the project worked with farmers to develop breeding nuclei of white and colored Angora goats and established a super nucleus supported by the Livestock Institute. The team successfully completed second artificial insemination (AI) campaign with imported frozen semen in the fall of 2012. Mr Ramin Aliverdi of Iran helped the Khujand team to inseminate 250 goats from eight private farms and one super nucleus flock maintained by the Livestock Institute. Regardless of the low fertility rate, the crossbred kids produced through the AI and born in 2012 and 2013 are showing good results regarding fiber quality and adaptability, are highly valued by farmers and provide a strong impetus for improving Angora goat breeding in Tajikistan.

In Badakhshan, in spite of the difficult winter of 2012, the project received a number of offspring from the Altai bucks in 2012 and 2013 (122 and 465 respectively). The Altai crosses are showing signs of improved productivity - a large volume of quality fiber and good body condition.

The breeding campaign in fall 2012 was successful. The villagers are pleased with the crossbred kids and are actively collaborating with the project on setting up a sustainable breeding system that includes castration of all inferior males. A total of 107 women farmers collaborate on the breeding.

In Kyrgyzstan, the gradual replacement of fat-tailed coarse wool sheep by Tian Shan offspring in Min-Bulak and Lakhol has led to considerable improvement in the quality of wool and interest of farmers in wool production. The crossbred wool produced by the target flocks in Lakhol has already reached a quality which allows the artisan groups to use it for felt products.

Fiber processing and marketing

In northern Tajikistan, in spring 2012, the women processors and the project team implemented a new model of fiber processing that incorporates all key processing operations. Most of the operations including fiber purchase, dehairing, carding and spinning were improved in 2012. The team started to add value to the new yarn by producing socks for export and made progress in organizing the production of luxury knitwear based on imported design. In 2012 the project developed blanket weaving for export and for local luxury markets such as the Hyatt hotel gift shop in Dushanbe and started organizing the production of mohair carpets in Istaravshan.

The ties between fiber producers, processors, the hub and local and international buyers are strengthening. The processing groups are becoming coherent organizations and their participants – farmers, spinners, knitters and weavers —are developing stronger ties with one another. The product buyers are becoming more familiar with the products and also with the producers and are passing the

information to the consumers. Gradual increase in knowledge, capacity, trust and connectivity among all participants is speeding up the development of the processing and marketing chain.
The project continued to collaborate with Clothroads and created new linkages with Knit Outta the Box company, Peace Fleece and Hyatt Hotel gift shop in Dushanbe. It also developed a hub that will be operated by Farhod Kosimov and other members of the Kosimov family. The hub plays an active role in helping the groups fulfill export orders and assists them with communication, international shipping and other logistics. The marketing hub successfully arranged the first shipment of mohair products to the USA.
In Badakhshan, women earn USD 21 from selling 1kg of combed cashgora fiber. They used to earn USD 2-3 from selling 1kg of sheared fiber previously. Yarn spinning is developing fast and the spinners will start earning sustainable income and exporting yarn before the end of the project.
The project delivered spinning machines and a carding machine to the lead processing group in Andarob village. The project also collaborated with women and men in Andarob to organize a spinning workshop. The workshop is equipped with spinning wheels, chairs, tables, lighting and heating. Women come there to train in spinning and make yarn for sale.
The project organized fiber dehairing in Herat with the help from Aga-Khan Foundation in 2012 and arranged dehairing in Faizabad, Afghanistan in 2013. The team is developing new knitted products from the new yarn including an improved model of Pamiri Jurabe socks and also luxury knits for export. First samples of cashgora yarn and products were shown to buyers in fall 2012 and received a highly positive review. Companies that collaborate with the project on marketing mohair yarn and products are ready to market cashgora yarn and products as well.
In Kyrgyzstan, in 2012, the project developed several new products including quality felt slippers that are in demand on local, regional and international markets. Other products such as chair mats and scarves were also improved. The new version of chair mats received an award of excellence from UNESCO. Ms. Svetlana Balalaeva from CACSARC-kg and other members of the project team succeeded in introducing the products at a variety of crafts markets in Hungary, the Netherlands, Germany and Belgium. The test-marketing was overall very successful and provided the project team and the artisans with valuable information that can be used in new product design, improvement of existing products and development of marketing strategies. The CACSARC-kg team is finding new, creative ways of collaborating with the groups. It promotes the artisans and their products through its contacts with international donors and agencies that support Kyrgyz art and culture. With the help of CACSARC-kg, chair mats made by the groups were submitted to compete for the UNESCO Award of Excellence for Handicraft Products and CACSARC-kg is now helping the groups to apply for participation in the Santa Fe Folk Arts Market in the USA. The Naryn artisans can also come and work on products in the CACSARC-kg office during winter. CACSARC-kg plans to collaborate with the groups after the project ends.

