# PROJECT ON CONSERVATION AGRICULTURE IN IRRIGATED AREAS OF AZERBAIJAN, KAZAKHSTAN, TURKMENISTAN AND UZBEKISTAN

# Final Report

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**ICARDA and NARS of Azerbaijan, Kazakhstan and Uzbekistan**

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# Executive summary

In most Central Asian countries, including the republics of Azerbaijan, Kazakhstan and Uzbekistan, livelihoods of most people are rooted in agriculture contributing between 6 to 45 percent of GDP and employs up to 50 percent of the population. Agriculture's contribution to GDP varies among these countries; it represents around 6% of GDP in Azerbaijan, 28% in Kazakhstan, 29% in Turkmenistan and 11% in Uzbekistan. The economy of Azerbaijan was the fastest growing economy in the world, exceeding 30% of growth rate in 2006 while in 2012 the growth rate was 2.3.

In all four countries the changes in the agricultural sector during the last few decades, especially after the break-up of the Soviet Union in 1991, have been enormous. The economic transformation has led to the conversion of large state and collective farms into small private farms. This transformation, which also changed the settings for the new farmers, significantly impacted the availability of machinery. The effort for the economic and agricultural development in Kazakhstan, Uzbekistan, and Azerbaijan, is continuing in order to achieve national food security by intensively investing in strategic crops.

Degradation of soil resources as a result of poor agricultural land management is widespread in the Central Asia region, leading to sub-optimal output and efficiency of resources. Degradation is also a direct threat to the sustainability of agricultural production. Conventional tillage based agriculture requires changes in soil and landscape management concepts and practices, including changes in cropping system management, to counter the degradation threat as well as to rehabilitate agricultural land so that productivity and ecosystem services can be enhanced sustainably. Conservation Agriculture (CA) offers options for such fundamental changes to be brought about as a basis for future economic, social and environmental development that can help address a broad variety of challenges including food insecurity, poverty alleviation, rural livelihoods, rising cost of energy and production inputs, natural resource management, resource scarcity, and global warming. At the farm and landscape management level, CA can address issues related to soil health, water resources, erosion control, mechanization and tillage, mulching, cropping system. However, new CA-based knowledge and practices must be formulated and applied at the farm and landscape level in order for this to happen. Similarly, at the production system level the adoption of CA offers the possibility of sustainable intensification for rainfed and irrigated farming systems. This also calls for new knowledge on CA-related crop, soil, nutrient, water, labour and farm power management within those farming systems, and the corresponding supply chain service support.

In mid-2006 the Government of Turkey, represented by the Ministry of Agriculture and Rural Affairs (MARA) and FAO signed, an agreement setting up an FAO/Turkey Partnership Program (FTPP). As part of this agreement Government of Turkey would contribute USD 2 million per year over an initial period of five years (2007– 2011) for the benefit of the countries assisted by the FAO Sub-Regional Office for Central Asia (FAO-SEC). The primary objectives of the FTPP, as described in the Partnership Framework Agreement (PFA), is to provide a substantive, financial and operational framework for active cooperation in the areas of food security and rural poverty reduction in the beneficiary countries of Central Asia.

Demonstration and research activities were carried out in at least one selected benchmark site of 25 ha size per in each project country. This on-farm project showed that laser leveling operations lead to increase water use efficiency. Even distribution of water through furrows determines even seed

germination of agricultural crops with optimal plant density. Effective land-leveling reduces the work in crop establishment and crop management, and increases the yield and quality. And also it can improve water use efficiency by reducing high spots in a field that back up water, or filling low spots that contribute to excess irrigation.

Soil analysis was carried-out in each country according to the work plan. Soil organic matter content was higher under no-till wheat than conventional tilled wheat in the 0-10 cm depth. This is explained by the well- known fact that preservation of crop residues on soil surface in a CA system and slower mineralization of these residues building up the soil organic matter.

Permanent bed planting technologies tested in Azerbaijan, Kazakhstan and Uzbekistan proved to be suitable for irrigated conditions and can provide similar or higher crop yields but saving considerable resources including fuel, seeds and labour. The maximum grain yield of 7.51 t $ha^{-1}$ was recorded in Uzbekistan while lowest yield was recorded in Kazakhstan 4.45 t $ha^{-1}$ in Kazakhstan. The main benefit of bed planting is water savings. Therefore, under high production situations, bed planting exceeds the yields possible on the flat bed. We observed an improvement of the water use efficiency by 21–30% combined with an approximate 17% savings in applied irrigation. Water use efficiency was significantly higher with the bed planting (2.36 and 2.11 kg $m^{-3}$) compared to conventional planting (1.67 and 1.85 kg $m^{-3}$).

No-till maize, sunflower, winter wheat in Azerbaijan and Kazakhstan, and no-till mung bean and winter wheat in Uzbekistan under irrigation provided yields comparable to those obtained through conventional and reduced tillage.

The project identified new crop rotations and studied their potential impacts for use in conservation agriculture. Sorghum and pearl millet in Azerbaijan, pearl millet in Uzbekistan, as well as, kidney bean and mung bean in Kazakhstan were introduced as new crops.

The analysis of cost-effectiveness of no-till winter wheat, no-till maize, alfalfa, mung bean and soybean showed feasibility of this technology in the respective project countries. The cost benefit analyses of technologies revealed that many of the technologies developed and disseminated under the Project have considerable advantage than those currently practiced by the farmers in Central Asian countries. The economic assessment of technologies was based both in quantitative and qualitative methods of analysis. Among those technologies, the application of no-till practices and bed planting of winter wheat, new crop rotation options with inclusion of legumes in cropping systems, etc. were found to be useful for increasing farmers' income and improving their livelihoods.

Some of the striking features of CA experience noted and reported by many farmers in the project countries include reduction in inputs (i.e. fuel, seed and water) and in wear and tear of tractors and machinery. Most of the farms in Central Asia use float irrigation which results in excessive, water usage in the region.

Twelve field days, involving 187 farmers and representatives of local authorities, farmers and scientists in Azerbaijan, 183 in Kazakhstan and 208 in Uzbekistan were organized. During these field days, improved technologies of irrigation, conservation agriculture and crop diversification have been demonstrated by the scientists and collaborating farmers.

Many local researchers and farmers were trained in a variety of best practices in agriculture. The greatest focus of these training activities was on conservation agriculture practices such as no-till and bed planting, crop residue retention and crop rotation. In total, 540 participants (Azerbaijan 170, Kazakhstan 172 and Uzbekistan 198) attended these courses, including policy makers, delegates 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 on the required skills and tools to be used in better targeting of conservation agricultural research in order to increase adoption of conservation agriculture technologies in the respective countries. At formal training courses, officials, national consultants, researchers and farmers joined to discuss CA promotion in the project countries.

To ensure wide and effective dissemination and adoption of the CA practices leaflets, poster and other publications been distributed to farmers. Additionally project consultants have published 15 scientific papers based on the results achieved under the project. Also, several manuscripts deal with CA in the irrigated areas under preparation. Based on the results of the project, a Preliminary Guide on the Practice of CA was prepared.

A signal variant of a no-till drill has been produced in a factory located in Karshi, near the Uzbekistan project site. The newly-developed no-till drill is a direct result of the project, modifying a disc type conventional seeder into a no-till drill, with the advantage over the models from Turkey being that this type can handle residues and it follows the contours of each row independently and are not fixed.

The results from this project provided convincing evidence for farmers and policy makers to start adoption of conservation agriculture in respective project countries. For instance, as a result of this project, irrigated areas under CA reached 1,800 ha in Azerbaijan, 1,100 ha in Kazakhstan and 2,050 ha in Uzbekistan in 2013.

# Acknowledgments

Strong support was provided by the government authorities of Azerbaijan, Kazakhstan and Uzbekistan and was the driving force behind the success of this project. The strong support of the local authorities was illustrated through the large and high level delegation participation to the implementation of the project on conservation agriculture.

Strong technical cooperation of ICARDA and FAO with the national partners and the financial support provided by the Government of Turkey for implementation of the project is highly appreciated.
Special thanks go to our NARS (National Agricultural Research Systems) leaders from Azerbaijan, Kazakhstan and Uzbekistan for their excellent cooperation during the project implementation.

Thanks are also due to the National Coordinators from all the three countries for their untiring efforts to make this project a success.

Finally, we appreciate the contribution of all NARS and ICARDA scientists, other collaborators, officials and farmers, who were involved in this important regional project.

# Acronyms

ADB – Asian Development Bank
AZ – Azerbaijan
BP – Bed planting
CA – Conservation Agriculture
CP – Conventional planting
CT – Conventional till
CWANA – Central and West Asia and North Africa
DSIPS – Diversification and Sustainable Intensification of Production Systems
EC - Emulsifiable concentrate
EU – European Union
FAO – Food and Agriculture Organization
FAO/SEC – FAO Sub regional Office for Central Asia
FI - Float irrigation
FTPP – FAO/Turkey Partnership Program
FuI - Furrow irrigation
GDP – Gross Domestic Product
GIZ – German Society for International Cooperation
GoT – Government of Turkey
GPS – Global Positioning Systems
Ha – hectare
ICARDA – International Center for Agricultural Research in the Dry Areas
ICARDA-CAC – International Center for Agricultural Research in the Dry Areas for Central Asia and the Caucasus
JIRCAS – Japan International Research Center for Agricultural Sciences
Km – Kilometer
KZ – Kazakhstan
M ha – Million hectare
MARA – Ministry of Agriculture and Rural Affairs
MT – Metric Tonnes
MT – Metric Tonnes
N – Nitrogen
NARS – National Agricultural Research Systems
NGO – None Governmental Organization
NPC - National Project Coordinator
NPK – Nitrogen, Phosphorus and Potassium
NPM – national project manager
NT – No-till
$^{o}$C – Celsius
OM – Organic matter
PFA – Partnership Framework Agreement
PFU – Project Facilitation Unit
PhD – Doctor of Philosophy
RCBD – Randomized Complete Block Design
S.C. – Suspension Concentrate

SK – South Kazakhstan Province
SZ 3.6 – Cereal Seeder 3.6
TDS – Total Dissolved Salts
UNDP – United Nations Development Programme
USA – United States of America
USD – United States Dollars
UZ – Uzbekistan
W.S. – Water Solution
WB – World Bank
ZEF – Center for Development Research

# 1. INTRODUCTION

Agriculture in the Central Asia region is diverse and has a great potential to revitalize the economies of the Central Asian countries. In Kazakhstan, Uzbekistan and Azerbaijan, there have been enormous changes in the agricultural sector since the break-up of the Soviet Union in 1991. The economic transformation has led to the conversion of large state and collective farms into small private farms, a step which also changed the settings for the new farmers, and which significantly impacted on the availability of agricultural machinery and other production inputs. The efforts for the economic and agricultural development have continued in different ways in order to overcome the challenges and achieve national food security by intensively investing in strategic crops.

The climate in the region is mostly arid and semiarid, and strongly continental, with hot summers and cold winters. Average annual precipitation, which is concentrated in the winter and spring, is about 270 mm, and varies from 600 to 800 mm in the mountainous zone, and 80-150 mm in the desert regions (Figure 1).

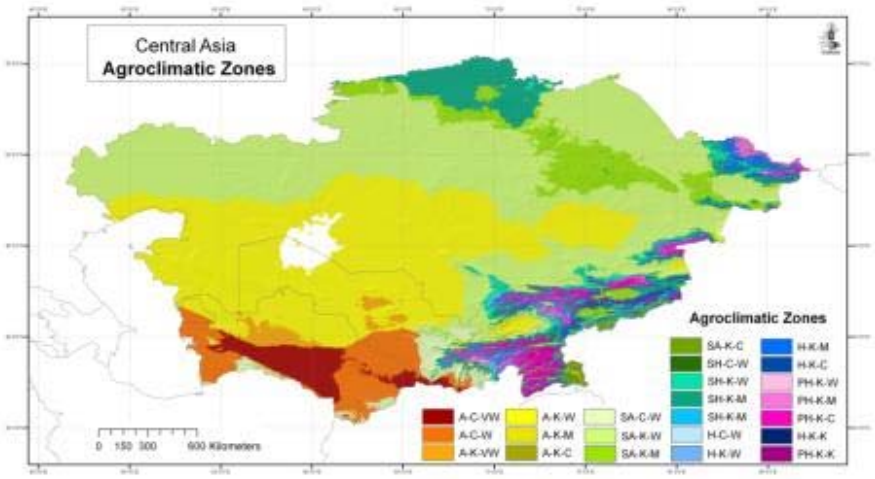


Figure 1: Agro-climatic zones of Central Asia (De Pauw, 2008)

The Republic of Azerbaijan has diverse agro-ecological regions and climatic conditions (Figure 2). Traditionally, agriculture of Azerbaijan has been based on high water consuming crops, and thus water shortages are recorded during the summer period in many regions including the Tartar district where the project demonstration site is located. One of the main constraints for further increase in agricultural production is the limited irrigation water. Therefore, the adoption of improved irrigation technologies through CA has become very important in the country.

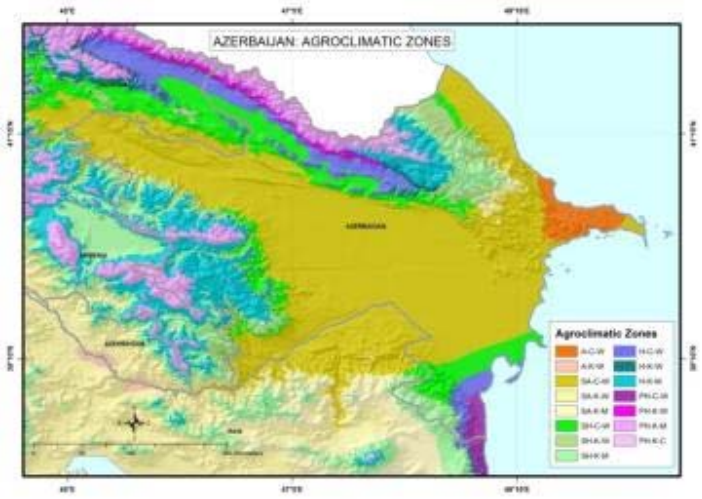


Figure 2: Azerbaijan agroclimatic zones (De Pauw, 2008)

Traditionally, agriculture in South Kazakhstan (SK) province is dominated by medium-size and small farms. Agricultural production is based on irrigated farming. Most of the farmland is privatized comprising mostly agricultural enterprises/individual farms, several agricultural co-operatives, joint-stock companies, limited partnerships and a few state-owned enterprises. Water deficiency has remained one of the most important issues in the irrigated crop sector of South Kazakhstan province. The province with its shallow groundwater level and saline soils needs water-saving technologies and efficient irrigation systems for diversified cropping. Currently, grain crops such as winter wheat or winter barley are grown continuously. In most cases, wheat and barley are irrigated by level basin float irrigation resulting in crop kill due to rise of highly mineralized ground water and soil crusting. An effective alternative approach can be bed-planting with furrow irrigation.

**Table 1: Land resources and population and agricultural indicators of project countries**

| | Countries | | | |
|---|---|---|---|---|
| Indicators | Azerbaijan | Kazakhstan | Uzbekistan | Total |
| Total territory (M ha) | 8.6 | 272.49 | 44.74 | 325.83 |
| Land area (M ha) | 8.2 | 269.7 | 42.54 | 320.44 |
| Cropland (M ha) | 1.77 | 24 | 4.9 | 30.67 |
| Cropland % | 20 | 8.8 | 10.9 | 9.4 |
| Agriculture GDP % | 5.5 | 5.2 | 18.5 | 9.7 |
| Population (million) | 9.3 | 15.7 | 30 | 55 |
| Population density ($km^{-2}$) | 104 | 6 | 65 | 16 |
| Rural population % | 45 | 42.8 | 63.5 | 50.4 |
| Per capita cropland (ha) | 0.19 | 1.52 | 0.16 | 0.55 |

Source: National statistical books of Azerbaijan Kazakhstan and Uzbekistan 2013

In Uzbekistan, the area under irrigated winter wheat has increased to ensure national food security, so that the former longer-cycle cropping system based on cotton and alfalfa was largely replaced by a shorter crop rotation based on winter wheat and spring cotton. As a result, the annual wheat production

in Uzbekistan has increased by more than 600 percent reaching around 7.5 Metric Tonnes (MT). In Kazakhstan, winter wheat production went down to about five MT due to decreased planting area in rainfed conditions.

The land area of the three project countries covers about 320.44 M ha, which is about 98% of the total area. Kazakhstan with 270 M ha is the largest, comprising almost 81.2% of the entire area, followed by Uzbekistan 44.74M (15.7%), while Azerbaijan comprising 8.20M ha (3.04%).The population is sparsely distributed with the highest density of 104.0 person $km^{-2}$ in Azerbaijan and the lowest in Kazakhstan; 6 person $km^{-2}$. Cropland amounts to 30.67 M ha. Reported average per capita cropland is 0.55 ha (**Table 1**) where smallest area being in Uzbekistan (0.16 ha) and Azerbaijan (0.19 ha), and largest being in Kazakhstan (1.45 ha).

In Azerbaijan an attempt was made to strengthen the promotion of sustainable farming practices in collaboration with other organizations already actively working in the country in this field. These were FAO, ADB, WB, EU funded research projects. All shared their resources and experiences with FAO and worked to complement each other in the promotion of CA. Several projects were implemented in Azerbaijan by ICARDA. The projects aimed to introduce CA practices to achieve the sustainability of farming mainly through improvement in soil structure; reduction in wind and water erosion; saving water and making cropping less vulnerable to unfavorable climatic conditions. Due to the above mentioned projects the area under CA reached 1246.1 ha in 2012. The results of the projects also convinced policy makers to support the introduction of CA Azerbaijan. Today the country has taken measures to implement programs on resource saving technologies, as envisaged in the agriculture development document.

The development of conservation tillage in rainfed areas of Central Asia was instigated by the massive soil erosion occurring at the time when the reclamation of virgin and fallow lands in Kazakhstan became of enormous importance in ensuring food security. In 1954, special surveys by agronomists, soil scientists and land developers examined vast tracts of the land stocks of Kazakhstan. Those expeditions identified more than 21 M ha of arable virgin and fallow lands of which more than 13 M ha are lands of good to medium quality that could be used for agricultural crops, and primarily for planting of cereal crops without significant costs (Dvurechenskiy, 2010). According to the Ministry of Agriculture of Kazakhstan, in 2011, the area covered by no-till and conservation tillage practices was 11.7 M ha, which was 70% of all the area sown to wheat in Kazakhstan. Consequently, in 2011, the country harvested record gross output of grain of 20 M t corresponding to a yield of 1.7 t $ha^{-1}$. The area under no-till in Kazakhstan in 2011 was 1.7 M ha.

In Uzbekistan, no-till production of wheat, sunflower, mung bean, sesame and sorghum has been investigated and the results have been encouraging. The lodging of sunflower was less under no-till planting as compared to the traditional tilled planting, which is an important factor for higher yield. Raised bed planting of winter wheat has been shown to produce higher yields than conventional planting and also save seeds (around 50%) and water (around 30%). Planting of sorghum on beds also saves water up to 32%. Hence, raised bed planting technology could be useful in the case of winter wheat, maize, sorghum and other crops such as sunflower and soybean. For raised bed planting practice to spread, there is a need to ensure the availability of raised bed planters and no-till drills so that scaling of CA in Uzbekistan becomes possible.

## 1.1. General introduction to the project

### *1.1.1. Project background*

In mid-2006, The Government of Turkey, represented by the Ministry of Agriculture and Rural Affairs (MARA) and FAO signed, an agreement whereby setting up an FAO/Turkey Partnership Program (FTPP) with an annual trust fund contribution of USD 2 million by the Government of Turkey over an initial period of five years (2007– 2011) for the benefit of the countries assisted by the FAO Sub regional Office for Central Asia (FAO/SEC).

The primary objectives of the FTPP, as described in the Partnership Framework Agreement (PFA) reported is to provide a substantive, financial and operational framework for active cooperation in the areas of food security and rural poverty reduction in the above beneficiary countries. The FTPP is demand-driven, as much as it responds to the priority problems identified by national and/or sub regional stakeholders and is expressed in the form of official requests. National ownership of all FTPP program and projects approved and implemented in each beneficiary country will be ensured by concerned governments driving the process of integration of the FTPP support within national development strategies and programs.

In this respect, each beneficiary country will appoint a FTPP Focal Point at senior level, liaising and coordinating communications between the government and FAO. In addition, for each project, the concerned national or sub regional partner institution will appoint, on behalf of the government, a National Project Coordinator (NPC) as direct counterpart responsible for its implementation. The partner institution and the NPC will ensure appropriate follow.