Capacity building

In northern Tajikistan, the project team trained farmers how to evaluate Angora goats and how to use the nucleus groups to improve the quality of their goats and fiber.
In Badakhshan, the project team trains households in improved methods of goat husbandry including the importance of winterfeed and vaccination to ensure health and good reproductive capacity of their goats. The villagers are learning how to organize vaccination and castration jointly with the help of local veterinarians. The training in goat husbandry is helping the households to improve care of sheep, cows and other livestock.
In Kyrgyzstan, the Naryn artisans are becoming highly motivated to succeed in developing sustainable businesses. They invest their own resources to buy raw materials and to participate in fairs, training courses and internships with product designers. They are also increasing the volume and assortment of products and their sales in 2012 doubled compared to 2011.

Center: ICARDA
Donors: International Fund for Agricultural Development
Project period: 2009-2013
Countries: Kyrgyzstan, Tajikistan

INTRODUCTION OF FARMING WITH ALTERNATIVE POLLINATORS (FAP) IN UZBEKISTAN

Aims and scope of work

'Farming with Alternative Pollinators' (FAP; Christmann and Aw-Hassan, 2012) is a new self-supporting, community-based low-cost measure to simultaneously enhance climate change resilience of agro-ecosystems and income. Improved pollination services due to habitat enhancement on - and if possible - close to crop fields can increase income providing strong incentives for producers' motivation to engage in habitat improvement. FAP thus realizes the TEEB approach.

Introduction of Farming with Alternative Pollinators (FAP) in Uzbekistan: a new ecosystem-based climate change adaptation strategy

In cooperation with the Uzbek Institute of Zoology, Samarkand State University, Uzbek Scientific Research Institute of vegetables, cucurbits and potato and local authorities of Parkent and Boysun, ICARDA started a new project funded by the German Federal Ministry for the Environment, Nature Protection and Nuclear Safety within the International Climate Change Initiative.

Climate change is one of the most severe risks for pollinators, but pollinators, specifically wild pollinators, are indispensable for agricultural production of most high value crops, for 60-90% of all plant species and for climate change adaptation of agro-ecosystems (cross pollination increases genetic diversity and thus promotes the development of varieties better adapted to future climate).
As seasonal abnormalities will increase and honeybees can fly only if weather conditions are fine, future horticulture production might depend more (often) for instance on bumblebees, which are more robust concerning rough weather conditions than honeybees. But agriculture (monocultures, landscape fragmentation, chemicals, tillage etc) threaten wild pollinators additionally to climate change. Wild pollinators don't fly far from their nest, only 300-2000 m (whereas honeybees fly up to 5 km far). Therefore, on or close to the field they require nesting areas, forage (flowers offering nectar and pollen during three seasons) and shelter.

Such habitat enhancement is not costly, but requires some additional work and experience. On the other hand, improved pollination can increase the yield in economic terms. So there is a potential win-win-situation for farmers and the environment. Therefore, the project introduces 'Farming with alternative pollinators', which includes habitat enhancement, economic assessment on the total harvest and assessment of pollinator biodiversity. The project will develop field data (economic effect, effect on pollinator diversity, outscaling options) to support broad introduction of this new socioeconomic and agro-ecological method.

First results on cucumber fields showed significant enhancement of cucumber harvest both in quality and quantity, significant increase of pollinators on the FAP-field and significant impact concerning predators of pests and reduction of pests.

Center: ICARDA
Donors: The German Federal Ministry for the Environment, Nature Protection and Nuclear Safety (BMU)
Project period: 3/2013-12/2013
Countries: Uzbekistan

TABLES/FIGURES

Table 1. Cereal crop varieties developed on the basis of CIMMYT germplasm, officially tested and released in Kazakhstan by 31 December 2012

Variety	Crop	Research Institutions	Year	
			Submitted	Released
Egemen	WBW	Kazakh Research Institute of Farming	2001	2007
Konditerskaya	WBW	Krasnovodopad Experimental Station	2006	2011
Stepnaya 60	SBW	Aktobe Experimental Station	2006	2010
Orda	TCL	Krasnovodopad Experimental Station	2004	2009
Kuralay	BRL	Kazakh Research Institute of Farming	2007	2011
CIMKAR 20	SBW	Karabalyk Experimental Station	2011	-
Alikhan	WBW	Kazakh Research Institute of Farming	2011	-
Azharly	WBW	Kazakh Research Institute of Farming	2011	-
Vodopad 100	TCL	Krasnovodopad Experimental Station	2011	-