The initial outline of this project was submitted by FAO for consideration by the Steering Committee of the FTPP and was approved with an estimated budget of USD 600 000.

ICARDA provided technical backstopping to the project on conservation agriculture as per a Letter of Agreement between FAO and ICARDA.

### *1.1.2. Project goal*

The expected long-term impact of the project is focused on the improved rural livelihoods and food security through increased productivity of irrigated farming systems in four Central Asian countries - Azerbaijan, Kazakhstan and Uzbekistan - using the principles and practices of CA to achieve sustainable land and water management.

### *1.1.3. Stakeholders and Target Beneficiaries*

Main project beneficiaries were medium and small farms through increased profits and/or a reduced need to purchase food supplies on the market. Other project beneficiaries include farmer organizations, small implements manufacturer enterprises, research institutions, service providers, NGOs and input suppliers (seed, fertilizer nutrients, agrochemicals).

This action/research project aimed at targeting the aforementioned beneficiaries through capacity development and accelerated dissemination of improved techniques and measures at farmer level utilizing a participatory approach.

The overall expected benefit of the project was to enhance the socioeconomic development of farmers, local stakeholders and selected private-sector firms and service providers, with spillover benefits to the whole society.

### *1.1.4. Institutional linkages*

The project was implemented in partnership with national programs in Azerbaijan, Kazakhstan and Uzbekistan. Each concerned country appointed National Project Coordinator (NPC) to be located on-site and to provide full-time orientation, coordination and supervision during project implementation. Twelve national consultants were selected. Recruitment of subject matter specialists on crop production, water management, farm mechanization and economics, in each country, is done in the first project year. In general, selection of national consultants was conducted by the governments of respective project countries and in all cases was based on expertise in particular areas of the Project. National consultants were recruited according to FAO procedures. The national consultant in crop management worked as a national project manager (NPM) and coordinated all field activities including planting of crops, field days, and formal training courses.

### *1.1.5. Project duration*

The legal duration of the project was planned for 24 months, starting 1st of January 2011 and finishing 31st December 2012. The project duration was extended up to 31st December 2013 in order to have three cropping seasons in the project sites.

# 2. SELECTION CRITERIA AND ANALYSIS OF THE PROJECT DEMONSTRATION SITES

### *2.1. Selection criteria and selection of project sites*

The selection criteria were developed by project regional coordinator and national consultants of the project in each country during the national seminars which were held February through March 2011. The selection criteria was based on local conditions in agriculture of the participating countries in the project. During the national seminars the project was briefly introduced to the local stakeholders and followed by partly controversial but overall constructive discussions on project sites, selection criteria, crop rotations and equipments to be purchased. Project regional coordinator and the project team and local counterparts agreed on project farms for each country.

### *2.1.1. Selected farms in Azerbaijan*

Ibragimov Ahmad, Jumshudov Ehtibar and Babaev Mehmon were selected as project farmers in Azerbaijan. A total area of 24 ha, distributed over 3 farms, were selected for the demonstration of permanent beds, diversified crop rotations and improved field irrigation. Of the 3 selected project farmers one had an own tractor, the second owned some equipment, and a third one was renting a tractor.

### *2.1.2. Selected farms in Kazakhstan*

Several individual farms were visited and then three individual farms (owned by Yusufjonov Gafurjon, Sattarkhonov Musakhon and Babakhodjaev Avazkhan) were selected according to selection criteria developed by project team taking into consideration local conditions in the South Kazakhstan province. All selected three farms were functioning under the Production Cooperative Farm named after "Yassaviy".

### *2.1.3. Selected farms in Uzbekistan*

Uzbekistan project team and project regional coordinator visited farms around Beshkent town which is in proximity to Karshi city to select project farms according to selection criteria. After partly controversial and lively discussions three farms were selected (namely "Ismatova Farangiz Azamatovna", "Kholov Sobir" and "Meyliev Sayli Yoldoshevich". Owner of a farm named after "Ismatova Farangiz Azamatovna" Ismatov Azamat showed a great enthusiasm and interest on conservation agriculture technologies.

## 2.2. Analysis of the project sites

### *2.2.1. Characterization of Selected project demonstration sites in Azerbaijan*

The Republic of Azerbaijan has diverse agro-ecologic and climatic conditions. Traditionally, agriculture of Azerbaijan is based on high water consuming crops and water shortage is recorded during summer in many regions including Tartar and Barde districts where the project demonstration field is established. One of the main constraints for further increase of agricultural production is limited irrigation water. Therefore, adoption of improved irrigation technologies through CA has become very important in the country.

Tartar and Barde sites are located in Karabakh steppe in the southern subzone of the Ganja climatic region. Kura-Araks lowlands lie between Kura and Kar-Karchai rivers which are in Minor Caucasus. Long term mean rainfall ranges between 300-400 mm and occurs mostly in November-December in winter and March-April in spring season. There is almost no rain between July and September. The climate is continental with an average annual temperature of 13.4$^{o}$C. Summer temperatures sometimes surpass 35°C; winter temperatures average 3°C in January. Climate varies within the district - mild and semi-desert climates are specific to different regions.

During the project the warmest air temperature was observed in July 2011 while lowest air temperature was recorded in January 2012. The air temperature fluctuates from 2.9 to 28.2 (Figure 3).

The year 2011, in contrast with 2012 and 2013 was characterized by favorable weather conditions for the production of agricultural crops. Spring of 2011 was relatively humid and heavy rainfalls and showers occurred in May. In general, the winter of 2011 was favorable to the winter wheat growth and development and was warmer than usual and almost without snow. The spring of 2011 was characterized by sufficient rainfall that promoted wide growth and development of winter wheat. According to the data of the Tartar Meteorological Station, located in Tartar district, the highest (501 mm) precipitation was recorded in 2011 which is almost 30 percent higher annual long-term data. The April of 2013 was characterized by insufficient rainfall and as a result most of the spring crops suffered due to water shortage during the vegetation period (Figure 4).

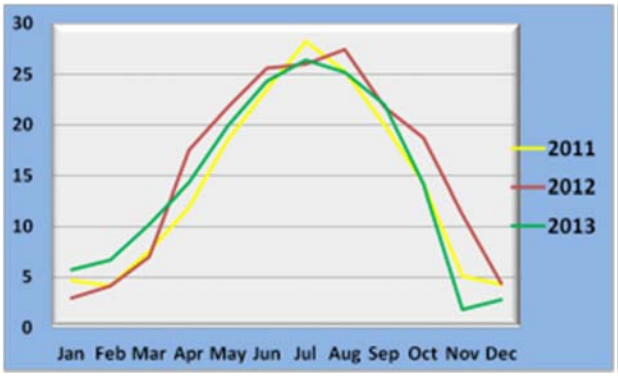


Figure 3 Average air temperatures in Tartar, Azerbaijan (2011-2013)

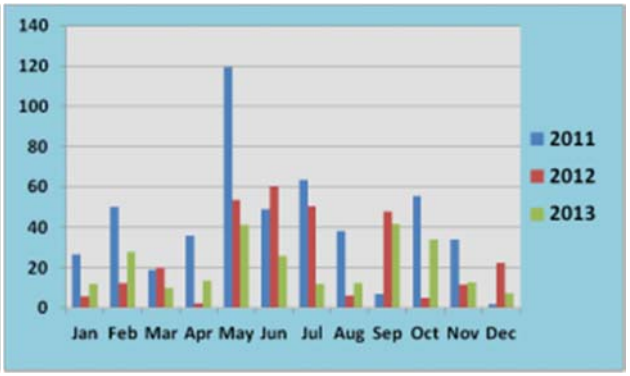


Figure 4 Mean annual precipitation, Tartar, Azerbaijan (2011-2013)

A ground water table is 3-10 m deep with TDS from 1-10 g $l^{-1}$. Soil is greybrown, heavy loam with organic matter content from 2.69-3.09% in topsoil. The whole area is served by earth canals providing surface irrigation for the cultivated crops.

The irrigation and drainage infrastructure has been deteriorating since the country's independence in 1991. Before independence, the normal period for overall maintenance of the canals used to be around three years but since then maintenance has been very erratic and insufficient. Because of insufficient flow control infrastructure, irrigation water flows constantly into most canals up to the tertiary level for most of the irrigation season. This leads to high water losses through the irrigation scheme. Water is provided to farmers for free and they do not participate in the management of the irrigation scheme.

### *2.2.2. Characterization of selected project demonstration sites in Kazakhstan*

Agriculture has long been a major contributor to Kazakhstan's economy. Most of the farmland is privatized comprising mostly agricultural enterprises/individual farms, several agricultural co-operatives, joint-stock companies, limited partnerships and a few state-owned enterprises.

The crop production sector is dominated by cereal crops, mostly wheat, which accounts for 66% of the total crop output. Other important crops are fodder crops, potatoes and vegetables. Agriculture continues to be a major source of export with agricultural products constituting about 10% of total export revenue. Major agricultural exports include grain (50%), meat and wool. In 2000 the country exported 5.5 MT of wheat, mostly to Russia, down from 12 MT in 1991. Most domestic food supply is met from domestic production.

South-Kazakhstan (SK) territory is equal to 116,400 square kilometers (4.4% of total Kazakhstan land size). Agricultural production in the province occupies 10,269,300 ha, of which 786,300 ha is under cultivation. Approximately 50% of the cultivated land is irrigated.

The soils are sirozem, gray-brown, brown desert, takyr-like, and in the irrigated area -meadow-marshy, mostly saline with salt amount of 33 to 325 t $ha^{-1}$ in 2 m layer and humus content of 0.5 to 2.5% in the cultivated layer. The soil of experimental site is rather dense with the bulk density fluctuating between 1.4 and 1.6 g $cm^3$. The highest bulk density was noted in the depth of 20-40 cm. All soil parameters were analyzed by the method developed in Uzbek Research Institute of Cotton (UzRIC, 1973). Over the past 12 years, more than 50% of fields in the whole Arys district have been ranked as low to very low in $P_2O_5$. Almost all the areas of the project pilot site are located in hunger desert zones.

Climatic conditions of SK are very diverse, comprising steppes, hot and dry semi-deserts, and mountains. The climate is continental, with hot temperatures and low air humidity in summer time and

cold and quiet unstable winter with low snow fall. Average frost-free period lasts for about 225 days. Average daily temperature is 16.9ºC. June through August is the hottest months sometimes temperature can go up to 40ºC while lowest temperature is observed in January and February months when lowest temperature can go down to -35ºC (Figure 5). A long term annual precipitation level is around 350 mm. However, rainfall varies strongly over the year for example in 2011 average rainfall high up more 1000 mm per (Figure 6). Precipitation starts at the end of September and early October. The highest precipitation is observed in winter and spring seasons (78%) followed by autumn (18%) and summer (4%). Low precipitation level permits only irrigated crop production.

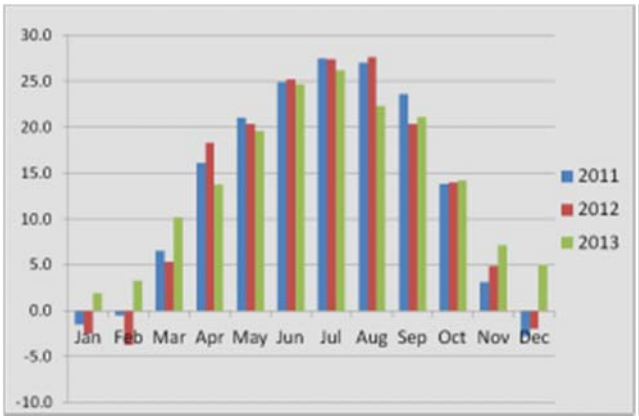


Figure 5 Average air temperature in Chimkent, Kazakhstan

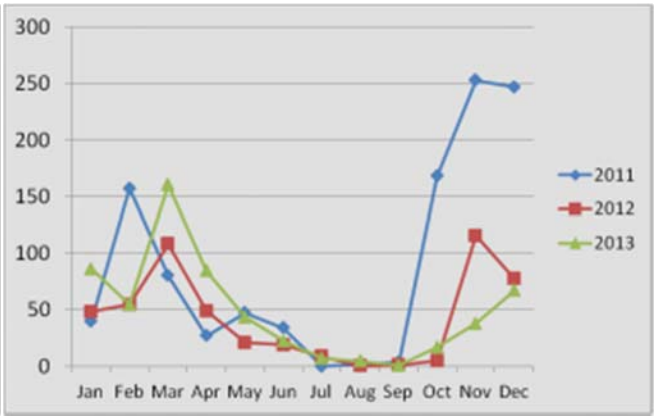


Figure 6. Mean annual precipitation in Chimkent, Kazakhstan

Water deficiency has remained one of the most important issues in the irrigated crop sector of South Kazakhstan province. The province with its shallow groundwater level and saline soils needs water-saving technologies and efficient irrigation systems for diversified cropping systems. Currently, grain crops such as winter wheat are grown continuously after wheat or winter barley which is not a good crop rotation system. In most cases, wheat and barley are irrigated by flood irrigation resulting in crop kill due to rise of highly mineralized ground water and soil crusting. Effective alternative approaches such as bed-planting technology can improve irrigation practices. Some on-farm research in the country have shown that bed planted crops have yielded better and consumed less irrigation water (about 40%) with lower seed rate, soil tillage and fuel expenses than flood irrigated crops. The soil quality was improved, especially on the top of the beds. Bed planting combined with reduced/zero tillage technologies looks promising to improve farming profitability, introduce diversified rotations, reduce the turn-around period between harvesting and planting of the following crop to a minimum with a goal to produce two and more crops per year.

The project, therefore, also targeted crop diversification and conducted on-farm trials and demonstrations using alternative crops such as:

Cereals: sorghum

Leguminous: Mung bean, kidney bean, field pea.

### *2.2.3. Characterization of selected project demonstration sites in Uzbekistan*

After achieving independence, Uzbekistan laid major emphasis on agricultural growth and efforts towards developing its own market economy. During this transition, large inefficient shirkat farms were disintegrated and a number of small private farms have been established. Therefore, high input use

technologies may not be suitable for these small farms. It is right time to look for an appropriate and realistic strategy by which the cropping intensity could be enhanced and diversification in agriculture could be achieved. For development of this new type of farms, there are constraints associated with limited potential and abilities in cropping, tillage methods, soil fertility improvement and on-farm water management. There is an urgent need to pilot changes in agricultural practices in the region in order to improve agricultural production in the irrigated areas of Uzbekistan.

Kashkadarya is located in southeast of the country, in the Kashkadarya River Basin and on the western edges of the Pamir-Alai Mountain Range. Main agricultural crops are cotton, winter wheat, vegetables and cocoon production. The agricultural input of the province makes slightly more than 10% of the Uzbekistan's total agricultural production. Livestock farming, especially sheep husbandry, is well developed in the mountainous areas.

There are several deserts and these are namely: the Karshi Desert covers the north and northwestern part of the province; the Nishon Desert covers the south whereas the Sundukly sands - the southwestern parts; the eastern part of the province consists of the Kitob-Kamashi foothills. There are three types of climates; continental, partly subtropical and dry. The mountain ranges that have semi-rounded the province from northwest, east and south prevent the penetration of cold weather and create a convenient atmosphere for the condensation of the western humidity. Winters are warm and summers are hot and long. Average long term precipitation ranges widely among foothill, mountain and desert zones between 100 and 450 mm. The main river is the Kashkadarya River with its numerous streams originating from the mountains.

Average annual air temperature is +16.8ºC, January average is 1.2ºC, and July average is +31.7ºC. Spring of 2012 was very favorable with air temperature close to normal and 2013 was hot with air temperatures above the annual average during grain filling period of winter wheat (Figure 7).

The precipitation observed 2011-2013 at the project site varied throughout the project years. Autumn 2011 was wet and most of the precipitation was received between October and April 2012 (Figure 8). Winter of 2011/12 was among the most severe winters in Uzbekistan. In some cases, cold conditions improved crop growth and development, while in some other cases cold negatively affected the winter survival of the plants. Between July and September, a little precipitation was received, which essentially stopped the growth of vegetation. Hence during these dry months crop cultivation could only be done in irrigated areas.

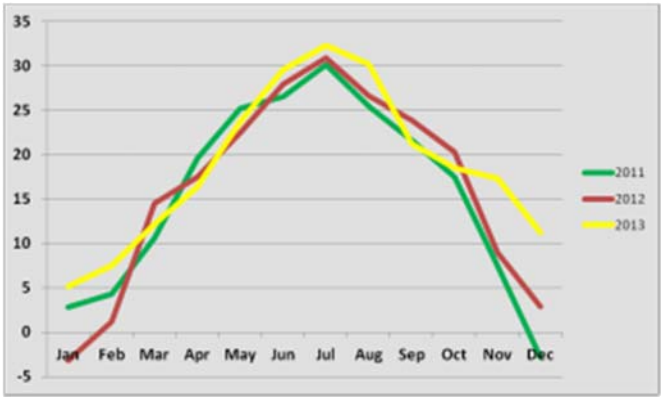


Figure 7 Mean air mean temperature in Qarshi, Uzbekistan (2011-2013)

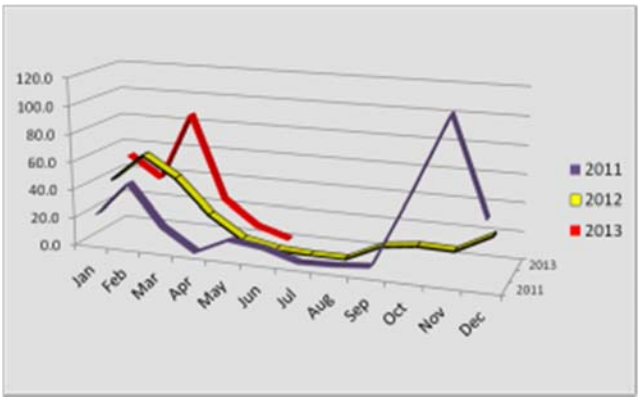


Figure 8. Monthly average rainfall in Qarshi, Uzbekistan (2011-2013)

# 3. FIELD ACTIVITIES

## 3.1. Field activities in Azerbaijan

### *3.1.1. Improved crop production and management through accelerated adoption of conservation agricultural practices*

#### *3.1.1.1. Effect of planting methods on productivity of winter wheat (Triticum aestivum) varieties in the irrigated conditions of Karabakh lowlands*

**Introduction**

Bed planting systems on wheat cultivation are gaining importance in various environments of all over the world. Bed planting system is very low compared to mega planting practices which are widely distributed in the irrigated conditions of Azerbaijan. The introduction of this technique in North Mexico had improved the wheat grain yield by at least 10% and water economy by up to 35% in comparison with the conventional system (Aquino, 1998). Similar results achieved in the irrigated conditions of Azerbaijan by using winter wheat cultivation on raised beds.

**Study objective**

The objective of this experiment were i) to test two methods of planting and four different planting rates of winter wheat in irrigated conditions, and ii) to adopt the bed planting systems to irrigated conditions of Karabakh lowlands, in order to intensify wheat production in the Republic of Azerbaijan.

**Materials and Methods**

The Bed Planting System was compared to Flat Planting System based on conventional and seedbed preparation for planting winter wheat. The experiment conducted in the three farmers' field to evaluate field performance, productivity of the winter wheat and also economy and water use efficiency.

Soil was taupe (Mamedov, 1989) and clay (Kachinsky, 1958). The initial dry soil bulk density, particle density and field capacity ranged from 1.35 g $cm^{-3}$ to 1.41 g $cm^{-3}$, 2.62 to 2.74 g $cm^{-3}$, and 29.9 to 32.4%, respectively throughout the 100 cm deep profile. Initial content of absorbed ammonia, total nitrogen, available phosphorus and organic matter ranged from 16.0 to 42.0 mg $kg^{-1}$, 0.196 to 0.308%, 5.3 to 9.3 mg $kg^{-1}$ and 2.69 to 3.09%, respectively throughout the 30 cm deep profile.

**Experimental Design**

a) Factors: Planting methods

1) Bed planting

2) Conventional planting

в) Factors: Varieties

1) Azamatli-95

2) Murov-2

3) Tale-38

Randomized Complete Block Design (RCBD) was used in the experiment. Replications – 4; plot size – 100 $m^2$ (2,5x20) for each treatment and number of farmers – 3. Standard agronomic practices and fertilizer doses were applied during winter wheat vegetation. Analysis of variance (ANOVA) was used to determine treatments' effect. Preceding crop was maize in the first project year and in the second project year sunflower. Winter wheat was planted in the beginning of November which is optimal seeding date for winter cultivation in the irrigated conditions of Karabakh lowlands of Azerbaijan. Harvesting was done at full maturity stage of winter wheat.

**Results**

Bed planted winter wheat (*Triticum aestivum*) compared to conventional planting in this research. Soil bulk density at demo site was lower and more adequate on raised beds: 1.18, 1.21 and 1.22 g $cm^{-3}$ as compared to more compacted soil: 1.28, 1.26 and 1.30 g $cm^{-3}$ respectively. Crop growth was much better and advanced by 5-6 days on bed planting. Water used for irrigation was reduced on raised bed planting by 27 %. It was 1780 ha $m^3$ on control as compared to 1550 ha $m^{-3}$ on bed planting. Water use efficiency was by 25% higher at raised bed planting amounting to 2.90 kg $m^{-3}$ against 2.32 kg $m^{-3}$ in control.

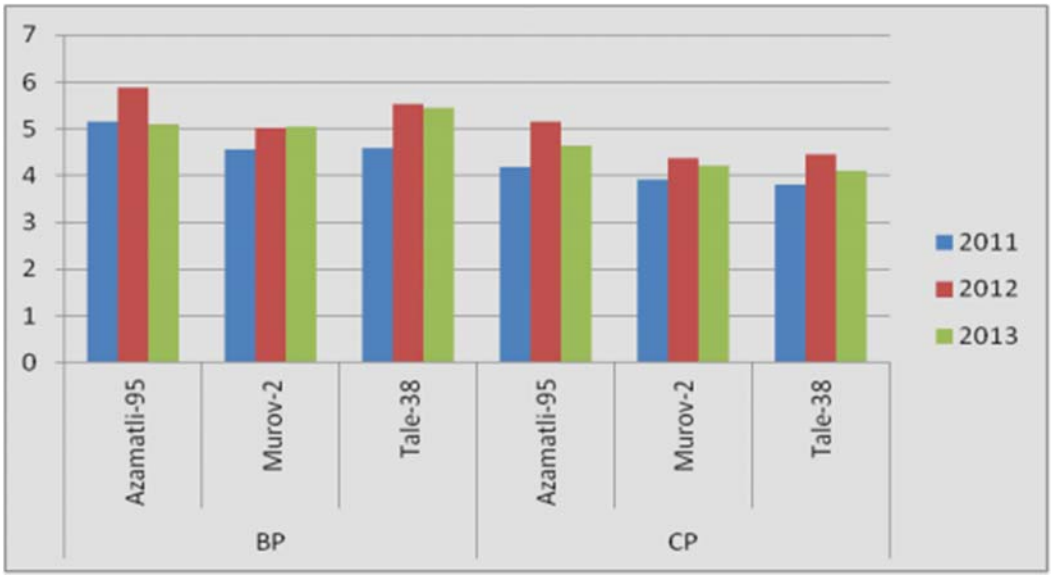


Figure 9: Effect of planting method on productivity of winter wheat varieties

It is well known that weather conditions and planting date can impact winter wheat grain yield not only on rainfed conditions but also it can affect productivity of agricultural crops in the irrigated conditions. Our results show that weather conditions in 2012 were conducive to getting high grain yield as compared to 2011 and 2013 years (Figure 9). In 2012, air temperature was lower than 2011 and 2013. Grain yield was significantly affected by varieties (<.001) and planting method across the investigated years. The high tillering winter wheat variety Azamatli-95 had maximum grain yield (5.88 t $ha^{-1}$) in 2012 in bed planting while winter variety Tale-38 had the lowest grain yield (3.82 t $ha^{-1}$) in 2012 in conventional planting.

**Economic assessment**

In all the three cases the bed planting winter wheat proved to be more profitable than the conventional planting. It should be mentioned the bed planting generated 13.33%, 38.22% and 73.37% more revenues than conventional planting in all three varieties respectively. **Table 2**: presents the average cost structure

of raised bed planting and conventional planting for the three varieties in 2013. The maximum net benefit was recorded (584.1 US$) in variety Tale-38 with bed planting while lowest benefit was recorded (358.9 US$) in variety Murov-2 conventional planting.

**Table 2: Cost benefit analysis of winter wheat varieties under conventional and bed planting methods 2013 (US$ ha$^{-1}$)**

| | Winter wheat varieties | | | | | |
|---|---|---|---|---|---|---|
| | Azamatly-95 | | Murov-2 | | Tale-38 | |
| | Conventional planting | Bed planting | Conventional planting | Bed planting | Conventional planting | Bed planting |
| Yield (t ha$^{-1}$) | 4.63 | 5.11 | 4.21 | 5.04 | 4.11 | 5.44 |
| Total production value (US$ ha$^{-1}$) | 1018.6 | 1124.2 | 926.2 | 1108.8 | 904.2 | 1196.8 |
| Total production cost (US$ ha$^{-1}$) | 567.3 | 612.7 | 567.3 | 612.7 | 567.3 | 612.7 |
| Net benefits (US$ ha$^{-1}$) | 451.3 | 511.5 | 358.9 | 496.1 | 336.9 | 584.1 |
| Profitability rate, % | | 113.33 | | 138.22 | | 173.37 |

**Conclusions**

The high tillering winter wheat variety Azamatli-95 had maximum grain yield (5.88 t ha$^{-1}$) in 2012 in bed planting while winter variety Tale-38 had the lowest grain yield (3.82 t ha$^{-1}$) in 2012 in conventional planting.

Economic assessment of this research showed that bed planting is more profitable than conventional planting for growing winter wheat due to to higher yields and savings in planting costs obtained under raised bed planting.

## *3.1.2. Crop rotations diversified with crops suitable for conservation agriculture*

### *3.1.2.1. Study short term crop rotation system in the irrigated conditions through application of conservation agriculture technologies in Karabakh low lands*

*Introduction*

It is well known that short-term rotations usually involve only annual crops, such as cereals, legumes, vegetables and etc. In many investigations on short-term rotations have been shown that there are many beneficial effects in this system of the rotation. For example, winter wheat or barley grown after legume crops usually performs better by 10 to 20 per cent (ranging from 0 to 50 per cent) than a cereal grown after a similar cereal crop. Also short term crop rotation can improve weed control in the field. Many crops can be used for double cropping after wheat harvest in the irrigated conditions of Azerbaijan. In this context maize, soybean, pearl millet, sunflower, kidney bean and sorghum are used as summer crops after the wheat harvest in the project demonstration sites.

*Study objective*

The main objective of this experiment is to study short term crop rotations by using CA practices and well adapted crops with full participation of farmers.

*Materials and Methods*

This experiment conducted at the demo sites of the three project farmers. Randomized Compete Design was used in the experiment. Replications – 4; plot size – 200 м$^2$ for each treatment and number of farmers – 3. Standard agronomic practices and fertilizer doses applied for the crops. Analysis of variance (ANOVA) will be used to determine treatments' effect. Soil samples collected for moisture content and for soil nutrient analysis at the time of sowing and harvesting. The treatments were: continuous winter wheat (WW), winter wheat+legume (soybean)+winter wheat+kidney bean (WSBWKB) and winter wheat+corn+wheat+pearl millet (WCWPM). All treatments involved no-till and direct seeding of second crops after winter wheat harvest under stubble mulch. All crops were seeded in optimal seeding dates for these crops and all crops were harvested at full ripening stage of those crops.

**Results**

The experiment was started in 2011 and the data presented were obtained in 2013. Wheat yields were higher with the WSBWKB than with the WW and WCWPM rotations.

Moisture content for growing winter wheat in rainfed conditions depends a great deal on preceding crop or fallow (Table 3). One can see that water storage before sowing winter wheat is very low in wheat after wheat. It is much better after cereals but after legume crops soil moisture accumulation was the highest almost one and half time more than compared to control.

Table 3**: Soil moisture content as affected by preceding crop to wheat % (2012)**

| Soil layer, cm | Wheat after wheat | | Wheat after cereals | | Wheat after legumes | |
|---|---|---|---|---|---|---|
| | Seeding | Harvest | Seeding | Harvest | Seeding | Harvest |
| 0-10 | 9.2 | 7.5 | 11.2 | 11.8 | 14.1 | 12.1 |
| 10-20 | 9.7 | 7.8 | 12.8 | 12.5 | 15.5 | 13.5 |
| 20-30 | 11.5 | 10.2 | 14.5 | 13.1 | 17.1 | 14.1 |
| 30-40 | 10.2 | 9.5 | 16.8 | 13.2 | 20.3 | 18.3 |
| 40-50 | 10.0 | 9.1 | 17.2 | 14.1 | 17.8 | 16.9 |

Weeds widespread in the project area are as follows: Canada thistle, cleavers, coriander, wild cabbage, chickweed and wild oats. Weed infestation is not only common in CA, but rather CA causes a change in the dynamics of weed growth that are already present in traditional production systems. Effects of crop rotation on weeds have been intensively studied in cotton growing areas during 1975-1984 (Tursunkhodjaev and Bolkunov, 1981; Ismailov, 2004) with different combinations of cotton-alfalfa-wheat rotations. The principles still hold true that crop rotation helps to suppress weeds and appropriate strategy is needed for CA as well. Our findings shows that weed infestation was remarkably lower in wheat grown after cereals not only because there was efficient weed control during cereal growing period but also because wheat tillering capacity and plant growth was high thanks to better moisture availability. Breaking continuous wheat with legumes cultivation has changed situation dramatically: weed number after legumes crops were high compared to control treatment (Table 4).

The wheat–legume rotation resulted in the highest winter wheat yield and better yield components compared to WW and WCWPM rotations (Table 5). The winter wheat grown on the legume rotation

yielded 25.1% more than winter wheat grown on the cereal rotation. Winter wheat grown on cereal rotation yielded 1.5 % more than winter wheat growing on spring wheat stubble. Spring wheat yielded more on fallow than stubble with no other significant effects of crop rotation. Higher winter wheat yield was achieved when legume crops are used as second crops while cereal crops are used as second crop winter wheat yield was lower. It can be explained that legume crops can fix nitrogen and improve soil fertility so there will be more than enough recommended rate of fertilizer. More information is needed concerning the effects of diversification of cropping systems to choose right legume crops to be included to the crop rotation.

Table 4: **Weed number in winter wheat stand as affected by preceding field, pieces per 1 $m^{-2}$,**

| Preceding crops | Wheat stage | |
|---|---|---|
| | Tillering | full maturity |
| Wheat | 120 | 43 |
| Cereals | 84 | 21 |
| Legumes | 63 | 16 |

Table 5: **Wheat yield response to rotation**

| Crop rotations | Land use efficiency, % | Plant height, cm | Height difference, % | Winter wheat yield, t $ha^{-1}$ | Yield differences, % |
|---|---|---|---|---|---|
| WW | 50% | 110.04 | 100.00 | 4.50 | 100.0 |
| WCWPM | 100% | 105.41 | 95.79 | 4.99 | 110.8 |
| WSBWKB | 100% | 101.23 | 91.99 | 5.88 | 125.1 |

## Conclusions

Grain yield in continuous wheat (4.50 t $ha^{-1}$) was the lowest because plants were less supplied with moisture and were competing with large number of weeds. Winter wheat grain yield was 10.8 % higher compared to continuous wheat yield (4.99 t $ha^{-1}$). However when wheat was rotated with legumes its yield was also high: 5.88 t $ha^{-1}$ or 25.1 %. In discussion about continuous wheat, it has been emphasized about soil intoxication which was not proved by any data. In further studies one should control weeds in continuous wheat by efficient herbicides which may change assessment of continuous wheat growing. Also weed control is very important to change attitude to replacement of cereals with legumes. As per this research the wheat–legume rotation seemed to be the best practice in the irrigated conditions of Azerbaijan. Also this short term crop rotation can improve land use efficiency in the irrigated areas which is extremely important in the country. Short term wheat-legume crop rotation under no-till practices can be recommended to the farms of the country. Many aspects of crop rotation and second cropping are compatible with current crop rotation in the country and could become more accessible to farmers if government policies are restructured to reflect the true environmental costs of agricultural production.

### *3.1.2.2. Effect of tillage on productivity of corn, sunflower and soybean in the irrigated conditions of Azerbaijan*

**Introduction**

Tillage is one of the important agronomic techniques in most agricultural crops while no-till is the most modern tillage technique which is a part of conservation agriculture. No-till controls soil erosion because the plant material protects the soil surface from high winds, rainfall and irrigation and prevents loosening and carrying away of soil elements. Touchton and Jonson (1982) conducted an experiment on the effect of 3 different methods of tillage and plantation on the yield of wheat and soybean. The three tillage methods included chisel, Moldboard plow and no tillage. The results were that the yield of soybean in the 2 mentioned tillage methods didn't differ, but yield of wheat in case of Plow with Chisel Plow was less than Moldboard plow. Taking this into account it is decided to study effect of tillage on productivity of no-till corn in the irrigated conditions of Karabakh lowlands.

**Study objective**

A main objective of this research is study effect of tillage on productivity of succeeding no-till corn in the irrigated conditions of Karabakh lowlands.

**Materials and Methods**

Three different crops (Corn, Soybean and Sunflower) were grown in this experiment and all crops planted after winter wheat harvest by using no-till planter. The experiment was laid out in randomized complete block design. Plot size was 200 $m^2$ (25x8 m). Tillage treatments include conventional tillage or plough (CT) as control, minimum tillage with chiseling (MTC) and no-till (NT) respectively. Fertilizers in the form of nitrate ammonium and ammonium phosphate were applied at the rate of 300 kg $ha^{-1}$ and 100 kg ha-1, respectively, just before sowing in conventional tilled field and in no-till treatment the same type of fertilizers were applied with seeding. Each crop was seeded into moisture following a pre-seeding irrigation. This is a common strategy used by farmers in the region as part of their weed control strategy. Normally two or three post-emerge irrigations were applied to the corn, soybean while one irrigation to the sunflower. Conventional seed broadcasting done with local seeders (conventional planter) after implementation of the soil tillage under standard corn, soybean and sunflower management technology. No till planting was done using special disk seeder.

**Results**

Tillage systems had a significant effect on the yields of corn, soybean and sunflower grown on stubble (**Figure 10**). Overall evaluations of responses indicated that some crops better adapted to no-till practices than other crops. For instance, NT increased the yields of sunflower over conventional till and minimum till with chiseling up to 19.33% while in soybean yield was a little lower than conventional till but saved up to 70 % fuel for planting. In this study, the yield of corn was not affected by tillage systems through 2011-2013 years in Azerbaijan. The highest yield was recorded in no-till corn (4.95 t $ha^{-1}$) while lowest yield was recorded with conventional till corn (4.71 t $ha^{-1}$). The same trend was observed in sunflower growing.

Effect of tillage methods was not significant for grain yield of soybean (**Figure 10: Effect of tillage system on double cropped corn, soybean and sunflower yields in Azerbaijan, 2011-2013.**). It values of 1.86, 1.89 and 1.90 t $ha^{-1}$ in NT, MTC and CT respectively. It can be concluded that soybean grain yield is less affected by the different tillage methods.

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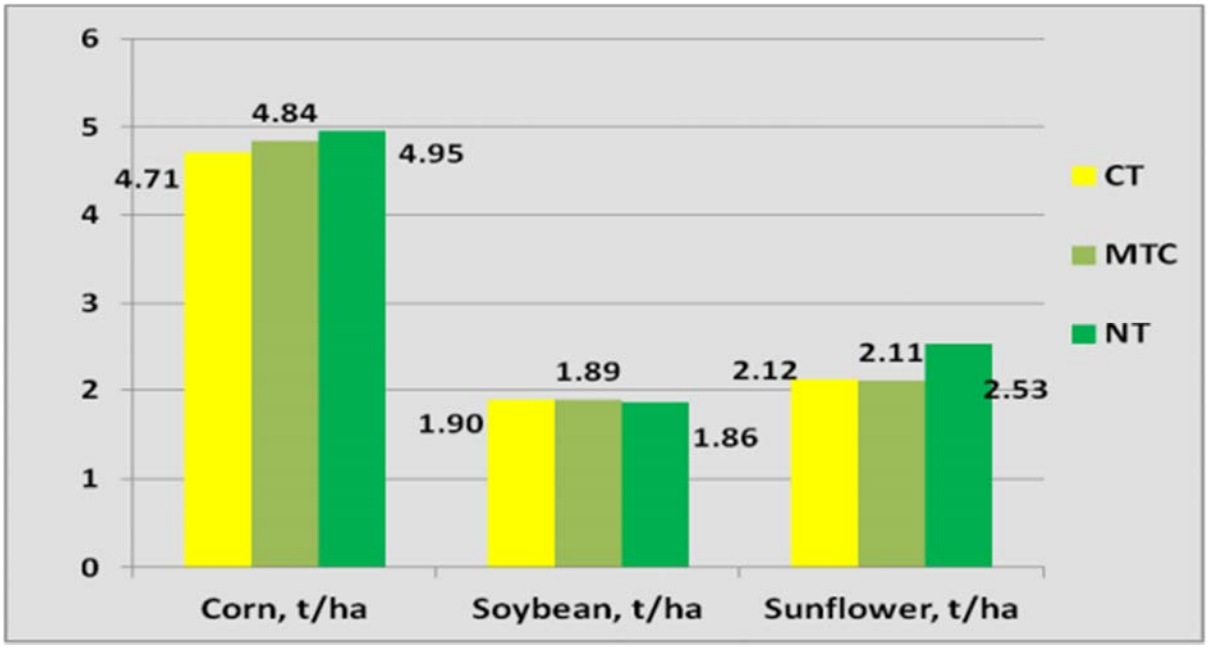



**Figure 10: Effect of tillage system on double cropped corn, soybean and sunflower yields in Azerbaijan, 2011-2013.**

**Conclusions**

Overall, the results of this study indicate that tillage system and double cropping practices are compatible and need to be more investigated in irrigated conditions of Azerbaijan. Corn Soybean and sunflower yields are less affected by the different tillage methods the obtained yield was same across treatments. Best tillage option was assessed and recommended to be adopted in Karabakh low lands and introduced to the farms of the country. These investigations can be included following: planting and seeding date, fertilizer rate and application date, irrigation date and rate.

*3.1.3. Raised-bed planting and land leveling technology adjusted and applied and lower and more efficient water utilization for the crop rotations introduced, as compared to traditional cropping systems*

### 3.1.3.1. *Effect of traditional and bed planting on winter wheat yield and water use efficiency*

**Introduction**

Agricultural production in Azerbaijan is constrained by scarce water availability during winter wheat grown season. Water use efficiency is also very low leading to high water losses through the commonly used irrigation scheme in the country. There are a lot of disadvantages of the float irrigation and the main disadvantage of the float irrigation is the water losses and, consequently, coefficient of water use is very low. Water saving can be increased up to 30% by using bed planting method. The number of farms that are using furrow irrigation is increasing from year to year. The advantage of the new technology is that soil erosion will be reduced and also dynamics of soil moisture is well-kept and used. There is a need for new irrigation practices such as furrow irrigation.

**Study objective**
To study the effect of improved irrigation technologies and to identify the best combination to increase winter wheat yield while decreasing the water consumption in the irrigated conditions of Karabakh lowlands.

**Materials and Methods**
The experimental site is located in Karabakh steppe in the southern subzone of the Ganja climatic region. Specifically, the Kura-Araks lowlands are located between the rivers Kura, Kar-Karchai and Minor Caucasus. Mean rainfall during the cropping season ranged from 300 to 450 mm and occurs mostly in November-December and April-May. There is almost no rain from July to September. The climate is continental with an average annual temperature of 14-15ºC. Summer temperatures reach 35°C with an absolute maximum of 38-40ºC. The sum of effective temperature, during the cropping period is 3585ºC.The ground water table is 3 to 10 m deep with Total Dissolved Salts (TDS) from ranging from 1 to 10 mg l-1. Soil is greybrown, heavy loam with organic matter (OM) content from 1.77 to 2.23% in the 0-20 cm depth. The whole area is served by earth canals providing surface irrigation for the cultivated crops.

**Results**
The main benefit of bed planting is water savings. Almost all farmers reported 30-35 % less irrigation time. Therefore, under high production situations, bed planting exceeds the yields possible on the flat bed (Nurbekov, 2008). Our results are in accordance with the results of Fahong et al. (2004) in China. These authors observed an improvement of the water use efficiency by 21–30% combined with an approximate 17% savings in applied irrigation water use efficiency was significantly higher with the bed planting (2.36 and 2.11 kg $m^{-3}$) compared to conventional planting (1.67 and 1.85 kg $m^{-3}$) (Table 6). The grain yields were less conclusive, only on the farm 1 a significantly higher grain yield was observed with the bed planting method while on farm 2 there was a little difference across the two years.