Figure 1. Progress of no-till area in Kazakhstan

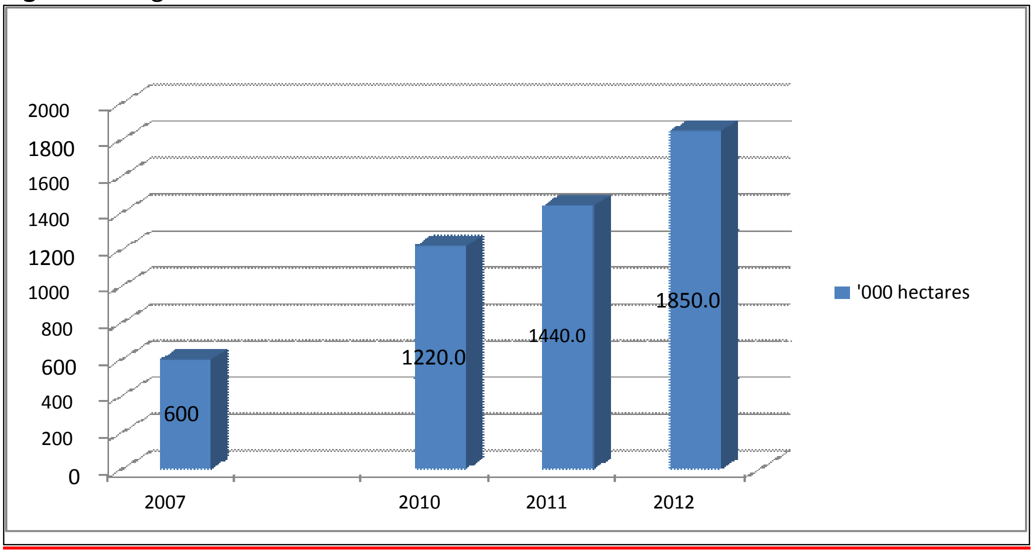


Figure 2. Incremental production due to no-till technology in 2012 in Kazakhstan

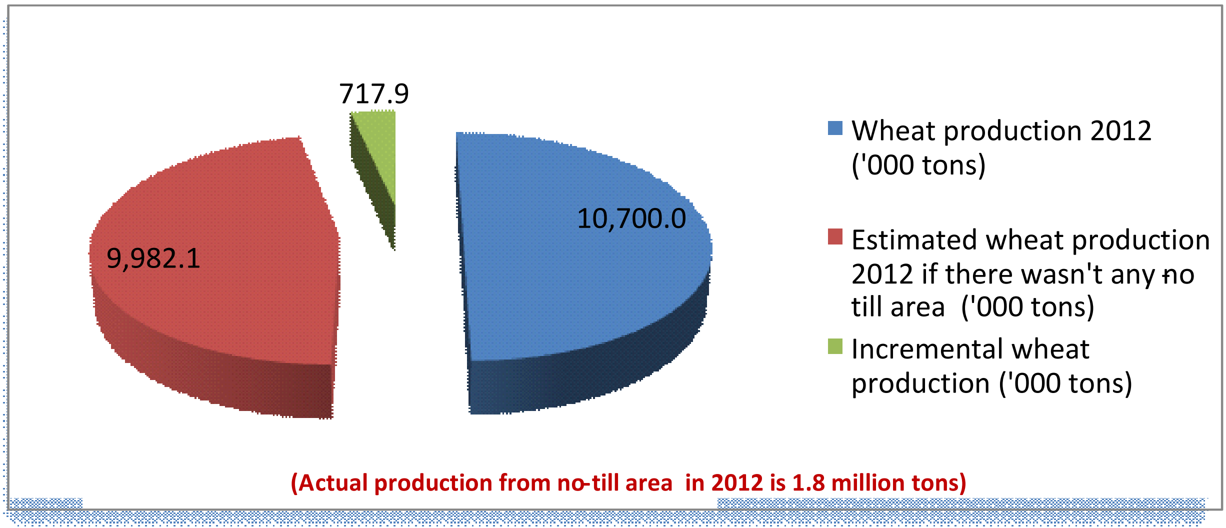


Figure 3. Wheat productivity in Kazakhstan

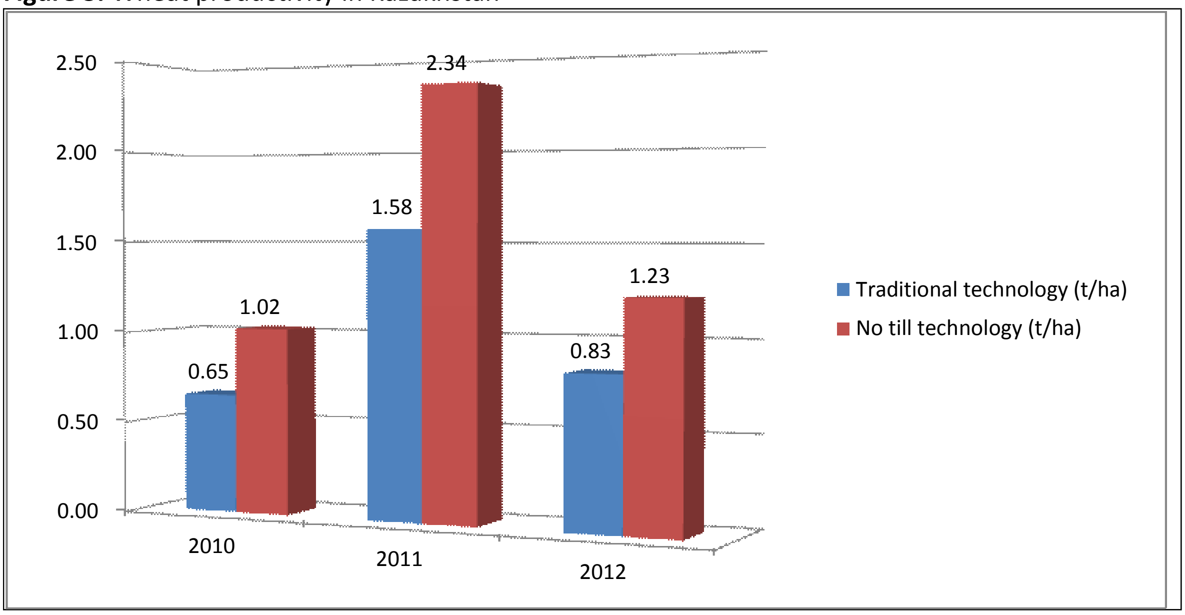
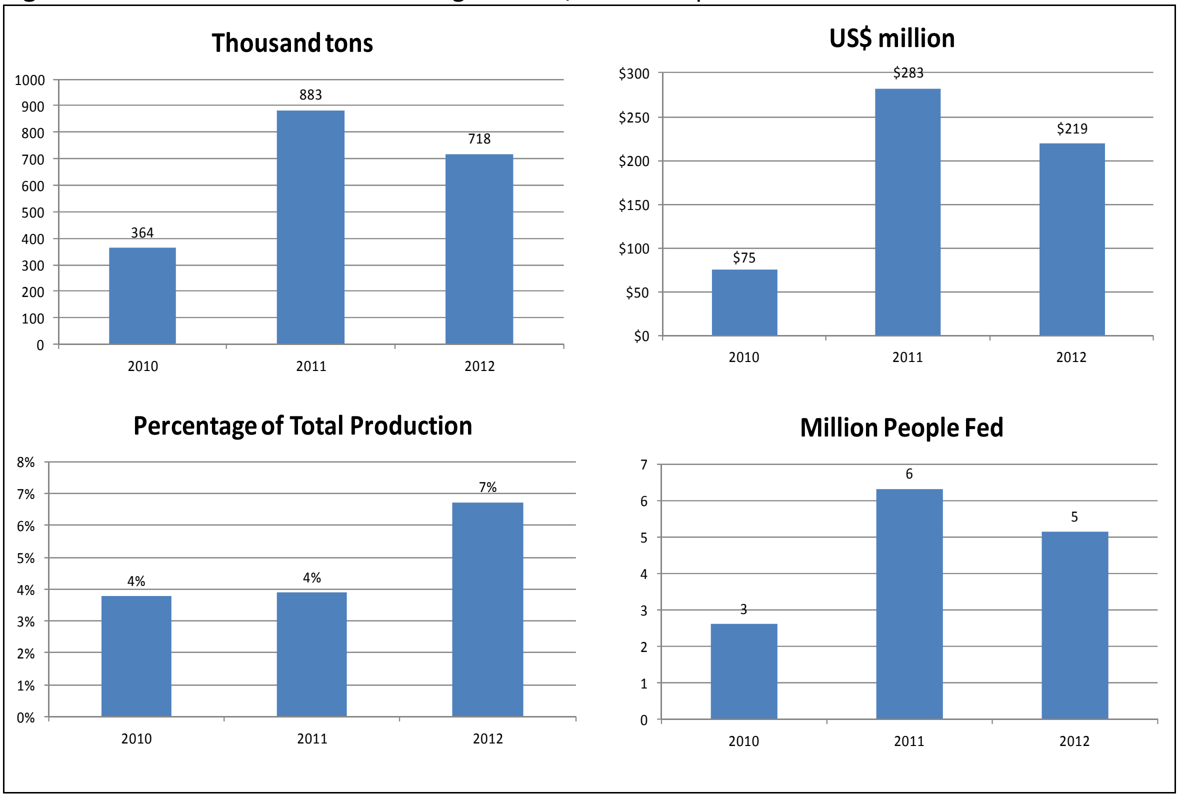


Figure 4. Kazakhstan - Benefits resulting from CA/no-till adoption at national level



PUBLICATIONS

Journal articles

Carli, C., Yuldashev, F., Khalikov, D., Condori, B., Mares, V. and Monneveux, P. 2013. Effect of different irrigation regimes on yield, water use efficiency and quality of potato (*Solanum tuberosum* L.) in the lowlands of Tashkent, Uzbekistan: a field and modeling perspective. *Field Crops Research.* Elsevier (accepted for publication: 4 September 2013)

Christmann, S., Aw-Hassan A. A. 2012. Farming with alternative pollinators (FAP) - an overlooked win-win strategy for climate change adaptation. Agriculture, Ecosystems and Environment, 161. pp. 161-164

Jumaboev, K., Reddy, J. M., Mukhamedjanov, S., Anarbekov, O. and Eshmuratov, D. 2013. Public-Private Partnership for Irrigation Extension in Fergana Valley of Central Asia. *International Journal of Agricultural Extension and Rural Development*, 5 (1), pp. 21-30.