Table 6: **Effect of traditional and bed planting on winter wheat yield and water use efficiency**

| Farmers | Treatments | Yield, t $ha^{-1}$ | | Water rate, $m^3$ $ha^{-1}$ | Water use efficiency, kg $m^{-3}$ |
|---|---|---|---|---|---|
| | | 2011 | 2012 | | |
| Farm 1 | Traditional planting | 3.76 | 3.54 | 1900 | 1.67 |
| | Bed planting | 5.23 | 5.10 | 1600 | 2.36 |
| Farm 2 | Traditional planting | 2.57 | 2.23 | 1950 | 1.85 |
| | Bed planting | 3.42 | 3.52 | 1600 | 2.11 |

**Economic assessment**

The highest net benefits (745 USD $ha^{-1}$) were obtained with bed planting while the conventional method achieved the lowest net benefits (Table 7). The profitability was highest for bed planting. Furthermore, the net benefits heavily depend on the market price of wheat grain that can decrease considerably in good rainfall years when grain becomes more abundantly available on the markets.

Table 7: **Economics of planting methods on winter wheat productivity in Azerbaijan**

| Planting methods and seeding rates | Grain yield, Mg $ha^{-1}$ | Production cost 1$ $ha^{-1}$ | Production value 1$ $ha^{-1}$ | Net benefits, $ | Profitability rate ,% |
|---|---|---|---|---|---|
| Conventional – 220 kg $ha^{-1}$ | 3.02 | 465 | 960 | 495 | 106 |
| Bed – 130 kg $ha^{-1}$ | 4.29 | 535 | 1280 | 745 | 139 |

**Conclusion**
Water use efficiency is important in Azerbaijan in view of the limited water resources in the country. The results have to be considered as preliminary. More detailed studies of the factors influencing farmers' choices and preferences are required. The results are useful for identifying suitable varieties for bed planting method in Azerbaijan.

## 3.2. Field activities in Kazakhstan

### *3.2.1. Improved crop production and management through accelerated adoption of conservation agriculture practices*

#### ***3.2.1.1 Effect of planting rate on productivity of bed planted maize in irrigated conditions of South Kazakhstan province.***

**Introduction**
In South Kazakhstan population growth rate is very high compare to other province of Republic of Kazakhstan. In this particular case there is need to increase food production in the province by improving cultivation of agricultural crops including forage crops.
A major crop planted in the region, as succeeding crop, is a dual propose maize and is very important to supply livestock with fresh forage in the second half summer. Maize growing technology on permanent beds is not studied yet and is a new approach in maize cultivation management in the region. In the conditions of free market economy there is a need to develop new resources saving technologies such as no-till, minimum tillage and improved water saving technologies at the same time maximum use of promising varieties and hybrids which can be given high productivity forage crops by using warm period of vegetation period and bio-climatical potential of the region.

**Study objective**
To test different planting rates of bed planted maize in irrigated conditions of South Kazakhstan province.

**Materials and Methods**
Soil samples collected at 0-100 cm depth for moisture content, and for soil nutrient analysis at the time of sowing and harvesting. Main nutrition elements determined by the Granvald-Lyaju and Machigin methods. Plot management was similar to production practices of producers in the area. The experimental design was Randomized Complete Block Design with four replicates. Individual plot size was 1250 $m^2$. Analysis of variance (ANOVA) was used to determine treatments' effect. There were six treatments 40-90 thousands. Starter fertilization applied at the time of seeding at the rate of $P_{70}N_{140}$ kg

ha-1, which facilitated the development of the root system and also good emergency rate of maize. Starter fertilizer is a common practice used in some areas of the USA to improve early corn growth (Kaiser et al., 2005).

**Results**

Table 8 shows treatment averages for plant height. Seeding rate increased corn plant height across from 40000 to 90000 seeding rate. The 2012 and 2013 rainfall in South Kazakhstan was, in general, favorable with near (2012) and above average (2013) rainfall. The highest plant height was recorded (226) with seeding rate 60000 in 2013 while seeding rate 40000 had the lowest plant height (212 cm) in 2012 (table 6). There was no significant difference between seeding rate and plant height across the tow years.

Table 8: **Bed planted maize plant height response to seeding rate**

| Seeding rate | Plant height, cm | Plant height, cm | Mean, plant height, cm |
|---|---|---|---|
| | 2012 | 2013 | |
| 40000 | 212 | 216 | 214 |
| 50000 | 218 | 219 | 218 |
| 60000 | 220 | 226 | 223 |
| 70000 | 221 | 224 | 222 |
| 80000 | 220 | 225 | 222 |
| 90000 | 223 | 223 | 223 |

In this experiment the plants grew higher in 2013, but excessive precipitation in May and June 2012 reduced grain yield due to disease pressure, particularly corn smut. No difference in germination rates was found between the four planting dates. The best seeding rate with regard to grain yield across years was 60000 but with little difference to 70000 (**Figure 11**). The seeding rate 60000 had highest yield (6.5 t $ha^{-1}$) in 2013 year while the lowest yield (3.2 t $ha^{-1}$) was obtained at the seeding rate 40000 in 2012 year. Maize grain yield significantly affected by seeding rate.

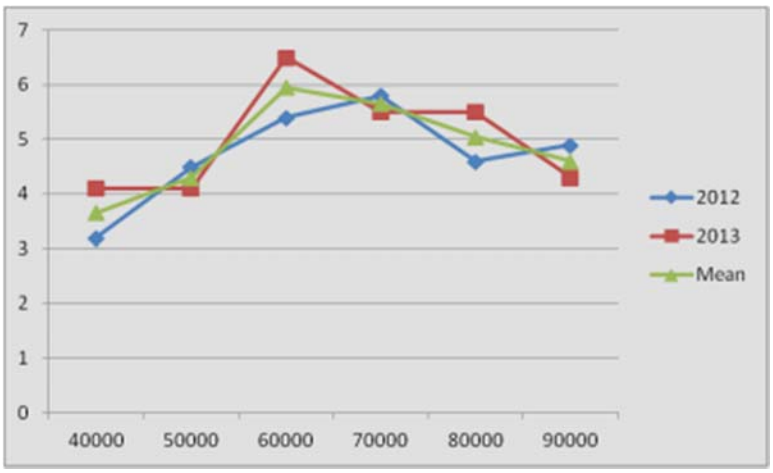



**Figure 11: Effect of seeding rate on productivity of bed planted maize in South Kazakhstan.**

**Conclusion**

In conclusion, 60000 seeding rate had the highest plant height (226 cm) while 40000 seeding rate had the lowest plant height and there was no significant difference between the plant height and seeding rate. It should be mentioned here that the higher seeding rates gave almost similar yields while the low seeding rate frequently reduced grain yield of bed planted maize.

### *3.2.1.1. Effect of planting date on productivity no-till maize in South Kazakhstan province of Kazakhstan.*

**Introduction**

Traditionally, agriculture in south Kazakhstan (SK) is dominated by mid-size and small farms. Agricultural production is based on irrigated farming. A significant part of the cropping area is suffering from water scarcity. Therefore, improving agricultural production in irrigated areas through water-saving technologies is critical for achieving sustainable economic development of the region. Maize grain production is amounted to 462.000 tonnes while total area is 95600 hectares in Kazakhstan (FAO, 2010). The national average maize yield is about 4.6 tons ha-1, while potential exists for increasing the yield to over 8 tons $ha^{-1}$ through increased use of improved hybrids or varieties, fertilizers and good crop husbandry including optimum planting date. Low maize productivity is associated with several constraints, including water shortage during the vegetation period, land degradation, biotic and abiotic stresses, and uncertain planting dates. Successful corn production requires an understanding of the various management practices and environmental conditions affecting crop performance. Planting date, seeding rates, hybrid selection, tillage, fertilization, and pest control all influence corn yield in the irrigated conditions. Olson and Sander (1988) found that crop management practices such planting date, N fertilizer rate, hybrid maturity selection and harvest timing can affect grain yield, moisture and test weight. The keys to developing a successful production system are to recognize and understand the types of interactions that occur among production factors, as well as various yield limiting factors, and to develop management systems that maximize the beneficial aspect of each interaction in the irrigated conditions of South Kazakhstan. Knowledge of corn growth and development is also essential to use cultural practices more efficiently to obtain higher yields and profits. Silantev (1986) reported the positive effect of early planting on maize grain and biomass yield. Early planting generally produces shorter plants with better standability while delayed planting increases the risk of frost damage to corn and may subject the crop to greater injury from various late insect and disease pest problems, such as *Ustilago maydis* and some other diseases in the irrigated conditions of South Kazakhstan (Sydyk et al., 2009). The main objective of this study is to determine optimum planting date in the irrigated conditions of South Kazakhstan province under no-till technology.

**Materials and methods**

Availability of earlier hybrids with shorter plants, lower leaf number, upright leaves, smaller tassels and reduced anthesis silking interval has enhanced the ability of maize to withstand high plant populations without showing excessive barrenness (Sangoi, 2001). Experiments were conducted under irrigated conditions in 2012 and 2013 to determine the optimum combination of planting date to maximize the yield of maize. A randomized complete block design with four replications was established to study yield potential and economics of improved fodder production. Four planting dates (April 15, repeated every 15 days until May 30) were evaluated for maize biomass yield with its agronomic traits. Seed was placed with 6 cm of soil cover in all treatments. Considering the importance of nitrogen (N), phosphorus (P), and potassium (K), recommended fertilizer rate was held constant for all treatments each year and the fertilizer rate was $N_{180}P_{90}K_{60}$. The maize field was irrigated three times during the vegetation period

at the rates 600 $m^3$. Field data for both experiments were collected on seed germination, plant density, plant height, days to maturity, grain and biomass yield. We determined number of plants per $m^{-2}$ at the stage of plant maturity. The experimental data analysis was performed using GenStat program 11th edition.

**Results**

Corn seed begins germination when the seed contains at least 25-30% moisture. Adequate soil moisture is most important feature to get rapid, uniform germination and emergence of maize and help set the stage for maximum grain yield at the end of the season. The data in Table 1 indicated that seed germination of maize was significantly (<.001) affected by years with highest seed germination of 82.6% obtained in farmer 2, when the crop was sown on May 30 in 2009. Lowest seed germination of 64.9 % was noted, in farmer 1, with planting on 15 April in 2008. In our experiment four planting dates showed a relatively small trend of seed germination. The seed germination ranged from 64.9 to 82.6 % across treatments, farms and years. At planting date on 30 May, the seed germination increased up to 27% during the vegetation period. Farms not differed significantly (0.004) for seed germination.

Number of plants per $m^2$ is the most important agronomic trait to determine maize biomass and grain yield. Number of plants was significantly affected by treatment (i.e. planting dates). The highest number of plants per m2 was 9.35 in farm 1 in the treatment where maize was sown on April 30, 2008. The lowest number of plants was recorded (6.55) also in farm 2 where maize was planted on 30 May, 2009. Number of plants per $m^2$ ranged from 6.55 to 9.35 across the years and treatments.

On the basis of our experiment it was found that the maize crop grew the tallest (291 cm) and a high biomass yield when the plant is planted on May 15 (Table 9). The results revealed that plant height is an important variety trait and late sowing date reduced plant height. ANOVA statistics show that there were significant differences in maize plant height within years, treatments and farms (P<0.001). There was also close interaction between year and treatment on maize plant height while there was not interaction between year and farm, farm and treatment.

Table 9: **Seed germination, plant density and height of maize at the experimental in South Kazakhstan**

| Farm | Treatment | Seed germination, % | | | Number of plants, $m^2$ | | | Plant height, cm | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2012 | 2013 | Average | 2012 | 2013 | Average | 2012 | 2013 | Average |
| F1 | 15-Aprl | 77.8 | 64.9 | 71.3 | 8.60 | 7.58 | 8.09 | 230.0 | 283.8 | 257 |
| | 30-Aprl | 72.8 | 69.5 | 71.2 | 9.35 | 8.25 | 8.80 | 238.5 | 284.2 | 261 |
| | 15-May | 74.3 | 66.6 | 70.5 | 8.75 | 7.72 | 8.24 | 257.1 | 325.5 | 291 |
| | 30-May | 78.5 | 65.5 | 72.0 | 7.07 | 7.08 | 7.08 | 242.5 | 237.8 | 240 |
| F2 | 15-Aprl | 74.8 | 74.8 | 74.8 | 8.19 | 8.20 | 8.20 | 210.7 | 260.5 | 236 |
| | 30-Aprl | 70.0 | 78.6 | 74.3 | 8.90 | 8.92 | 8.91 | 218.4 | 269.8 | 244 |
| | 15-May | 71.5 | 71.7 | 71.6 | 8.33 | 8.34 | 8.34 | 235.4 | 311.3 | 273 |
| | 30-May | 75.5 | 82.6 | 79.1 | 7.43 | 6.55 | 6.99 | 222.1 | 244.5 | 233 |
| ANOVA | Year | <.001 | | | 0.083 | | | <.001 | | |
| | Farm | 0.004 | | | 0.715 | | | <.001 | | |
| | Treatment | 0.229 | | | <.001 | | | <.001 | | |

Grain yield is obviously one of the most important factors to determine total production of maize. Results on grain yield (Table 10) revealed that planting date April 30 in farm 1 and farm 2 gave highest grain yield at a density of 8.80 and 8.91 m-2, respectively. The 2012 and 2013 growing conditions for maize in South Kazakhstan were, in general, very favorable with near (2012) and above average (2013)

rainfall. Low climatic and disease pressure resulting in higher grain yields in 2012 compared to 2013. Thomson et al. (2009) reported that excessive rainfall may cause serious injury to a corn crop depending on its stage of development and decrease productivity. Grain yield was lowest for planting date 30 May at a density of 7.08 plants $m^{-2}$. Grain yield was highest with April 30 planting. Yield reduction was associated with planting dates. High yields can thus be obtained by planting date. The results revealed that grain yield was decreased by 2.0 and 0.7 t $ha^{-1}$, with early and late planting.

Decrease of 8 and 40% in grain yield under early and late sowing, respectively might be due to lower nutrient uptake and reduced photosynthetic translocation in the developing grain. It is therefore, evident that April 30 is optimum planting time for maize grain production in South Kazakhstan province. These results are in line with Fakorede (1985) who also reported a decrease of 30-38 kg $ha^{-1}$ in maize grain yield for each day of delayed sowing. Ahmad *et al.* (2001) concluded that delayed sowing decreased shelling percentage, which ultimately resulted in lower grain yield. Highest grain yield with optimum planting time has been reported by Martiniello (1985) and Albus *et al.*(1990). McWilliams (1999) reported positive effect of planting date on maize yield. This is in line with our results. The planting date analysis showed that the best sowing date was April 30, and grain yields of other three dates were relatively lower (Table 10).

Table 10: **Grain yield of maize (2012-2013)**

| Farms | Treatment | Grain Yield, t $ha^{-1}$ | | |
|---|---|---|---|---|
| | | 2012 | 2013 | Mean |
| Farm 1 | 15-Aprl | 4.4 | 3.9 | 4.2 |
| | 30-Aprl | 7.4 | 4.9 | 6.2 |
| | 15-May | 6.0 | 5.0 | 5.5 |
| | 30-May | 5.7 | 4.8 | 5.2 |
| Farm 2 | 15-Aprl | 4.7 | 3.6 | 4.1 |
| | 30-Aprl | 6.8 | 4.6 | 5.7 |
| | 15-May | 5.1 | 4.7 | 4.9 |
| | 30-May | 4.1 | 3.3 | 3.7 |
| ANOVA | Farm | <.001 | | |
| | Year | <.001 | | |
| | T | <.001 | | |

**Conclusion**

On the basis of our experiment it was found that the maize crop grew the tallest (291 cm) and a high biomass yield when the plant is planted on May 15. There were significant differences in maize plant height within years, treatments and farms. There was also close interaction between year and treatment on maize plant height.

It should be mentioned here that the higher seeding rates gave almost similar yields while the low seeding rate frequently reduced grain yield of bed planted maize. In our experiment four planting dates showed a relatively small trend of seed germination. The seed germination ranged from 64.9 to 82.6 % across treatments, farms and years.

Number of plants was significantly affected by treatment i.e. planting dates while year and farm were not significant. Effect of planting date on maize grain yield was significant. Analysis of variance showed that grain yield had significant difference within treatments (<.001) while number of plants within farms

was unrelated to biomass yield. The planting date analysis showed that the best sowing date was April 30, and grain yields of other three dates were relatively lower.
The results of this study proves that planting dates have significant effects on number of plants and grain yield in maize.

### *3.2.2. Crop rotations diversified with crops suitable for conservation agriculture*

#### ***3.2.2.1. The effect of no-till practices on productivity of crops under short-term cereal crop rotation in the irrigated conditions of Southern Kazakhstan.***

**Introduction**

Conservation agriculture practices greatly influence the environment on positive way. Crop rotation is main the principle of CA while short-term cereal-legume crop rotation system is good for farmers and good for the environment as well and also have a great potential to increase agricultural production through implementation of no-till practices. Additionally, short-term crop rotation system can improve soil quality by increasing soil organic matter levels in the upper layers of the soil. Within a crop rotation, different root systems influence different soil horizons and improve the efficiency of the soil nutrient use. In general, the soil structure becomes more stable (Bot and Benites, 2005). Many crops can be used for short-term crop rotation system in the irrigated conditions of South-Kazakhstan province. Several agricultural crops were selected and these are namely wheat, maize, mung bean, field pea and soy bean are used for short-term crop rotation. Wheat crop is the easiest crop to begin conservation agriculture while after wheat harvest succeeding crops can be cultivated.

**Objective**

The objective of the experiment is to explore the possibilities for short-term crop rotation increases in cereal-legume production through implementation of no-till practice and to improve soil fertility in the demo site.

**Materials and Methods**

A short-term cereal-legume crop rotation experiment will be initiated in 2012 at Experimental Station of South-West Kazakhstan Research Institute of Livestock and Crop Production in South-Kazakhstan province. The two crop rotations used in this study were both 2 year in length and included a total of four different crops, winter wheat, winter field pea, maize, mung bean and soy bean. All fields in both rotations are represented each year. The three crop rotations are: 1) WwMbWWM: Winter wheat-mung bean-winter wheat+maize; and 2) WfpMWWSb winter field pea-maize-winter wheat-soy bean. Experimental design was a randomized complete block design with four replicates. Plot area was 20 × 7.2 m and the size was 144 $m^2$. All treatments involved no-till and direct seeding of second crops after winter wheat harvest under stubble mulch.

**Results**

Crop rotation effects were observed for flax, winter and spring wheat (Table 11). The winter wheat grown on the cereal-legume rotation yielded 9.2% more than winter wheat grown on the cereal-legume-maize rotation. Maize grown on winter field pea stubble yielded 18.6 % more than maize growing on spring wheat stubble. Spring wheat yielded more on fallow than stubble with no other significant effects of crop rotation.

Table 11: **The effect of crop rotation on the yield of winter wheat and maize from 2012 to 2013 at South Kazakhstan province**

| Crop rotation | Yield t $ha^{-1}$ |
|---|---|
| | Winter wheat |
| WwMbWwM | 4.12 |
| WwMWwMb | 3.77 |
| | Maize |
| WfpMWwSb | 4.23 |
| WwMWfpSb | 5.18 |

**Conclusions**

The results confirmed the findings from the experiment testing winter wheat and maize yield's depending on preceding crops in South Kazakhstan. The winter wheat and maize provided more yields in cereal-legume crop rotation.

The introduction of cereal-legume crop rotation in the no-till practices could help to improve soil fertility and increase crop productivity. This beneficial aspect of crop rotation should be further investigated in the Central Asian region.

### *3.2.2.2 Effect of planting methods and seeding rates on productivity winter wheat in the irrigated conditions of South-Kazakhstan province*

**Introduction**

The bed-planting technology is growing crops on raised beds and using the beds permanently with consecutive crops which adds to the benefits of zero-till to bed planting and is a more sustainable system (Nurbekov 2008). Most research in the RWC has used beds about 70 cm apart two beds can be made between the two tractor tires. The main benefit of bed planting is water savings. Bed planting would provide the benefits of water saving in systems of surface irrigation. Under CA, the beds would be converted into permanent beds whereas any soil tillage would be limited to a periodic cleaning and reshaping of the furrows. A few researches were done on winter wheat seeding rate under bed planting system in the irrigated conditions of South-Kazakhstan but all research done by locally made bed planter. This is the first research on study effect of seeding rate on productivity of bed planted winter wheat with using new Brazilian no-till drill adjusted to bed planting.