Karabayev, M., Iskandarova, K., Zelenskiy, Y., Ramanculov, E., Baitassov, A., Zhapayev, R., Mba, Ch. and Ghosh K. 2012. *Mobilization of plant genetic resources and biotechnology for breeding in Kazakhstan: current state and ways to improve*. CIMMYT-Kazakhstan, Astana, Kazakhstan. 82 p.

Keatinge, J. D. H, Chadha, M. L., Hughes, J. A., Easdown, W. J., Holmer, R., Tenkouano, A., Yang, R. Y., Mavlyanova, R., Neave S., Afari-Sefa, V., Luther, G., Ravishankar, M., Ojiewo, C., Belarmino, M., Wang, J. F. and Lin, M. 2012. Vegetable gardens and their impact on the attainment of Millennium Development Goals. *Biological Agriculture & Horticulture: An International Journal for Sustainable Production Systems*. (Available at: D0I:10. 1080/01448765. 2012. 681344)

Koyshibayev, M., Zhanarbekova, A. B., Morgounov, A. I., Zelenskiy, Y. I. and Chudinov, V. A. 2012. Screening of the gene pool of spring wheat for resistance to highly dangerous diseases in northern Kazakhstan/Collected articles of international scientific conference, dedicated to 125th anniversary of the birth of Nikolai Vavilov. *Immunological protection of crops from diseases: Theory and Practice*. pp. 221-229.

Kunypiyaeva, G. and Zhapayev, R. 2012. *Conservation Agriculture for winter wheat productivity and soil moisture: Prospects and Results*. pp. 127-128

Matsuo, N., Ojika, K., Shuyskaya, E., Radjabov, T., Toderich, K. and Yamanaka, N. 2013. Responses of the carbon and oxygen isotope compositions of desert plants to spatial variation in soil salinity in Central Asia. *Journal of Ecological Research*. pp. 48-55 (Available at: DOI 10.1007/s11284-013-1068-3)

Li, E. V., Shuyskaya, E.,V., Matyunina, T. E. and Toderich, K. N. 2013. Conjugative development of reproductive structures of H*aloxylon aphyllum* (Minkw.) Iljin along the soil salinity gradient. *Russian Journal of Arid Ecosystems,* Vol. 2, pp. 56-62

Mavlyanova, R. 2012. Innovations in the agrarian sector of Uzbekistan. 2012. *Ecological Herald of Uzbekistan*, Vol. 8 (137), pp. 13-15

Magzieva, K., Magzieva, S., Karabayev, M. and Zhambakin, K. 2012. The assessment and introduction of productive guayule and Taraxacum koksaghyz genotypes, and agro-technology for large-scale production of natural biorubber in Kazakhstan. *Biorubber for Europe in Global Perspective.* Wageningen, Netherlands. 38 p.

Masumov, R. and Masumov, A. 2012. Hydrometry issues at integrated water resources management. *Collection of scientific papers on water management and integrated water resources management in the countries of EECCA: challenges and solutions.* pp. 113-117

Mukhamedjanov, Sh. and Khaliullina, A. 2012. Innovative partnership. *Collection of scientific papers water management and integrated water resources management in the countries of EECCA: challenges and solutions.* pp. 139-144

Mukhamedjanov, Sh., Alikhodjaeva, S. and Sagdullaev, R. 2012. Role of new varieties in water resources saving with keeping the higher economic characteristics when growing under water scarcity conditions. *Collection of scientific papers water management and integrated water resources management in the countries of EECCA: challenges and solutions.* pp. 135-139

Nurbekov, A., Suleimenov, M., Friedrich, T., Taher, F., Ikramov, R. and Nurjanov, N. 2012. Effect of tillage methods on productivity of winter wheat in the Aral Sea Basin of Uzbekistan. *Journal of Arid Land Studies*, Vol. 22-1. pp. 255-258

Reddy, J. M., Mukhamedjanov, S., Jumaboev, K. and Eshmuratov, D. 2012. Analysis of Cotton Water Productivity in Fergana Valley of Central Asia. *Agricultural Sciences.* Vol. 3 (6). pp. 822-834

Reddy, J. M., Jumaboev, K., Eshmuratov, D. and Matyakubov, B. 2013. Evaluation of Furrow Irrigation Practices in Fergana Valley of Uzbekistan. *Agricultural Water Management*. Vol. 117. pp. 133-144

Sommer, R., Glazirina, M., Yuldashev, T., Otarov, A., Ibraeva, M., Martynova, L., Bekenov, M., Kholov, B., Ibragimov, N., Kobilov, R., Karaev, S., Sultonov, M., Khasanova, F., Esanbekov, M., Mavlyanov, D., Isaev, S., Abdurahimov, S., Ikramov, R., Shezdyukova, L. and De Pauw, E. 2013. Impact of climate change on wheat productivity in Central Asia. *Agriculture, Ecosystems & Environment.* Vol. 178. pp. 78-99. (Available at: http://www.sciencedirect.com/science/article/pii/S0167880913002168)

Shamanin, V. P., Morgunov, A. I., Zelenskiy, Y. I., Chursin, A. S., Levshunov, M. A., Pototskaya, I. V., Likhenko, I. E., Manko, T., Karakoz, I. I., Tabachenko, A. V. and Petukhovskiy, S.L. 2012. Creating of adaptive breeding material of spring wheat with the use of shuttle breeding CIMMYT. *Modern problems of science and education,* Vol. 2. (Available at: http://www.science-education.ru /102-5735)

Shamanin, V. P., Morgunov, A. I., Manes, Y., Zelenskiy, Y. I., Chursin, A. S., Levshunov, M. A., Pototskaya, I. V., Likhenko, I. E., Manko, T., Karakoz, I. I., Tabachenko, A. V. and Petukhovskiy, S. L. 2012. Breeding and genetic evaluation of populations of spring wheat of Siberian shuttle breeding nursery. *Vavilov Journal of Genetics and Breeding.* Vol.16 (1), pp. 21-32.

Zou, C. Q., Zhang, Y. Q., Rashid, A., Ram, H., Savasli, E., Arisoy, R. Z., Ortiz-Monasterio, I., Simunji, S., Wang, Z. H., Sohu, V., Hassan, M., Kaya, Y., Onder, O., Lungu, O., Yaqub Mujahid, M., Joshi, A. K., Zelenskiy, Y., Zhang, F. S. and Cakmak, I. 2012. Biofortification of wheat with zinc through zinc fertilization in seven countries. *Plant and Soil*. Vol. 361 (1-2), pp. 119-130.

Books and book chapters

Carli, C., Khalikov, D. and Yuldashev, F. 2013. Five TPS families for long day conditions of CAC highlands identified and documented. Proceedings of the 80th Anniversary of the Institute of Vegetables, Melon and Potato. In: Khakimov, R. A. et al. (eds). 2013. *Science contribution to the development of vegetable, melon and potato growing in Uzbekistan*. Tashkent: Turon-Iqbol.

Carli, C., Bonierbale, M., Amoros, W., Yuldashev, F., Khalikov, D., Abdurakhmanov, T., Rasulov, A. I. and Partoev, K. 2013. Three new candidate potato varieties for Uzbekistan and Tajikistan selected and proposed for variety release with national partners. Proceedings of the 80th Anniversary of the Institute of Vegetables, Melon and Potato. In: Khakimov, R. A. et al. (eds). 2013. *Science contribution to the development of vegetable, melon and potato growing in Uzbekistan*. Tashkent: Turon-Iqbol.

Carli, C., Yuldashev, F., Khalikov, D., Ali, A., Rakhimov, O., Saidova, J., Buriev, U., Kudoinazar, G. and Tursunov, D. 2013. True potato seed (TPS) as an alternative seed potato production technology, tested and documented in the highlands of temperate Regions in Uzbekistan, Tajikistan and Afghanistan. Proceedings of the 80th Anniversary of the Institute of Vegetables, Melon and Potato. In: Khakimov, R. A. et al. (eds). 2013. *Science contribution to the development of vegetable, melon and potato growing in Uzbekistan*. Tashkent: Turon-Iqbol.

Carli, C. and Z. N. Kadirova. 2013. Potato virus distribution in different agro-ecological conditions of Uzbekistan. Proceedings of the 80th Anniversary of the Institute of Vegetables, Melon and Potato. In: Khakimov, R. A. et al (eds). 2013. *Science contribution to the development of vegetable, melon and potato growing in Uzbekistan*. Tashkent: Turon-Iqbol.

Mavlyanova, R. 2012. Enhancing livelihoods in Central Asia and the Caucasus through the increased production and consumption of nutritious vegetables. In: Nath P (ed.) 2012. The Basics of Human Civilization: Food, Agriculture and Humanity. Vol. 1. Bangalore, India: PNASF.