**Study objective**

The objective of this experiment was to test two planting method and four seeding rates of bed planted winter wheat in irrigated conditions and to adopt the bed planting systems to irrigated conditions of South-Kazakhstan.

**Materials and Methods**

This experiment was conducted at the demo site in Sayram district. Randomized Complete Design was used in the experiment. Replications – 4; plot size – 100 $m^2$ (2,5x20) for each treatment and number of farmers – 3. Analysis of variance (ANOVA) used to determine treatments' effect. Soil samples were collected for moisture content and for soil nutrient analysis at the time of sowing and harvesting.

*Treatments:*

1. Wheat planting on conventional (200 kg $ha^{-1}$) – control

2. Wheat planting on beds (100 kg $ha^{-1}$)
3. Wheat planting on beds (120 kg $ha^{-1}$)
4. Wheat planting on beds (140 kg $ha^{-1}$)

Total water consumption was an average of 2400 $m^3$ $ha^{-1}$ and 800 $m^3$ $ha^{-1}$ for conventional and bed planting respectively.

Effect of different type of herbicides on productivity of no-till winter wheat was studied by Nurbekov (2007) in Karakalpakstan, Uzbekistan. The overall weed infestation observed in conventionally tilled wheat with application of Puma Super in spring was essentially equal to that found in no-till wheat with Dafosat applied in the fall followed by spring-applied Puma Super. Some recommendations on herbicide applications to control specific weeds have already been developed for Kazakhstan by Sydyk et al., 2008. In Northern regions of Kazakhstan, during the early growth of wild oats (usually when soils warm up to 10-12°C), it is recommended that herbicide Glyphosate (which has uniform impact) should be applied before planting of cereals. Herbicides could be applied at minimum dose – up to 1.0 l ha-1. Favourable environment, such as mass sprouting of wild oats, cool weather, sufficient soil moisture, provides highly efficient suppression of this weed. Sydyk et al. (2008) report that multi-year research shows that a new generation of systemic herbicides effectively reduces weed infestation of crops (by 82-94%). Before booting stage of winter wheat and at the beginning of development stages of perennial and annual dicotyledon weeds, Dialen Super 480 water solution at the rate of 0.5-0.7 l $ha^{-1}$ was applied.

For effective weed management, the use of a combination of herbicides Dialen Super 480 water solution – 0.7 l $ha^{-1}$ + Topic 080 EC – 0.4 l $ha^{-1}$ was applied. It should be noted that Dialen Super 480 water solution at the rate of 0.6-0.7 l $ha^{-1}$ was very effective against field pea, wild cabbage, bindweed, bur, Russian knapweed and other types of dicotyledon weeds.

The climatic conditions of this Southern Kazakhstan are favorable for the cultivation of various agricultural crops. Annual rainfall in the region is ranged from 350 to 500 mm with more than 66% of it falling in growing season. The soil was light sierozem, nonsaline and with low level of NP and high level of K. Soil is light and medium loam with particle density of 2.67-2.70 g $cm^{-3}$ and bulk density of 1.28-1.40 g $cm^{-3}$. Groundwater level varied from 5.0 to 10 m.

**Results**

The Bed Planting System is compared to Flat Planting System based on conventional and seedbed preparation for seeding winter wheat. Studies have shown that the planting method results in significant increases in grain yield of winter wheat (Table 12).

Water deficiency has remained one of the most important issues in the irrigated crop sector of South Kazakhstan province. The province with its shallow groundwater level and saline soils needs water-saving technologies and efficient irrigation systems for diversified cropping systems. Currently, grain crops such as winter wheat are grown continuously after wheat or winter barley which is a good crop rotation system. In most cases, wheat and barley are irrigated by wild flooding resulting in crop kill due to rise of highly mineralized ground water and soil crusting. Effective alternative approaches can be improved irrigation practices such as bed-planting technology.

Using no-till raised-beds, yields of the cotton-wheat system in Uzbekistan did not differ significantly from that under conventional tillage (Suleymenov et al., 2004; 2006). In the Chu Valley in Kyrgyzstan, yields of irrigated winter wheat varieties ‘Manas’, ‘Intensive’, and ‘Asyl’ were at least equal if not higher than that under no-till raised-bed planting compared to conventional practices from the first year of experimentation (Kienzler et al., 2009b).

The winter wheat grain yield ranged between 3.91-4.54 t $ha^{-1}$. The two year average data showed that bed planted winter with seed rate 120 kg $ha^{-1}$ treatment tended to lead to higher winter wheat yield

compared to control where winter wheat was planted on flats with seeding rate 200 kg $ha^{-1}$. Therefore this technology not only reduces the cost of production by using lower seed rate but also provides higher grain yield, thereby increasing the net income of the farmers. The reason for higher yields of bed planted winter grown is improved water management because irrigated water can be distributed evenly across the beds and also keeping soil moisture longer than flood watering. There are a number of changes which take place in the soil with a true permanent bed system in long run.

Table 12: **Effect of different planting on productivity of winter wheat in South Kazakhstan province (2012)**

| Planting methods | Seed rate kg/ha | Yield, t/ha | Yield, difference, % | Saved water, % |
|---|---|---|---|---|
| Winter wheat planting on flats | 200 | 3.91 | 0.00 | 0 |
| Winter wheat planting on beds | 100 | 4.65 | 118.9 | 35% |
| Winter wheat planting on beds | 120 | 4.74 | 121.2 | 35% |
| Winter wheat planting on beds | 140 | 4.68 | 119.7 | 35% |

**Cost benefit analysis**

Cost-benefit analysis for bed planting of winter wheat shows that lower seeding rates were needed in Kazakhstan. For example, at a seeding rate of 100-120 kg $ha^{-1}$, the highest production cost per ha with plant nutrients applied to bed in early spring at the rate of $N_{60}$ kg $ha^{-1}$ amounts to 866-933 USD. This helps to achieve the highest net operating revenue of about 733 USD and lower the production cost per quintal of grain to about 150 USD.

**Conclusions**

Bed planting system tested in Southern Kazakhstan reduced seed rates by almost half and provided higher winter wheat yields. At the same time, effective weed management appeared to be critical for the success of this technology.

There were some on-farm research in the country has shown that bed planted crops have yielded better and consumed less irrigation water (about 40%) with lower seed rate, soil tillage and fuel expenses than flood irrigated crops. The soil is improved, especially on the top of the beds. Bed planting combined with reduced/zero tillage technologies looks promising to improve farming profitability, introduce better diversified rotations, reduce the turn-around period between harvesting and planting of the following crop to a minimum with a goal to produce two and more crops per year.

Benefits of planting winter wheat on beds in irrigated systems in terms of yield and water savings from project demonstration site were significantly and ranged from 24-32%. Irrigation farmers must realize that seed rate decrease will be essential if they attempt to adopt permanent bed planting systems even though their primary goal may be simply to realize lower production costs.

### *3.2.2.3. Effect of tillage on productivity of maize in irrigated conditions of South-Kazakhstan province*

**Introduction**

No-till has certain advantages, as it prevents soil erosion, reduces water loss and decreases crop cultivation costs in comparison with conventional soil tillage with a plough. Under no-till system soil biota can build and maintain soil pore networks. Since the soil is never tilled the soil structure changes. A system of continuous macro pores is established, facilitating water infiltration and aeration of the soil

as well as root penetration into deeper zones. Soil organic matter contents increases with higher values near the surface, gradually declining at increases depth. Soil macro- and micro- fauna and flora is re-established resulting in better soil fertility. In this study, different methods of soil preparation included the conventional method of the region with keeping the vegetative remains in the field with plowing and tillage and without plowing or tillage, was investigated.

**Study objective**

The objective of this experiment is to see effect of different tillage on productivity of winter wheat in South-Kazakhstan province.

**Materials and Methods**

The experiment conducted in 2012-2013 at project demonstration sites. The experiment was laid out in randomized complete block design with four replicates. Plot size was 200 $m^2$ (25x8 m).

*Treatment*

1. Control – Conventional tillage (CT)
2. Minimum till (MT)
3. No-till (NT)

Preceding crop was alfalfa. Dialen-Super 480 herbicide was used in maize production. Pre-sowing irrigation was carried-out at a low rate of 350-450 $m^3$ $ha^{-1}$, after previous crop harvest. For rational use of irrigation water on different types of soil in the south of Kazakhstan in no-till maize production soil moisture kept at the level of 70-80% of field capacity during the growing season. Maize harvesting is carried out at the milky-waxy grain ripeness stage.

**Results**

The benefits of tillage on maize green forage productivity in irrigated systems of the project demonstration site are given in Figure 7. According to the results obtained from the demonstration site no-till improves green forage yields, and saves agricultural inputs. Agricultural inputs saving, as indicated, were significant across treatments, which is a critical issue in the irrigated conditions of South Kazakhstan.

Touchton and Jonson (1982) conducted an experiment on the effect of 3 different methods of tillage and plantation on the yield of wheat and soybean. The 3 tillage methods included chisel, Moldboard plow and no tillage. The results were that the yield of soybean in the 2 mentioned tillage methods didn't differ, but yield of wheat in case of Plow with Chisel Plow was less than Moldboard plow.

Tanaka's findings (1989) on the comparison of the yield of pea while using different tillage treatments including no tillage, reduced tillage and conventional tillage (Moldboard Plow) support the obtained results in the present study as it was indicated in their study that the yield difference for the mentioned tillage treatments was not significant and even no tillage showed a better yield trend.

Green forage yields of maize ranged from 44.3 t $ha^{-1}$ to 50.0 t $ha^{-1}$. The yields for no-till and conventional till were significantly higher than for minimum till in both years (Figure 12). Finally, our results emphasize the necessity of taking into account the NT method in the cultivation of maize in the

irrigated conditions of South Kazakhstan to stabilize maize production in the region. The results show that no-till practices are feasible for the production of maize green biomass yield.

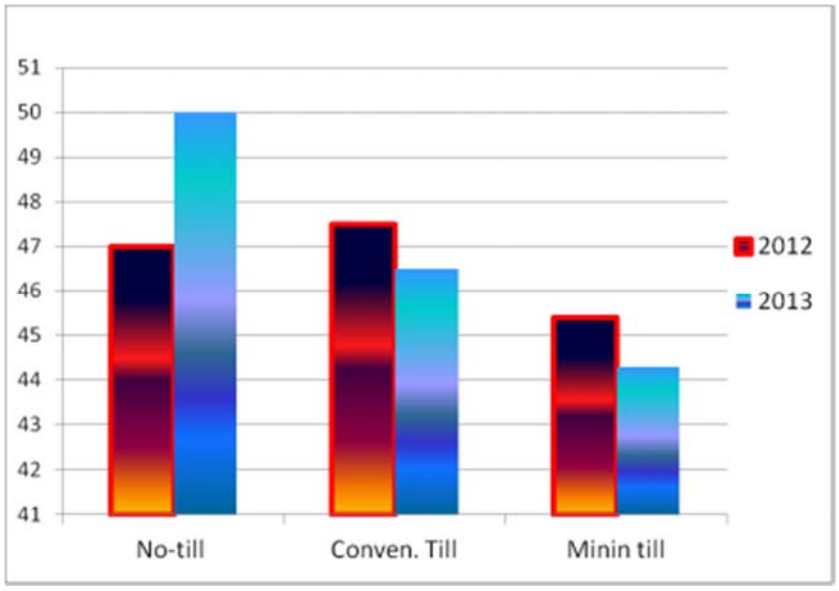



Figure 12: Maize green biomass yield affected by tillage method, t $ha^{-1}$, (Kazakhstan) 2012-2013.

**Cost benefit analysis**

Economic information on no-till maize cultivation is not readily available for Central Asian countries. So in this case, recent introduction of new technology such as the no-till system offers an opportunity to increase farmers' income. No-till is significantly more profitable and efficient than conventional till practices for growing maize in Southern Kazakhstan. With the expected continuation in the rise of fuel prices, the relative profitability of direct seeding compared to traditional practice will only increase over time. No-till cultivation of the maize have provided savings for the producer, with a greater benefit also recorded for minimum till due to the less total production cost. Consultations with the farmers involved in these trials showed that farmers would be willing to introduce no-till practices in their fields. The net benefit from no-till (NT) and minimum till (MT) was US$ 736.5 ha-1 and US$ 641.9 respectively, which was 123.7 % and 107.8 % higher than conventional till (CT) US$ 595.3 ha-1. The benefit-cost ratio varied from 45.9% in CT to 57.3 in NT (

Table 13). Passage from conventional till to direct seeding in Southern Kazakhstan is not a fancy caprice, but it is the only possible way for agricultural survival in the current fuel price context. These results show that introduction of CA as a no-till maize forage crop will help livestock producers to have access to low-cost forage resources and thus improve the efficiency of livestock production in Kazakhstan, and perhaps in other Central Asian countries as well.

**Conclusions**

Maize green forage yield was higher in the treatment involving the no-till method compared to the other treatments. Further investigations of the effect of NT are needed to assess its effects in the longer term, specifically to monitor long-term effect of CA.
These results show that introduction of conservation agriculture as a no-till maize forage crop will help livestock producers to have access to low-cost forage resources and thus improve the efficiency of livestock production in Kazakhstan, and perhaps in other Central Asian countries as well.

Table 13: Benefit-cost ratio for forage production from no-till and conventional maize in Kazakhstan

| Treatments | Green mass yield, t $ha^{-1}$ | Total production cost, US \$ $ha^{-1}$ | Total income | Net benefit US \$ $ha^{-1}$ | Benefit-cost ratio |
|---|---|---|---|---|---|
| NT | 48.5 | 548.6 | 1285.1 | 736.5 | 57.3 |
| CT | 47 | 701.4 | 1296.6 | 595.3 | 45.9 |
| MT | 44.8 | 647.3 | 1289.2 | 641.9 | 49.7 |

### *3.2.3. Raised-bed planting and land leveling technology adjusted and applied and lower and more efficient water utilization for the crop rotations introduced, as compared to traditional cropping systems*

#### ***3.2.3.1. Effect of different irrigation rates on productivity of winter wheat in irrigated conditions of South Kazakhstan.***

**Introduction**
In some articles that are published in foreign countries have given some recommendations for using progressive technology with water saving furrow irrigation technology or raised bed technology. Bed planting systems have been used in cultivation for centuries. Raised bed cultivation has traditionally been associated with water management issues either by providing opportunities to reduce the impact of excess water in rainfed conditions or to more efficiently deliver irrigation water in high production irrigated systems (Cutforth and Selles, 1992).
With the dismantling of centralized management of irrigation system in Kazakhstan at farm level, the farmers in South Kazakhstan province were confronted with the challenge of maintaining local irrigation facilities on their own. Taking into account often inadequate financial capacities of farmers in the region, this task remains insurmountable for most farmers. From the other side, the growing water deficit in the region has not spared Kazakhstan, either. Hence the need for a wide dissemination of water saving irrigation technologies, such as furrow irrigation or alternate furrow irrigation instead of the traditional irrigation methods, whose water consumption levels are not sustainable. One of the key factors in obtaining high and stable maize yields, Southern Kazakhstan which is characterized by hot and dry summers, is maintaining the optimal water-air regime of soil during the growing period. However, when irrigation water is not sufficiently available during the most critical periods of plant life, a sharp decrease of grain yield is likely. Therefore, the timing and irrigation rates of that crop must be set strictly in line with the need of the plant, taking into account the biological characteristics of the cultivated varieties of winter wheat.

**Study objective**
To study the effect of improved irrigation technologies on winter wheat yield in the irrigated conditions of South Kazakhstan province through conservation agriculture technologies.

**Materials and Methods**
Maize crop is irrigated using all applicable methods in irrigated agriculture including permanent raised beds. Surface watering is widespread. Furrow irrigation, on permanent raised beds, is the new method of surface irrigation. This experiment was conducted at the demo site in Sayram district, South Kazakhstan. Randomized Complete Block Design was used in the experiment. Replications – 4; plot size - 1 hectare for each treatment and number of farmers – 3. There were six treatments in this experiment and these are as follows: Float irrigation (1200 ha $m^3$), Furrow irrigation (800 ha $m^3$), Float irrigation (1600 ha $m^3$), Furrow irrigation (1200 ha $m^3$), Float irrigation (2000 ha $m^3$) and Furrow irrigation (1600 ha $m^3$).
Standard agronomic practices and fertilizer doses applied for the crops. Analysis of variance (ANOVA) was used to determine treatments' effect. Soil samples collected for moisture content and for soil nutrient analysis at the time of sowing and harvesting.

**Results**
The most crucial period in ensuring the availability of water for maize plant - is the period 10-15 days before panicle initiation and ending 20 days after flowering just prior to the milk stage of maturity. Water consumption usually reaches its maximum value in this period and amounts to nearly 50% of the water requirement for the entire growing season.
Therefore, irrigation during the vegetative growth must be timed to this vital and critical period of maize development. The highest grain and green mass yields with irrigated agriculture are obtained by ensuring persistently high soil moisture, and if the moisture in the root zone (0.6-0.8 m) does not fall below 70% of field capacity in the period from planting to emergence and formation of 13-14 leaves and below 80% in the period from 13-14 leaves to grain filling.
The experiments in 2013 at the project demo in Sayram district confirmed that furrow irrigation at 1800 ha $m^3$, is more profitable than conventional float irrigation for planting maize on raised beds in 2012, because under furrow irrigation the yields of maize are in average 75.78% higher than under flood irrigation and also saves considerable water up to 30 %, while the input costs are basically the same. To sum it up, the experiments conducted in 2012 and 2013 left no doubt that the furrow irrigation at 1800, and 2200 $m^{-3}$ $ha^{-1}$ with raised bed planting are more efficient than conventional furrow irrigation with bed planting because they allow getting more output using less input (Table 14). Table 14 also highlights one of the main advantages of furrow irrigation as compared to conventional float irrigation, which is higher water productivity.

**Conclusions**
This experiment confirmed the relationship between grain yield of maize and the irrigation rate. Furrow irrigation at 1800 and 2200 $m^3$ $ha^{-1}$, is more profitable than conventional float irrigation for planting maize on raised beds. At these rates of furrow irrigation, the yields of maize were higher than under float irrigation and also saves considerable water up to 30 %, while the input costs are basically the same. Conclusions of this experiment shows that the experiment conducted in 2012 and 2013 left no doubt that the furrow irrigation at 1800, and 2200 $m^{-3}$ $ha^{-1}$ with raised bed planting are more efficient than conventional furrow irrigation with bed planting.

Table 14: **Yield difference float and furrow irrigation in Sayram site in South Kazakhstan (2012-2013)**

| Yield | Irrigation rate | 2012 | 2013 |
|---|---|---|---|
| Yield, t $ha^{-1}$ | FI* 2400 ha $m^{-3}$ | 3.22 | 4.84 |
| | FuI** 1800 ha $m^{-3}$ | 5.66 | 5.23 |
| Yield +- % | | 175.78 | 108.06 |
| Yield, t $ha^{-1}$ | FI 2600 ha $m^{-3}$ | 5.59 | 4.97 |
| | FuI 2200 ha $m^{-3}$ | 5.91 | 6.14 |
| Yield +- % | | 105.72 | 123.54 |
| Yield, t $ha^{-1}$ | FI 3000 ha $m^{-3}$ | 4.82 | 5.11 |
| | FuI 2600 ha $m^{-3}$ | 4.21 | 5.78 |
| Yield +- % | | 87.34 | 99.41 |

*FI - Float irrigation
** FuI - Furrow irrigation

*Adoption of farmers*
The best irrigate rate and improved water management technology were identified and were recommended. The bed planting technology can be introduced to the farms of the country.

## 3.3. Field activities in Uzbekistan

### *3.3.1. Improved crop production and management through accelerated adoption of conservation agricultural practices*

#### ***3.3.1.1. Effect of seeding rate on productivity of bed planted maize in the irrigated conditions of Kashkadarya***

**Introduction**
Maize (*Zea mays*) is a second important cereal crop after winter wheat in the irrigated conditions of Uzbekistan and is a dual propose crop. Corn yield potential per plant has not increased over the past 50 years, but the amount of yield per hectare has increased. A significant portion of the observed yield increase per year is directly correlated with increased plant populations (Abendroth and Elmore, 2007). In Uzbekistan, there are a lot investigations were done by different researchers on corn cultivation in the conventional till system and but there is no any research was done on bed planting or resource saving technologies in agriculture. For the first time effect of seeding rate on productivity of permanent bed planted maize was studied in this experiment in irrigated conditions of Kashkadarya province.

**Study objective**
Study effect of different seeding rates on productivity of bed planted maize

**Materials and Methods**

Maize hybrid Uzbekistan-601 planted in spring as a main crop at different planting rates. Seven different seeding rates of permanent bed planted maize were evaluated to determine grain yield. The seeding rates are as follows 40000 through 100000 live seeds $ha^{-1}$. The experiment was conducted at irrigated site in a farm. Plot size was 100 $m^2$ (3.6x28 m). Four replications and the experiment used a Randomized Complete Block Design (RCDB). Total area is 2800 $m^2$.

**Results**

Maize usually is a tall, warm season, annual plant. We tested seven different seeding rates of permanent bed planted maize after winter wheat as double cropping. Maize height fluctuated between 222-280 cm. The significant differences were observed for plant height across the treatments of this experiment (Table 15). The highest (280 cm) plant height of maize was observed with treatment 60000 live seeds per hectare followed by the treatment 70000 live seeds (267) in 2012 and the treatment 40000 live seeds attained minimum plant height (222 cm) in 2013. It should be mentioned here that treatments with 60000 and 70000 live seeds had taller than other treatments and performed excellent for grain yield potential.

The treatment with 60000 live seeds significantly out yielded across two years (7.83 t $ha^{-1}$) all other treatments in grain yield. 70000 live seeds (7.78 t $ha^{-1}$) ranked second followed by 80000 live seeds (7.13 t $ha^{-1}$). The treatment 40000 live seeds produced the lowest (3.92 t $ha^{-1}$).

Table 15: **Effect of seeding rate on plant height and productivity permanent bed planted in Qarshi, Uzbekistan (2012-2013)**

| Seeding rate | Plant height, cm | | | Grain yield, t $ha^{-1}$ | | |
|---|---|---|---|---|---|---|
| | 2012 | 2013 | Mean, cm | 2012 | 2013 | Mean |
| 40000 | 253 | 222 | 237 | 3.95 | 3.89 | 3.92 |
| 50000 | 238 | 267 | 252 | 4.72 | 7.14 | 5.93 |
| 60000 | 280 | 273 | 276 | 6.96 | 8.71 | 7.83 |
| 70000 | 267 | 258 | 262 | 6.81 | 8.76 | 7.78 |
| 80000 | 261 | 258 | 259 | 6.22 | 8.05 | 7.13 |
| 90000 | 259 | 239 | 249 | 5.75 | 7.41 | 6.58 |
| 100000 | 250 | 231 | 240 | 4.31 | 4.13 | 4.22 |

**Conclusions**

As results of the experiments it is concluded that treatments with 60000 and 70000 live seeds had taller plants than other treatments and performed excellent for grain yield potential.

Across the two years grain yield production of treatments 60000 and 70000 live seeds were higher than rest of the treatments. On the basis of the performance, 60000 and 70000 live seeds can be considered as best seeding rates for permanent bed planted maize cultivation in the irrigated conditions of Uzbekistan.

### *3.3.1.2. Winter wheat yield as affected by planting method and nitrogen rates*

**Introduction**

Nutrient deficiency at any time during a wheat plant's life will reduce yield, but if the nitrogen deficiency occurs during its rapid vegetative growth phase and at the beginning of the booting stage,

yield losses may be severe. Thus, the primary goal of timing fertilizer application is to ensure that fertilizer is sufficient at the time of application.

**Materials and methods**

In order to optimize nutrient uptake when cultivating winter wheat, it is important to apply rational rates of phosphorous fertilizers at the rate of $P_{90}$ kg $ha^{-1}$ of active substance at the time of seeding. Bed planting with winter wheat provides high grain yield, when fertilizer application is managed efficiently. Five nitrogen rates were evaluated in this experiment and these were as follows: 1. Conventional planting with N 120; 2. Bed planting N 160; 3. Bed planting N 180; 4. Bed planting N 220; 5. Bed planting N 220. Nitrogen was managed for intensive production with 1/3 of the N applied at tillering stage and the remainder at jointing stage. The experimental design for each experiment was a randomized complete block with four replications. Plot size was 200 $m^2$ (25x8 m). Data analysis was performed using the GenStat program. Preceding crop was cotton on both years. In the demonstration sites, nitrogen was managed for intensive production with 1/3 of the N applied at tillering stage and the remainder at jointing stage.

**Results**

Kurvantaev *et al*. (2004) reported results from raised bed system trials involving planting on preformed raised beds, with and without tillage, in Tashkent region. Tillage treatments were combined with maximum (250:175:125) and minimum (150:125:50) NPK fertilizer rates. Direct drilling on beds with maximum fertilizer rates resulted in higher yields (3.89 t $ha^{-1}$) compared to that under beds with tillage preparations and maximum fertilizer rates (3.65 t $ha^{-1}$). Minimum fertilizer rates on direct drilled beds yielded 3.45 t $ha^{-1}$ of cotton, whereas under tilled beds the yield was 3.33 t $ha^{-1}$. Research conducted in 2002-2004 demonstrated that permanent beds can be implemented without yield penalty in the initial years of switching to no-till Kurvantaev *et al*. (2004).

The increased fertilizer rates produced the greatest yield response. Most of the grain yield response was due to treatment bed planting+nitrogen (BP N) 180 $kgha^{-1}$ which produced an additional yield increase that was statistically significant across the four years. The highest yield (7.54 t $ha^{-1}$) was recorded in the treatment where nitrogen rate was 180 kg $ha^{-1}$ while the lowest yield was recorded (5.88 t $ha^{-1}$) in the treatment where nitrogen rate was 160 kg $ha^{-1}$ (Figure 13) while in the conventional planting (CP N) winter wheat yield was 6.0 t $ha^{-1}$. The two-year average data showed that bed planting with nitrogen 180 kg $ha^{-1}$ application treatments tended to lead to higher winter wheat yield.

**Conclusions**

The two-year average data showed that bed planting with nitrogen 180 kg $ha^{-1}$ application treatments tended to lead to higher winter wheat yield. Above stated findings shows that fertilizer use efficiency will be increased under bed planting in the region.

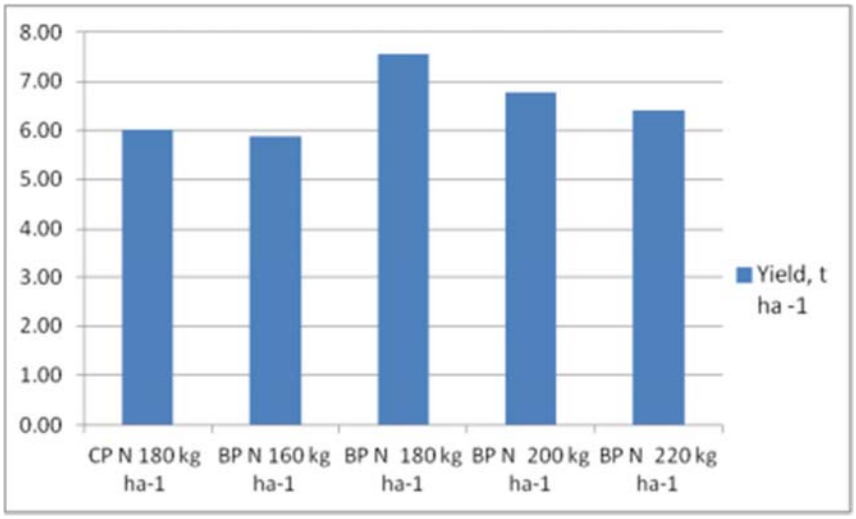



Figure 13: Winter wheat yield as affected by planting method and nitrogen rates (2012-2013)

### *3.3.1.3. Effect of rhizobial inoculation on productivity of bed planted soybean in soils of the Kashkadarya province of Uzbekistan.*

**Introduction**

Central Asia is the region of origin for soy bean (*Glycine max (L) Merrill*). The crop is the oldest cultivated crop not only in Uzbekistan but one of the world's oldest cultivated crops. It has been given recent prominence because of its broad utility and versatility for both human and animal nutrition, soil fertility, industrial usefulness, and geographical adaptability. Despite the above-mentioned characters and its ability to grow well with no added Nitrogen fertilizer, soybean cultivation in Uzbekistan has not been substantial and the crop is not widely grown in Uzbekistan because cotton and winter wheat are strategic crops. However, demand is growing.

**Study objective**

To study effect of Rhizobium with combination of Potassium and Phosphorus on productivity bed planted soybean in irrigated conditions of Kashkadarya province.

**Materials and Methods**

The Soybean variety Uzbek-6 was planted on eight different treatments using the bed planting method. Treatments applied in this experiment were a control that received no K or P fertilization (Control) and *Rhizobium*, second and third treatments received K 60 and P 120 (K 60 and P 120) and no *Rhizobium*, while remaining treatments received *Rhizobium* and P and K fertilizers combined: *Rhizobium* +K60, *Rhizobium* +P120, *Rhizobium* K60+P120. Soybean following the first corn crop was not fertilized. The experiment will be conducted at irrigated site in a farm. Plot size is 100 m2 (3,6x28 m). Four replications and the experiment will use a RCDB. Total area was 2800 $m^2$. Plant height, growth, and grain yield were observed during the vegetation period.

**Results**

The maximum plant height (104.8 cm) was observed in the treatment where *Rizobium*+K60+P120 was applied while the lowest plant height (82.3 cm) was observed in the control variant. Soybean grain yield

varied among the treatments. The same trend was observed in grain yield. This shows that soy bean grain yield increased with *Rizobium*+Fertilizer applications through-out experiment. Effect of *Rizobium* in different fertilizer rates: *Rizobium* application increased grain yield significantly; it should be mentioned here that the *Rizobium* application rate of enhancement was stable and steady increased across the treatments 0.20, 0.32, 0.42, and 0.28, 0.44, 0.54, 0.66 and respectively with and without *Rizobium* application, Statistical analysis shows that soy bean yield was significantly affected by treatments (<.001) and also there was a significant effect on plant height between the treatments. The eighth treatment (Control+ *Rizobium* K60+P120) received the highest grain yield 2.23 t $ha^{-1}$ and the control treatment got the lowest grain yield 1.62 t $ha^{-1}$ (Table 16).

Table 16: **Plant height and Grain yield of bed planted soy bean affected by different fertilization rate and Rhizobium (2011-2012)**

| Treatments | Plant height, cm | Grain yield, t $ha^{-1}$ | Yield difference, t $ha^{-1}$ |
|---|---|---|---|
| Control | 82.3 | 1.67 | 0 |
| Control+K60 | 88.8 | 1.97 | 0.20 |
| Control+P120 | 92.9 | 1.99 | 0.32 |
| Control+K60+P120 | 95.6 | 2.09 | 0.42 |
| Control+ Rizobium | 91.5 | 1.95 | 0.28 |
| Control+ Rizobium +K60 | 95.5 | 2.11 | 0.44 |
| Control+ Rizobium +P120 | 99.2 | 2.21 | 0.54 |
| Control+ Rizobium+ K60+P120 | 104.8 | 2.33 | 0.66 |
| T | <.001 | <.001 | |

**Conclusions**

Significant findings of this study were; soy bean was appeared high response to *Rizobium* application at all treatments, especially Control+ Rizobium+ K60+P120 then; the response was lowest in treatments where *Rizobium* was not applied.

## *3.3.2. Crop rotations diversified with crops suitable for conservation agriculture*

### *3.3.2.1. Effect of tillage on productivity of winter wheat in irrigated conditions of Kashkadarya province*

**Introduction**

No-till, including direct seeding practices that leave plant material of the previous crop on the soil surface, assists to control soil erosion and conserve our soil resource indefinitely as the residue mulch protects the soil surface from high winds and rainfall and prevents loosening and carrying away of soil elements. Thus, plant nutrients and soil organic matter remain in the field. Soil changes its structure in no-till system: macro pores, established in no-till system, facilitates water infiltration and aeration of the soil as well as root penetration into deeper zones; soil organic matter contents increases near the surface, gradually declining as depth increases; and soil macro- and micro- fauna and flora are re-established. Under reduced tillage and direct seeding systems soil biota can build and maintain soil pore networks. Conservation Agriculture is good for farmers and -the environment. Conservation Agriculture systems have a great potential for increasing agricultural production in the project countries at the same time to

maintain soil health and fertility. Wheat is the easiest crop to initiate CA while after wheat harvest succeeding crops can be grown under the no-till system.

**Study objective**

The objective of this experiment is to see the effect of different tillage on productivity of winter wheat growth and development in the Kashkadarya province.

**Materials and Methods**

Newly released winter wheat variety will be planted by using no-till planter in Azamat Ismatov's farm in Karshi district. The experiment was laid out in randomized complete block design. Plot size was 200 $m^2$ (25x8 m).

a) Factors: Seed rate

1) 4 mln live seeds

2) 5 mln live seeds

3) 6 mln live seeds

в) Factors: tillage methods

1) Conventional till (CT)

2) Minimum till (MT)

3) No-till (NT)

**Results**

Several experiments were conducted in the project countries with wheat-based cropping system. Effect of different tillage methods and seed rate on productivity of winter wheat were studied in these experiments. Nurbekov (2007) reported that the rate of nitrogen had no significant effect on the winter wheat yields in either of the two tillage systems, no-till and conventional. The 120 kg $ha^{-1}$ rate was as good as the 140 kg $ha^{-1}$ in traditional tillage with mouldboard ploughs, while no-till slightly increased grain yield with higher nitrogen rate. Nurbekov et al. (2012) reported that winter wheat yield was higher in the treatment involving the no-till compared to other treatments.The winter of 2012 was unfavorable for the growth and development of winter wheat and colder than usual and with heavy snow cover during the season and with daily temperature down to – 25°C. It negatively affected the productivity of winter wheat in the entire experiment and, as a result, yield was lower compared to that observed in 2013 (Table 17). Winter wheat productivity was higher in the treatment with no-till method compared to the other treatments. The absolute highest grain yield of 6.71 t $ha^{-1}$ was recorded in the no-till treatment in 2013 with 5 mln live seeds while in conventional tillage the maximum yield was 6.54 t $ha^{-1}$ also with 5 mln live seeds. No-till winter wheat results in an increase in crop production and higher grain yield as compared to conventional and minimum till.

Winter wheat yield under no-till system was numerically higher than conventional till practice (Table 17). This can be explained as the evaporative losses of water from no-till plots are lower than that of conventional till and with reduced evaporation, the accumulation of salts in root zone decreased that facilitates in proliferation of roots and in turn greater yields. In long-run, no-till practice with retention of crop residues helps in lowering down the salinity levels due to combined effects of reduced evaporation and recycling of organic matter.

Table 17**: Effect of different tillage methods and seed rate on winter wheat yield, t ha$^{-1}$**

| Tillage method | 4 mln live seeds | | 5 mln live seeds | | 6 mln live seeds | |
|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| CT | 6.04 | 6.08 | 6.36 | 6.54 | 6.20 | 6.13 |
| MT | 4.19 | 4.69 | 4.46 | 4.90 | 4.73 | 5.45 |
| NT | 5.85 | 5.40 | 6.30 | 6.71 | 6.65 | 6.41 |
| Tillage | | | | | | <.001 |

The reason for higher yields of no-till wheat is not clear at this time. There are a number of changes which take place in the soil with a true no-till system. It is felt that these changes would alter the amount of water available to the plant. To better understand this, the amount of water in the top 25 cm of soil was monitored in the no-till wheat during the late-vegetative stages of growth. The results presented in the following figure showed that significantly more water was found at each date of sampling in the no-till treatment. However, the moisture declined in the no-till treatment at a slower rate indicating that the moisture was more efficiently used in the no-till treatment (Figure 14).

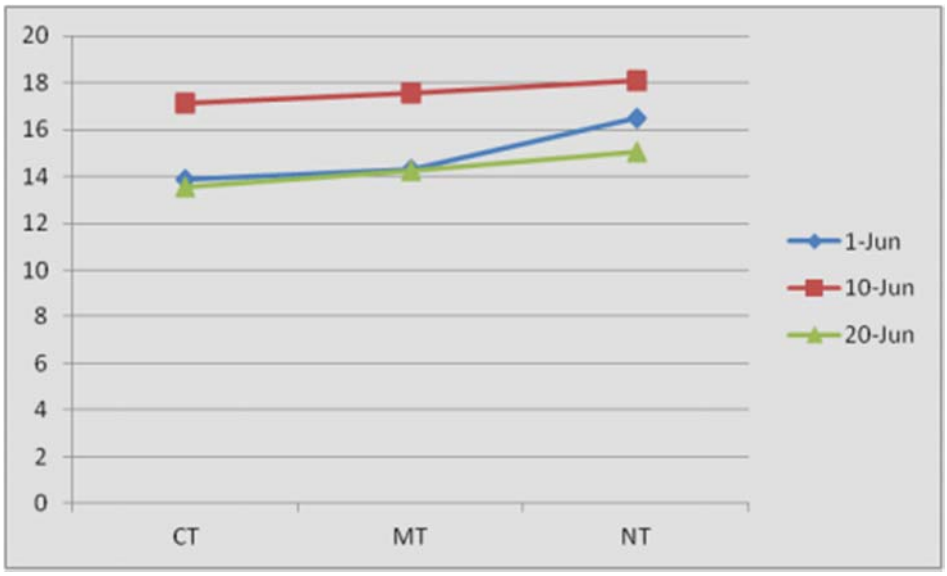



Figure 14: Soil moisture in the top soil with no-till wheat in the late-vegetative stage of growth (2012-2013)

**Conclusions**
No-till winter wheat results in an increase in crop production and higher grain yield as compared to conventional and minimum till.
The results also indicate that retention of crop residues may be essential to ensure the required enrichment of critical levels of the chemical, physical and biological soil parameters that are crucial to ensure and achieve sustainable long-term production. Farmers must clearly realize that some residue retention will be essential before they attempt to adopt permanent raised-bed planting systems even though the primary goal may be to simply realize lower production costs which are common with tillage reductions.

*Adoption by farmers*
Three till methods was assessed and was recommended to be adopted in Southern part of Uzbekistan and introduced to the farms of the country. Economic impact of the conventional and no-till practice will be further assessed.

### *3.3.2.2. The effects of short-term cereal crop rotation on productivity of crops under no-till practices in the irrigated conditions of Kashkadarya*

**Introduction**
Crop rotation is an integral part of the crop production system. The greatest benefit to a good crop rotation is increased yields and soil fertility. A well-planned crop rotation will help in insect and disease control and will aid in maintaining or improving soil structure and organic matter levels. Using a variety of crops can reduce weed pressures, spread the workload, protect against soil erosion and reduce risk. Legume crops in the rotation have become more valuable with the increased cost of nitrogen. Research and experience have proved that a good crop rotation will provide more consistent yields, build soil structure and increase profit potential. A well-planned crop-rotation system can help producers avoid many of the problems associated with conservation till, such as increased soil compaction, perennial weeds, plant diseases, insects and etc. The yield benefits of crop rotations are often overlooked if you choose right preceding crop taking into account above mentioned problems then you can get good more yield than continuous crop on the same farm. In this respect legume crops will be best preceding crop to any cereals. Crop rotations for this research were developed taking into account also farmers' interest and marketability of the selected agricultural crops of the project throughout the project countries.

**Study objective**
The objective of the experiment is to explore the possibilities for short-term increases in cereal-legume production through implementation of no-till practice.

**Materials and Methods**
Three 3-year crop rotations were included in the study. All fields in all rotations are represented each year. The three crop rotations are:

1. WwCrWw: Winter wheat-corn-winter wheat-
2. WwSBWwMb: Winter wheat- Soy bean-Winter wheat-Mung bean
3. WwSfWwSS: Winter wheat-sunflower-Winter wheat-sesame

**Experimental design**

Experimental design is a randomized complete block with four replicates. Main plots are composed of the crop rotation treatments and measure approximately 20 × 7.2 m.

**Results**

Improving soil physical and chemical properties is important for both conventional and CA production, but improving biological properties is particularly important for CA as the biological environment of soil is greatly modified by type and degree of tillage.