Nurbekov, A., Akramkhanov, A., Lamers, J., Kassam, A., Friedrich, T., Gupta, R., Muminjanov, H., Karabayev, M., Sydyk, D., Turok, J. and Bekenov, M. Conservation Agriculture in Central Asia: Past and Future. In: Ram A. J., Kanwar, L. S. and Kassam, A (eds). 2013. Conservation agriculture: Global prospects and Challenges. CABI 2013. 350-400 (Chapter was accepted by the publisher).

Toderich, K. N., Shuyskaya, E. V., Rajabov, T. F., Ismail, Sh., Shaumarov, M., Yoshiko, K. and Li., E. V. 2013. Uzbekistan: Rehabilitation of Desert Rangelands Affected by Salinity, to Improve Food Security, Combat Desertification and Maintain the Natural Resource Base. In: Heshmati, G. A. & Squires, V. (eds). 2013. Combating Desertification in Asia, Africa and the Middle East (Proven practices). Springer. pp. 249-279

Toderich, K. N., Shuyskaya, E. V., Taha, F. K., Matsuo, N., Ismail, Sh., Aralova, D. B. and Rajabov, T. F. 2013. Integrating agroforestry and pastures for soil salinity management in dryland ecosystems in Aral sea basin. In: Shahid, S. A., Abdelfattah, M. A. and Taha, F. K. (eds.). 2013. Developments in Soil Salinity Assessment and Reclamation-Innovative Thinking and Use of Marginal Soil and Water Resources in Irrigated Agriculture. Springer. pp. 579-602

Abstracts

Belan, I. A., Rosseyeva, L. P., Meshkova, L. V., Shepelev, S. S. and Zelenskiy, Y. I. 2012. Immunological assessment of KASIB material in southern forest zone of Western Siberia. *Bulletin of Altay State Agrarian University*. Vol. 10 (96), pp.39-43

Morgounov, A., Belan, I., Zelenskiy, Y., Tomoskozi, S., Bekes, F., Abugaliyeva, A., Cakmak, I., Vargas, M. and Crossa, J. Historical changes in grain yield and quality of spring wheat varieties cultivated in Siberia from 1900 to 2010. *Canadian Journal of Plant Science.* (in print)

Belan, I. A., Rosseyeva, L. P., Rosseyev, V. M., Badayeva, E. D., Zelenskiy, Y. I., Blokhina, N. P., Shepelev, S. S. and Pershina, L. A. 2012. Study of agronomic and adaptive traits in lines of spring wheat varieties Omskaya 37 carriers translocations 1RS.1BL and 7DL-7Ai. *Vavilov Journal of Genetics and Breeding*. Vol. 16 (1). pp. 178-186

Proceedings

Arifkhanova, D. D., Akinshina, N. G., Toderich, K. N., Yasui, H., Nishonov, B., Razikova, I. and Rakhimova, T. U. 2013. Ecological peculiarities of halophytes, grown on saline-affected desert lands in Uzbekistan.

Proceedings of International Conference: Biodiversity and Wild Life Conservation Ecological Issues, Tsaghkadzor, Armenia: pp. 40-45 (in Russian)

DeRuyter, T., Saito, L., Nowak, R. and Toderich, K. 2013. Halophytic Plants to Improve Agricultural Production and Water Quality in Arid and Semi-Arid Climates. UCOWR/NIWR Conference, July 2013, Lake Tahoe, California, USA.

Carli, C., Yuldashev, F. and Khalikov, D. 2013. Influence of water stress on growth, yield and quality of potato (*Solanum tuberosum* L.) under the arid climatic conditions of Central Asia. Proceedings of the 11th International Conference on Development of Drylands, Bejing, China, 18-21 March 2013.

Zhapaev, R., Iskanderova, K. A., Karabaev, M. K. and Toderich, K. N. 2013. The ecological estimation of genotypes of non-conventional sorghum and pearl millet under conditions of southeastern Kazakhstan. Collection of the Materials of the International scientific-practical conference agro-ecological bases of improvement the productivity and sustainability of agriculture in the XXI Century', dedicated to the 100th anniversary of the birth of Babavev K. B. pp. 124-127 (in Russian)

Jumshudov, I., Nurbekov, A., Muminjanov, H., Musaev, A. and Safarli, S. 2012. Effect of bed planting methods on the productivity of winter wheat in the irrigated areas of Azerbaijan. International Scientific Conference. The problems of Inculcation Innovational Technologies in Agriculture. Proceedings of Scientific Practical Conference, 15-16 November 2012. Samarkand, Uzbekistan. pp. 215-216.

Jumshudov, I., Nurbekov, A., Muminjanov, H., Musaev, A. and Safarli, S. 2012. Effect of bed planting methods on the productivity of winter wheat in the irrigated areas of Azerbaijan. Conservation Agriculture and Sustainable Upland Livelihoods. Innovations for, with and by Farmers to Adapt to Local and Global Changes. Background of conservation agriculture in Southeast Asia and prospect for the future. 10-15 December 2012, Hanoi, Vietnam. pp. 250-252.