Table 18: **Soil chemical parameters in the different crops under no-till system, Karshi, Uzbekistan (2011-2013)**

| Soil parameters | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0-10 cm | 10-20 cm | 20-30 cm | 30-40 cm | 40-50 cm | 50-60 cm |
| Corn | | | | | | | |
| Humus, % | 2011 | 0.670 | 0.767 | 0.670 | 0.767 | 0.603 | 0.547 |
| | 2013 | 0.683 | 0.787 | 0.677 | 0.780 | 0.587 | 0.547 |
| N-NO3, mg $kg^{-1}$ | 2011 | 22.90 | 21.90 | 21.47 | 18.53 | 17.90 | 15.77 |
| | 2013 | 23.23 | 22.23 | 21.60 | 18.77 | 17.90 | 15.73 |
| P2O5, mg $kg^{-1}$ | 2011 | 30.44 | 26.57 | 21.42 | 16.71 | 16.00 | 16.62 |
| | 2013 | 30.91 | 26.73 | 21.98 | 16.98 | 16.14 | 16.85 |
| K2O3, mg $kg^{-1}$ | 2011 | 118.7 | 96.0 | 138.7 | 157.7 | 196.0 | 126.0 |
| | 2013 | 122.0 | 100.3 | 139.7 | 164.7 | 201.3 | 129.3 |
| Winter wheat | | | | | | | |
| Humus, % | 2011 | 0.737 | 1.047 | 0.967 | 0.797 | 0.730 | 0.767 |
| | 2013 | 0.740 | 1.060 | 0.963 | 0.800 | 0.723 | 0.763 |
| N-NO3, mg $kg^{-1}$ | 2011 | 24.50 | 20.07 | 21.10 | 19.10 | 19.23 | 19.17 |
| | 2013 | 24.57 | 20.24 | 21.10 | 19.13 | 18.83 | 18.99 |
| P2O5, mg $kg^{-1}$ | 2011 | 26.4 | 16.66 | 13.20 | 9.38 | 8.49 | 7.56 |
| | 2013 | 26.6 | 16.96 | 13.11 | 9.57 | 8.51 | 7.29 |
| K2O3, mg $kg^{-1}$ | 2011 | 100.0 | 136.3 | 177.0 | 100.3 | 168.0 | 145.3 |
| | 2013 | 101.3 | 138.0 | 175.7 | 100.7 | 168.3 | 144.0 |
| Soybean | | | | | | | |
| Humus, % | 2011 | 0.837 | 0.940 | 1.063 | 0.973 | 0.88 | 0.927 |
| | 2013 | 0.863 | 0.950 | 1.070 | 0.963 | 0.88 | 0.960 |
| N-NO3, mg $kg^{-1}$ | 2011 | 22.57 | 21.07 | 19.80 | 19.87 | 17.57 | 15.87 |
| | 2013 | 22.84 | 21.23 | 20.07 | 19.77 | 17.70 | 16.00 |
| P2O5, mg $kg^{-1}$ | 2011 | 26.89 | 19.82 | 15.82 | 12.31 | 9.87 | 9.20 |
| | 2013 | 27.13 | 20.11 | 15.98 | 12.41 | 10.00 | 9.27 |
| K2O3, mg $kg^{-1}$ | 2011 | 132.7 | 138.7 | 188.7 | 206.0 | 103.0 | 108.7 |
| | 2013 | 135.7 | 140.3 | 189.0 | 205.3 | 102.3 | 109.3 |

Humus content was a little higher with no-till corn, winter wheat and soybean in the 0-10 cm depth while in lower depth 50-60 cm, in Uzbekistan, Table 3. This is explained by well-known fact of differentiation of soil fertility as a result of conservation tillage when soil is not turned up. Overall two years research shows that the no-till treatment had significantly more organic matter. There is general agreement that reduced tillage can increase soil organic matter. There were also differences in the nitrogen, phosphorus and potassium soil tests between the initial year 2011 and last year 2013. Nitrogen, phosphor and potassium content in the soil within different crops also slightly increased with no-till corn, winter wheat and soybean in the 0-10 cm (Table 18) while in the lower depths the content was similar or slightly lower in the some treatments. This shows that retention of crop residues can be essential to ensure that the required enrichment of critical levels of the chemical, physical and biological soil parameters, that are crucial to ensure long-term production sustainability, can be achieved.

The highest grain yield of winter wheat was obtained on cereal-legume (WwSBWwMb) crop rotation, where no-till practice was used, is normal as this field provided more moisture and nitrogen for crop. It was 34% higher than cereal-cereal (WwCrWw) crop rotation in winter wheat after corn. The same trend was seen in cereal-oil (WwSfWwSS) rotation or winter wheat after oil crops was 26% higher than cereal-cereal rotation oil crops provided quite good moisture supply and crop was as clean as after oil crops. In addition, cereal-oil rotation provided grain yield as high as cereal-legume. The response of wheat yield to crop rotation provides an example of the type of response to crop rotation that is possible (Table 19). The greatest benefit from crop rotation comes when crops grown in sequence belong to totally different families. Yield responses to crop rotation of 15 percent for soybeans and 10 percent for wheat are common. Crop rotations also can decrease the cost of crop production.

Table 19: Wheat Yield Response to Rotation

| Rotation | Yield, t $ha^{-1}$ | Yield difference, % |
|---|---|---|
| Winter wheat-corn-winter wheat | 5.18 | 100 |
| Winter wheat- Soy bean-Winter wheat-Mung bean | 6.94 | 134 |
| Winter wheat-sunflower-Winter wheat-sesame | 6.55 | 126 |

**Conclusions**

The results presented in this study have shown that adopting cereal-legume rotation can increase winter wheat crop productivity.

Crop rotations play an important role in the success of most crop production enterprises, but rotations are will be important for no-till crop production. With carefully planned crop rotations, the advantages of no-till crop production can be extended to soil types or situations where success is difficult. This should be further studied in no-till system.

**Adoption by farmers**

Short-term crop rotation identified and recommended to the farmers of Kashkadarya province through field days and field training courses. Advantages and disadvantages of the short-term crop rotations will be discussed during the field days and formal training courses.

### *3.3.2.3. Effect of tillage method on productivity of double-cropped mung bean*

**Introduction**

In Uzbekistan, there are two strategic crops cotton and winter wheat. Cotton and wheat production in Kashkadarya province are controlled by the Government which in turn provides credit to buy subsidized inputs. For crops other than cotton and wheat one has to go to market and purchase seeds and inputs which is problematic under the present circumstances. And also, they had no equipment, and had lack of knowledge about growing and marketing, and no resources to buy inputs.
Recent introduction of new technology such as the no-till system offer an opportunity to increase double-cropping in the irrigated conditions of Uzbekistan and to increase land use efficiency. And, fuel for producing agricultural products has become expensive and no longer is available in unlimited supply. By using no-tillage and the multi-cropping technique, two crops can be planted with the same fuel required for one conventional crop. Fuel for harvest, processing and transportation would be higher than in single crop production owing to increased production and the extra harvest. Farmers and researchers agree that double-cropping can add grain or forage production in Karakalpakstan. Besides increased output, the overall cost of production is reduced. Equipment is used more frequently and labor requirements spread more evenly through the year.

**Materials and methods**
The experiment on effect of tillage method on productivity of double cropped mung bean was initiated. Days to maturity, grain yield, biomass yield and profitability were studied in the experiment. Mung bean variety Durdona was studied. Field experiments were conducted on the irrigated plots of two households at Qarshi district, Qashqadaryo province during the 2012-2013. The seeding rate for mung bean was 20 kg $ha^{-1}$. The treatments were tested with four replications. Plot size was 100 $m^2$ (35x2.8 м) and total area of the experiment was 1200 $m^2$. At the time of planting, usually 13–17 days after the irrigation, the first flush of weeds are controlled by a shallow tillage at the time of planting with the conventional tillage system but for the permanent bed treatments, weeds were controlled by application of 0.8-1.0 l $ha^{-1}$ pivot immediately after planting. In most years, no further weed control was needed but appropriate post-emergence, selective herbicides were used when required. Normally two irrigations were applied to double cropped mung bean after winter wheat.

**Results**

No-till mung bean was grown after winter wheat harvest. The mung bean is double-cropped after the winter wheat. No-till Mung bean was successfully grown as a catch crop after winter wheat in the irrigated conditions of Uzbekistan and provided 3.3% yield advantage compared to traditional tillage practice, which were not significantly different. Even without significant differences in crop yields no-till system has an advantage in reduced costs of production (Nurbekov 2007).
A two year experiment and the demonstration module have been conducted at farmers' field in Qarshi district, Uzbekistan. Humus content was a little higher with no-till wheat in the 0-10 cm depth, Table 20. This is explained by well-known fact of differentiation of soil fertility as a result of no-till when soil is not turned up. Nowadays to keep soil fertility level in the same level is extremely important issue. Our experiment showed that there was a little difference on organic matter content between the treatments. This is to be expected since all the plant residue is placed on the soil surface and the plant residue positively affects soil fertility. The tilled plots mixed and diluted this effect.
The results recorded during the crop growth period are reported in Table 21.
Plant's root length is one of the key yield components in legume cultivation. Root length was changed not significantly according to the Table 21. It says that effect of tillage method is not significant to root length. The same trend was observed with plant height across the treatments.

Table 20: **Soil chemical parameters in the different tillage systems (2012-2013)**

| Soil characteristics | 2012 | | | 2013 | | |
|---|---|---|---|---|---|---|
| | CT | NTC | NT | CT | NTC | NT |
| Humus (%) | 0.612 | 0.612 | 0.612 | 0.612 | 0.618 | 0.627 |
| Nitrogen (%) | 0.045 | 0.045 | 0.045 | 0.045 | 0.049 | 0.059 |
| Phosphorus (%) | 0.141 | 0.141 | 0.141 | 0.141 | 0.152 | 0.161 |
| N-NO3, mg $kg^{-1}$ | 12.87 | 12.87 | 12.87 | 12.87 | 13.22 | 13.93 |
| $P_2O_3$, mg $kg^{-1}$ | 27.84 | 27.84 | 27.84 | 27.84 | 28.25 | 29.14 |
| $K_2O$, mg $kg^{-1}$ | 291 | 291 | 291 | 291 | 299 | 303 |

As Table 21presents, no-till was advantageous to crop yields and also it demonstrated advantages in terms of conservation of energy and labour resources. As fuel for producing agricultural products has become expensive farmers in Uzbekistan has already started alternative ways how to decrease fuel consumption. The lowest fuel consumption (5.9 l $ha^{-1}$) was obtained with no till mung bean, which was 47.7 lower than conventional mung bean. Fuel consumption per ha was 53.6, 13.6 and 5.9 litres under full tillage, minimum tillage and no-till, respectively. Labour productivity under conservation tillage and no-tillage was 129% and 282%, respectively, as compared to ploughing.

The crop was harvested for yield to determine the effects of tillage systems of mung bean. It appears that mung bean tend to yield more where wheat was grown in no-till situation. Grain yield was significantly affected by tillage method and across the years. Maximum grain yield of 1.94 t $ha^{-1}$ was recorded with no-till mung bean while minimum grain yield (1.61 t $ha^{-1}$) was recorded with conventional mung bean was grown. The no-till mung bean provided 330 kg $ha^{-1}$ (20.5 %) yield advantage compared to the conventional mung bean which was significantly different. The average yield advantage in no-till mung bean with one cultivation was 160 kg $ha^{-1}$ (9.9 %) more than control treatment.

Table 21: **Effect of tillage method on productivity of double cropped mung bean (2012-2013)**

| Planting method | Spent fuel for planting, l $ha^{-1}$ | Root length, cm | Plant height, cm | Yield, t $ha^{-1}$ | Yield difference, % |
|---|---|---|---|---|---|
| Conventional | 53.6 | 25.4 | 67.17 | 1.61 | |
| No-till with 1 cultivation | 13.6 | 23.5 | 68.83 | 1.77 | 9.9 |
| No-till | 5.9 | 23.8 | 65.35 | 1.94 | 20.5 |

**Cost benefit analysis**

Table 6 shows cost benefit analysis of tested tillage methods in the irrigated conditions of Qarshi site Qashqadaryo province of Uzbekistan. To estimate economic returns of tested tillage methods, cost benefit analysis was done. The highest profit was recorded with no-till mung bean 1,113 USD $ha^{-1}$ while lowest profit was obtained with conventional till mung bean which was 825 USD $ha^{-1}$ (Table 22).

**Conclusions**

The results presented in this experiment with double cropped mung bean cultivation indicate that tillage reduction for surface irrigated production systems reverberate in the same positive way in terms of production profitability and sustainability total grain production. It should be mentioned here that retention of crop residues will be essential to ensure that the required enrichment of critical levels of the chemical, physical and biological soil parameters, that are crucial to ensure long-term production sustainability, can be achieved. Land use efficiency will be increased with double cropping of no-till mung bean.

Table 22: **Cost-benefits of tillage methods in Mungbean**

| Tillage method | CT | MT | NT |
|---|---|---|---|
| Yield, t $ha^{-1}$ | 1.61 | 1.77 | 1.94 |
| Crop price, t USD | 800 | 800 | 800 |
| Total income, t USD | 1,288 | 1,416 | 1,552 |
| Total costs, t USD | 463 | 443 | 439 |
| Profit | 825 | 973 | 1,113 |

### *3.3.3. Raised-bed planting and land leveling technology adjusted and applied and lower and more efficient water utilization for the crop rotations introduced, as compared to traditional cropping systems*

#### *3.3.3.1. Effect of different irrigation rate on productivity of winter wheat in Kashkadarya province.*

**Introduction**

The Kashkadarya province heavily depends on river water for mainly cotton cultivation and winter wheat the dominant crops. Water shortage is a big problem in Kashkadarya region. There are water shortages in some areas because of mismanagement in the form of excessive use of water for irrigation. The water demand from current farming practices cannot be sustained and there is an urgent need to pilot changes in irrigation and agricultural practices in the region in order to address the issue of declining water availability.

**Study objective**

To study the effect of irrigation rate on winter wheat yield in the irrigated conditions of Kashkadarya province through conservation agriculture technologies.

**Materials and Methods**

This experiment was conducted at the demo sites of the three project farmers. Randomized Complete Block Design was used in this experiment. Replications – 4; plot size - 1 hectare for each treatment and number of farmers – 3. Standard agronomic practices and fertilizer doses were applied for the crops. Analysis of variance (ANOVA) was used to determine treatments' effect. Soil samples collected for moisture content and for soil nutrient analysis at the time of sowing and harvesting. Winter wheat planted in mid-October and harvested in mid-June.

*Treatment*

1. Float irrigation - 60-70-60
2. Furrow irrigation 60-70-60
3. Float irrigation 70-70-70

4. Furrow irrigation 70-70-70
5. Float irrigation 70-80-80
6. Furrow irrigation 70-80-80

**Results**
Irrigation rates and crop yields for the different irrigation technologies are summarized in Table 23. Furrow irrigation increased uniformity of water distribution and helped adjust irrigation rates and timing according to available soil moisture content, and consequently, increased crops yields as compared to float irrigation. Application of furrow irrigation for winter wheat increased grain yield by 27% in 2012 and 21% in 2013, as compared to the traditional float irrigation. The maximum grain yield (7.45 t $ha^{-1}$) was obtained from furrow irrigation where irrigation rate was 2550 $m^{-3}$ $ha^{-1}$ (**Table 23**). Water use efficiency of the irrigation technologies during 2012 and 2013 as compared to controls were, on an average, 30% higher for winter wheat. This is extremely important for winter wheat cultivation in Qashqadaryo province of Uzbekistan where water shortage happens very often.

Table 23: **Irrigation and productivity of winter wheat at Kashkadarya, Uzbekistan**

| Treatment % FC | Irrigation | | Grain Yield | |
|---|---|---|---|---|
| | m-$^{3}$ $ha^{-1}$ | m-$^{3}$ $ha^{-1}$ | t $ha^{-1}$ | t $ha^{-1}$ |
| | 2012 | 2013 | 2012 | 2013 |
| Float irrigation 60-70-60 | 1800 | 2250 | 5.11 | 5.89 |
| Furrow irrigation 60-70-60 | 1200 | 1600 | 6.54 | 7.18 |
| Float irrigation 70-70-70 | 2000 | 2450 | 6.74 | 7.28 |
| Furrow irrigation 70-70-70 | 1900 | 2350 | 6.86 | 7.35 |
| Float irrigation 70-80-80 | 2200 | 2690 | 6.34 | 6.32 |
| Furrow irrigation 70-80-80 | 2100 | 2550 | 6.66 | 7.45 |

**Conclusions**
Improved furrow irrigation technologies (raised bed planting) provide significant increase in WUE and good net returns due to increased crop yields.

*Adoption by farmers*
The best irrigate rate and improved water management technology was identified and was recommended to the neighbor farmers around project demo sites. The water management technology can be introduced to the farms of the country.

## 3.4. Field activities across project countries

### *3.4.1. Laser land-leveling*

In order to have effective Conservation Agriculture under furrow irrigation, the land first needs to be laser leveled. Laser leveling is a process in which the land is leveled using laser-equipped drag buckets to create a constant slope of 0 to 0.2%. This practice requires the use of tractors and soil movers equipped with global positioning systems (GPS) and laser-guided instrumentation. The soil is moved by

either cutting, or filling, to create the desired slope/level. The technique is well known for its high level of accuracy in land leveling and the process itself offers great potential for water savings and increased grain yields. While the concept of moving soil to level land is old, laser land-leveling is an improvement on the process, such that the actual surface finish can be controlled to very tight tolerances.

Prior to starting the laser land-leveling, the soil should be loosened with a tillage equipment (Photo 1) to make leveling process easier, and a topographic survey (Photo 2) should be carried out to determine the optimal slope and slope direction for the site. An example of a topographic survey is provided in The on-farm project showed that laser leveling operations lead to increase water use efficiency at the project demonstration sites. Even distribution of water throughout the furrow system led to uniform seed germination, resulting in a more optimal plant density. Effective land-leveling improved crop establishment in general and the ability to manage the crops, thereby increasing both yield and quality. In addition, it improved water use efficiency by reducing high spots in the fields that blocked water movement across the field, and by reducing low spots that resulted in flooded areas and poor crop production.

Table 24. The topographic map was developed for the project demonstration site at Karshi. According to the topographic survey a map was developed, and based on the map the tractor operator was able to accurately level the field (**It was** also observed that by improving water coverage, plant populations could be reduced by up to 40%, which resulted in less time spent on weeding operations, from 21 down to 5 labor-days per hectare. This represented a reduction of up to 16 person-days per hectare, a 75% decrease in the traditional labor requirement for weeding.

**Table 25**). For more information please visit the web site www.krass.uz and refer to the manual on laser land-leveling prepared by Ibragimov et al. (2011).

Photo 1. Ploughed field

Photo 2. Topographic survey

A laser-controlled land-leveling system consists of a rotating laser light source located somewhere in the field. As the laser rotates rapidly, a virtual "plane" of light is produced in the field (Photo 3). A "receiver" is mounted on the leveling equipment and connected hydraulically to the earthmoving blade (Photo 3). When activated, the receiver (and thus, the blade) will "lock on" to the laser source, thus, adjusting in relation to the height and distance from the laser, thus providing a smooth flat surface with the program slope. As the earthmover moves over a high spot in the field, the blade will penetrate deeper. If the earthmover moves across low spot, the blade will lift up, dumping soil into the low spot.

By tilting the rotating laser source to the desired angle/grade, the slope can be created in the field to provide for the optimal flow rate of irrigation water through a furrow system.

For the topographic survey, a GPS receiver is mounted on a truck and locked into a stationary staff (laser source) in the field. As the truck drives across a preset grid, the receiver will remain locked on to the laser source. The receiver registers the differences in elevation throughout the field and prepares a topographic map that will be used in conjunction with the land leveler.

Photo 3. A rotating laser and a receiver mounted to the land leveller

The on-farm project showed that laser leveling operations lead to increase water use efficiency at the project demonstration sites. Even distribution of water throughout the furrow system led to uniform seed germination, resulting in a more optimal plant density. Effective land-leveling improved crop establishment in general and the ability to manage the crops, thereby increasing both yield and quality. In addition, it improved water use efficiency by reducing high spots in the fields that blocked water movement across the field, and by reducing low spots that resulted in flooded areas and poor crop production.