Khujanazarov, T., Tanaka, K. and Toderich, K. 2013. Assessment of human activities impact in Zeravshan river basin. 6th Asia Pacific Association of Hydrology and Water Resources Conference, 2013, Seoul, Korea.

Mukhamedjanov, Sh. 2012. Innovation partnership on the way to water and land productivity improvement. Central Asia International Scientific Conference: challenges and solutions. pp. 60-61.

Nurbekov, A., Ziyadullaev, Z., Friedrich, T., Muminjanov, H. and Turok, J.2012. Effect of Rhizobium application on productivity of bed planted soybean in soils of Kashkadarya Region of Uzbekistan. International Scientific Conference. The problems of Inculcation Innovational Technologies in Agriculture. Proceedings of Scientific Practical Conference, 15-16 November 2012, Samarkand, Uzbekistan. pp. 213-215.

Nurbekov, A., Friedrich, T., Taher, F., Ikramov, R. and Ziyadullaev, Z. 2012. Conservation Agriculture Practices in Karakalpakstan. International Conference on 20 Years of Conservation Agriculture in China. 19-21 November 2012. Beijing, China. pp.59-65.

Nurbekov, A., Friedrich, T., Muminjanov, H., Ikramov, R. and Ziyadullaev, Z. 2012. Effect of fertilizer rate on productivity of winter wheat in the Aral Sea Basin of Uzbekistan. Extended summaries Vol. (3): 3rd International Agronomy Congress, 26-30 November 2012. New Dehli, India. pp. 1279-1280.

Nurbekov, A. and Ziyadullaev, Z. 2012. Adoption of no-till technology for sustainable agriculture in the drought-affected regions of Karakalpakistan. International conference on improving soil fertility through adoption of resource saving technologies in agriculture. 5-6 December 2012. Tashkent, Uzbekistan. pp. 101-105.

Nurbekov, A., Friedrich, T., Muminjanov, H., Ikramov, R. and Ziyadullaev, Z. 2012. Effect of tillage and fertilizer rate on productivity of winter wheat in the Aral Sea Basin of Uzbekistan. Conservation Agriculture and Sustainable Upland Livelihoods. Innovations for, with and by Farmers to Adapt to Local and Global Changes. Background of conservation agriculture in Southeast Asia and prospect for the future. 10-15 December 2012, Hanoi, Vietnam. pp. 272-274.

Shamanin, V. P., Morgunov, A. I., Levshunov, M. A., Zelenskiy, Y. I., Rsaliev, Sh., Pototskaya, I. V. and Petukhovskiy, S. L. Evaluation of the spring wheat collection and lines with *Sr* genes for resistance to stem rust in the conditions of southern forest-steppe of Western Siberia. 13th International Cereal Rusts & Powdery Mildews Conference. Beijing, China, 28 August - 1 September 2012.

Sydyk, D., Karabalayeva, A. and Nurbekov, A. 2012. Economic efficiency of bed planted winter in the irrigated areas of south Kazakhstan. International conference on improving soil fertility through adoption of resource saving technologies in agriculture. 5-6 December 2012, Tashkent, Uzbekistan. pp. 96-101.

Sydyk, D., Nurbekov, A., Friedrich, T., Muminjanov, H. and Turok, J. 2012. Effect of planting methods and seeding rates on productivity winter wheat in the irrigated conditions of south Kazakhstan Region. International Scientific Conference. The problems of Inculcation Innovational Technologies in Agriculture. Proceedings of Scientific Practical Conference, 15-16 November 2012, Samarkand, Uzbekistan. pp. 212-214.

Toderich, K. N., Akinshina, N. G. and Mun, Y. 2013. Biogas Production from Halophytes Planted for Soil Improvement in Aral Sea Basin. 9th Asia Pacific Conference on Sustainable Energy and Environmental Technologies, 2013, Narita, Japan.

Toderich, K. and Khujanazarov, T. 2013. Web-based platform of water quality of Zeravshan river basin integrated with promotion of technologies of marginal resources, World Environmental & Water resources Congress, May 2013, Cincinnati, Ohio, USA.

Working papers

Nurbekov, A. Conservation Agriculture practices in the drought and salt affected regions of Karakalpakstan. (Available at: http://www.fao.org/ag/ca/7.html)

Dissertations/PhD Thesis

Radjabov, T. 2012. Spatio-temporal changes of vegetation of semidesert rangelands under a grazing gradient (Karnabchul steppe as a case study) 03.00.05 -botanika, 03.00.16 - ecology. Institute of Botany, Tashkent, Uzbekistan.

Khujanazarov, T. 2012. Development of an interactive framework for river basin data management and hydrological modeling. Kitakiyushu University, Japan