Table 24**: Measurements of uneven field areas within 1 ha obtained using laser device with a 20x20 meter measurement points**[1]

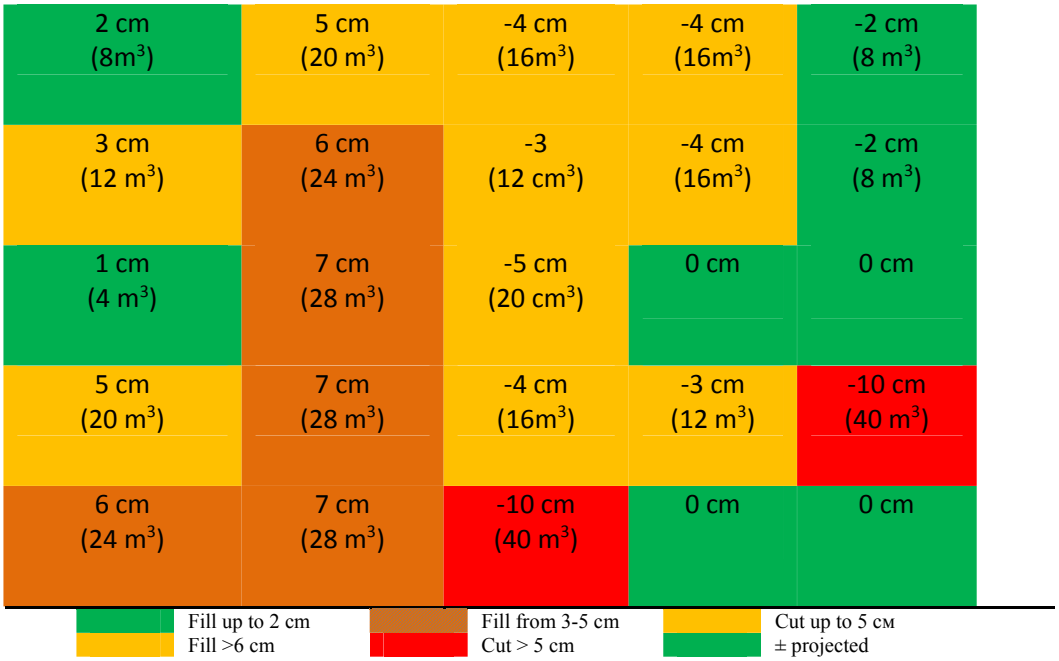
| | | 100 м | | | | | Mean, cm |
|---|---|---|---|---|---|---|---|
| | | 20 m | 20 m | 20 m | 20 m | 20 m | |
| 100 м | 20 m | 322 | 325 | 316 | 316 | 318 | 319 |
| | 20 m | 323 | 326 | 317 | 316 | 318 | 320 |
| | 20 m | 321 | 327 | 315 | 320 | 320 | 320 |

[1]Red – cut, blue – fill and green – equal to average.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 20 m | 325 | 327 | 316 | 317 | 310 | 319 |
| | 20 m | 326 | 327 | 310 | 320 | 320 | 320 |
| | Mean, cm | 323 | 326 | 315 | 317 | 318 | 320 |

It was also observed that by improving water coverage, plant populations could be reduced by up to 40%, which resulted in less time spent on weeding operations, from 21 down to 5 labor-days per hectare. This represented a reduction of up to 16 person-days per hectare, a 75% decrease in the traditional labor requirement for weeding.

**Table 25: Map and calculated depth and volume of cut and fill for each cell**




### *3.4.2. Seeding date and rate*

Optimal seeding dates and timely presowing irrigation pre-define the yield potential of agricultural crop in bed planting. In this section we elaborate upon these aspects. In southern Kazakhstan, optimal dates for bed planted winter wheat start on September 25 and last until October 15-20; in Kashkadarya province of Uzbekistan optimal planting date is mid-October while in Azerbaijan the optimal planting date is end of October and beginning of November. Autumn vegetation period, varies between 25 days and 45 days, and determines the efficiency of use of reserved soil moisture and the rate of crop growth when vegetative growth in the spring is resumed. Timely planting also stimulates plants' rapid growth with effective use of precipitations in the early spring. In the spring, raised-beds warm up faster and growth of winter wheat occurs earlier than with conventional seeding practice.

The winter wheat varieties, Azamatli-95, Tale in Azerbaijan, Almaly and Zhetysu in Kazakhstan, and Turkiston and Jayhun in Uzbekistan, were sown at a rate of 130 kg $ha^{-1}$ while the same varieties were

planted by using broadcasting method at a seeding rate of 200 kg $ha^{-1}$. Grain yield was significantly affected by planting method (**Figure 15**).

Depending on seeding methods, high rates do not always facilitate crop yield; on the contrary, at lower seeding rate, productive tillering factor, spike sizes, number of grains per spike and weight of 1,000 kernels increase and facilitates higher yields. , It is important to bear in mind the importance of timeliness of seeding with the use of high-quality seeds of locally adapted released varieties..

Bed planting seeding practice provides high yield of winter wheat with seeding rate at 1.5-3.0 millions live seeds in South Kazakhstan (Sydyk et al., 2008), 2.0-3.0 mln live seeds in Azerbaijan (Jumshudov et al., 2012) and in Uzbekistan (Qilichev and Khalilov, 2008). Mostly, the seeding rate depends on the biological characteristics of a variety, planting dates, land preparation work, soil water and fertilizer application.

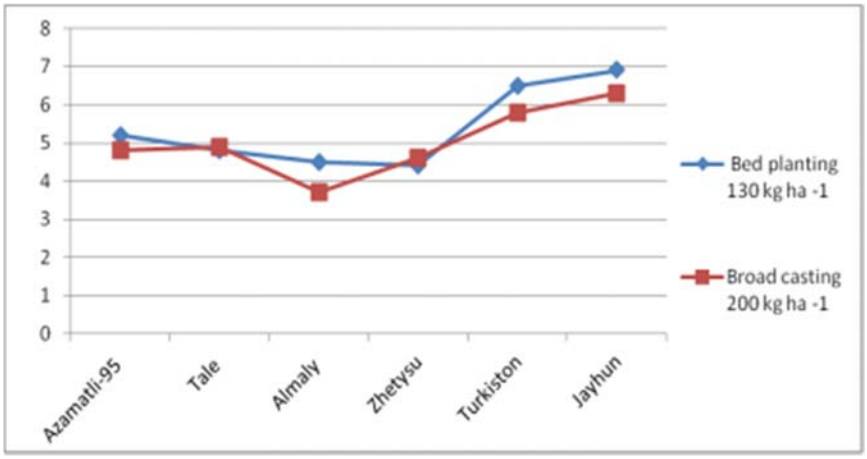



**Figure 15: Effect of planting method and seeding rate on productivity of winter wheat 2012-2013**

The benefits of planting wheat on beds in irrigated systems in terms of yield and water savings on various farms of the project demonstration site are given in **Table 26**. According to the results obtained from the first project, bed planting improves yields, and saves seed. In test sites across the three project countries a maximum grain yield of 7.51 t $ha^{-1}$ was recorded in Uzbekistan with bed planting while the lowest yield was recorded in South Kazakhstan, 4.45 t $ha^{-1}$. Water savings, as indicated, are significant and range from 27 to 36%, which is a critical issue in the irrigated conditions of Azerbaijan, South Kazakhstan and Uzbekistan.

The seeding of 2-4 defined rows of wheat on top of bed makes inclusion of wheat far more feasible but not all wheat varieties are appropriate for bed planting (Nurbekov, 2008). The following winter wheat varieties are most suitable for raised-bed-furrow seeding technology: a promising variety Almaly and released varieties Zhetysu, Intensivnaya, Steklovidnaya 24 and Yuzhnaya 12 in Kazakhstan (Sydyk et al., 2008), Azamatli-95, Gobustan and Tale-38 in Azerbaijan while in Uzbekistan Jayhun, Yaksart, Vostok, Turkistan, Start and Krasnodar-99. Further cooperation with wheat breeders can help to identify more wheat plant types, especially with high tillering capacity, for bed planting.

**Table 26: Wheat Yield Response to planting method (2011-2013)**

| Planting method | Wheat grain yields ($tha^{-1}$)[2] | | | Saved water, % | | |
|---|---|---|---|---|---|---|
| | Azerbaijan | Uzbekistan | Kazakhstan | Azerbaijan | Uzbekistan | Kazakhstan |
| Bed planted | 5.42 | 7.51 | 4.73 | 27 % | 36% | 30% |
| Broadcasted | 5.02 | 6.32 | 4.45 | 0 % | 0 % | 0 % |

The bed-planting technology is concerned about growing crops on raised beds and using the beds permanently with consecutive crops which adds to the benefits of zero-till to bed planting, making the system more sustainable (Nurbekov, 2008). This system is best designed for cropping systems where each succeeding crop is planted or seeded into the soil covered with residue mulch from the previous crop. There would be a need to include a variety of crops in the rotation to maintain effective diversification in the system to help to promote efficient crop, nutrient, water and weed management and reduce insect pests and diseases. Currently, bed planting systems for wheat production are gaining importance in other parts of the world. For example, the introduction of this technique in North Mexico had improved wheat grain yield by at least 10% and water economy by up to 35% in comparison with conventional system (Aquino, 1998).

Raised-beds are particularly favorable for seed multiplication and crop production using hybrid seed, as they significantly reduce seed rates. Therefore, the bed-planting system lowers production costs.

In Azerbaijan and South Kazakhstan province, the winter wheat crop yield under irrigation is still low, in the range 1.8-2.7 $tha^{-1}$. One of the reasons for this low productivity is the failure to observe the set of crop management activities in the course of its production, e.g., delay in planting dates, poor irrigation, failure to fulfill seeding rates, incorrect selection of varieties and others.

With raised bed technology, the land is prepared conventionally prior to preparing the raised-beds and furrows using a bed maker and a furrow opener on the laser leveled field. The raised-beds and furrows are prepared using a machine that makes 4 beds (70 cm width) in each pass. It is possible to plant 2 or 3 rows of a crop on each raised bed (Figure 16). The width of the beds can vary according from 40 cm to 90 cm, depending on the crop and on the soil type. Beds are wider in lighter soils and narrower in heavier soils.

Three rows of wheat have been tested by the project. Two rows have equal yields to that of three rows and give additional advantage that the weeds between the two rows of wheat can be managed mechanically, fertilizer can be placed as a top dress application between the rows (increasing efficiency) and there is less lodging due to larger plants. Bed planting also has the advantage of lowering seed rates, and produce bolder seeds with greater panicle length, an important issue for hybrid seed multiplication programs. In this test, planting was done using a new no-till drill adjusted to bed planting.

[2]All wheat treatments were fertilized with 90 kg $ha^{-1}$ of N and 60 kg $ha^{-1}$ P.

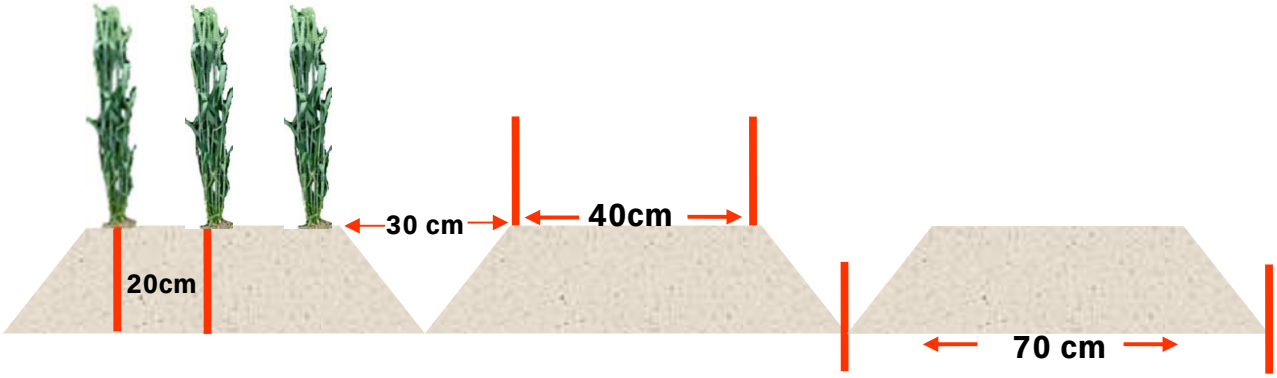



Figure 16: Configuration of raised beds and planting arrangements for irrigated wheat

**Economic assessment**

Similarly, cost-benefit analyses of improved technologies to assess the economic viability of useful options for better livelihood of farming communities in three participating countries under this project are completed. The cost benefit analyses of technologies revealed that many of the technologies developed and disseminated under the Project have considerable advantage than those currently practiced by the farmers in Central Asian countries. The economic assessment of technologies was based both in quantitative and qualitative methods of analysis. Among those technologies, the application of no-till practices and bed planting of winter wheat, new crop rotation options with inclusion of legumes in cropping systems, etc. were found to be useful for increasing farmers' income and improving their livelihoods.

# 4. MACHINERY FOR CA

The Project provided three no-till planters from Brazil which helped to widely introduce Conservation Agriculture which was absolutely new concept not only for farmers. To strengthen capacity of NARS involved in the project and to enhance their institutional base, two digital cameras have been provided to Kazakhstan and Uzbekistan. The project provided three boom sprayers for project countries. The boom sprayers are started working in the project demo sites in each country. Moreover the CA technology was appreciated by the Governor of the District who facilitated planting of winter wheat on area. Government officials on provincial level visited the demonstration sites in each country and expressed interest in no-till technology. Portable soil humidity measurements have also been supplied for all countries.

## 4.1. No-till planter

New machinery for CA practices was made available under the project to the farmers of the project demonstration pilot site. The planter can accommodate 5 row crop units in total. Good seed placement and soil contact is important to achieve healthy crop development and even germination. The sets are comprised of a support in which plastic reservoirs are fixed with the horizontal seeds distributing mechanism and motor system of the set. Weight of the no-till seeder is 1800 kg. Box capacity for wheat is 190 kg and box capacity for fertilizer is 505 kg. Working wide width for wheat is 2380 mm while for row crops it is 2400 mm. Traction is pull type which is very easy to transport from one place to another

place. The Fankhauser 2115 no-till seeder can be converted to plant either field or row crops which is universal.

### *4.1.1. Row unit for large grains*

Precision planter for large grains: It is a four or five row planter spaced at 40-90 cm (Photo 5). For each row there is a unit comprising seed hopper, metering mechanism including the drive mechanism and a line of furrow openers. Each row is independently metering the seed for accurate seed spacing in the row and has also independent furrow opener units allowing accurate depth placement of the seed (Photo 5). The operating depth adjustment of the coulter is obtained with adjustments on the frame leveler of the machine.

Photo 4: Four row no-till planter

Photo 5: Disc opener, gauge wheel, double disc closing wheels

Seed dosing disc replacement: Each disc comes with a bottom ring, which can have different shapes and thicknesses, depending on the size of the seeds and the thickness of the seed-disc. The seed discs are specified by the size of the holes, by the number of holes and thickness. Size of the holes 7.5 mm, number holes 90 and thickness of the disc is 5.5 mm, this is just an example of discs for soybean. The seed discs follow a universal standard and may be found easily on the market.

In this planter, number of seeds per meter can be ranged between 2.2 through 63.1 depending on crops. For row crops the speed should be maintained maximum at 6 km $h^{-1}$ to avoid seed breakage. With high and hard residues, high speed aids in cutting the residues, but more than 6 km $h^{-1}$ could break seeds. When doing the calibration for precision planting that requires a precise number of seeds per hectare, the correct setting of the planter is of utmost importance for obtaining an appropriate final stand for the crop to be established, considering the variety to be sown and the germination percentage. Another important factor for obtaining good stands is the correct choice of the seed distributing disks that should be determined from the form and size of the seeds.

It is a four row planter spaced at 60 cm. For each row there is a unit comprising seed hopper, metering mechanism including the drive mechanism and a line of furrow openers. Each row is independently metering the seed for accurate seed spacing in the row and has also independent furrow opener units allowing accurate depth placement of the seed. In case some rows are not used, for example for maize,

the entire hopper and furrow openers of the unused unit (with the seed metering disk) should be removed to avoid wear. In this planter, the seed rate can be regulated at 16 kg $ha^{-1}$ and fertilizer at 125 kg $ha^{-1}$. For row crops the speed should be maintained maximum at 6 km $h^{-1}$ to avoid seed breakage. With high and hard residues, high speed helps in cutting the residues, but more than 6 km $h^{-1}$ could break seeds. The planter can accommodate 5 row crop units in total. Good seed placement and soil contact is important to achieve healthy crop development and even germination. The first function is to place the seed in a soil environment that allows for rapid establishment of healthy, vigorous plants. Deep seed placement with good seed-to-soil contact provides the best seed-bed environment for most direct-seeded crops. Seed rate of agricultural crops can be regulated according to the rates shown in Table 27.

Table 27**: Large grains planting rate table**

| Transmission sprockets - number of teeth | | Disc 28 holes | Disc 40 holes | Disc 90 holes |
|---|---|---|---|---|
| Drive | Driven | Number of seeds per meter | | |
| 15 | 45 | 2.2 | 3.1 | 7.0 |
| 15 | 37 | 2.7 | 3.8 | 8.5 |
| 19 | 45 | 2.8 | 3.9 | 8.9 |
| 19 | 37 | 3.4 | 4.8 | 10.8 |
| 15 | 28 | 3.5 | 5.0 | 11.3 |
| 25 | 45 | 3.6 | 5.2 | 11.7 |
| 15 | 25 | 3.9 | 5.6 | 12.6 |
| 28 | 45 | 4.1 | 5.8 | 13.1 |
| 25 | 37 | 4.4 | 6.3 | 14.2 |
| 19 | 28 | 4.4 | 6.3 | 14.3 |
| 28 | 37 | 5.0 | 7.1 | 15.9 |
| 19 | 25 | 5.0 | 7.1 | 16.0 |
| 15 | 19 | 5.2 | 7.4 | 16.6 |
| 37 | 45 | 5.4 | 7.7 | 17.3 |
| 25 | 28 | 5.8 | 8.3 | 18.8 |
| 25 | 25 | 6.5 | 9.3 | 21.0 |
| 28 | 25 | 7.3 | 10.5 | 23.6 |
| 45 | 37 | 8.0 | 11.4 | 25.6 |
| 19 | 15 | 8.3 | 11.8 | 26.6 |
| 25 | 19 | 8.6 | 12.3 | 27.7 |
| 37 | 28 | 8.6 | 12.4 | 27.8 |
| 28 | 19 | 9.6 | 13.8 | 31.0 |
| 37 | 25 | 9.7 | 13.8 | 31.1 |
| 45 | 28 | 10.5 | 15.0 | 33.8 |
| 25 | 15 | 10.9 | 15.6 | 35.1 |
| 45 | 25 | 11.8 | 16.8 | 37.9 |

| | | | | |
|---|---|---|---|---|
| 28 | 15 | 12.2 | 17.4 | 39.3 |
| 37 | 19 | 12.7 | 18.2 | 41.0 |
| 45 | 19 | 15.5 | 22.1 | 49.8 |
| 37 | 15 | 16.1 | 23.1 | 51.9 |
| 45 | 15 | 19.6 | 28.0 | 63.1 |

### *4.1.2. Fertilizer metering*

The fertilizer transmission is located on the left side of the planter. After choosing the fertilizer application rate, the necessary sprockets should be installed. Prior to putting the planter into motion, observe the correct alignment of the idler, chain and sprockets (see **Error! Not a valid bookmark self-reference.**). There are two augers for fertilize metering: low-rate application auger and high rate application auger.

**Table 28: Fertilizer metering table - high rate auger**

| Sprockets - number of teeth | | Row spacing | | | | | |
|---|---|---|---|---|---|---|---|
| Drive | Driven | 400 mm | 450 mm | 480 mm | 700 mm | 800 mm | 900 mm |
| 15 | 45 | 63 | 56 | 52 | 36 | 32 | 28 |
| 15 | 37 | 76 | 67 | 63 | 43 | 38 | 34 |
| 19 | 45 | 80 | 71 | 67 | 46 | 40 | 36 |
| 19 | 37 | 96 | 86 | 80 | 55 | 48 | 43 |
| 15 | 28 | 99 | 88 | 82 | 57 | 50 | 44 |
| 25 | 45 | 102 | 91 | 85 | 58 | 51 | 45 |
| 15 | 25 | 112 | 99 | 93 | 64 | 56 | 50 |
| 28 | 45 | 114 | 101 | 95 | 65 | 57 | 51 |
| 25 | 37 | 124 | 110 | 103 | 71 | 62 | 55 |
| 28 | 37 | 136 | 121 | 113 | 78 | 68 | 61 |
| 15 | 19 | 141 | 127 | 117 | 81 | 71 | 63 |
| 37 | 45 | 151 | 134 | 126 | 86 | 76 | 67 |
| 25 | 28 | 163 | 145 | 136 | 93 | 81 | 72 |
| 25 | 25 | 180 | 160 | 150 | 103 | 90 | 80 |
| 28 | 25 | 196 | 174 | 163 | 112 | 98 | 87 |
| 45 | 37 | 221 | 197 | 184 | 126 | 110 | 98 |
| 19 | 15 | 230 | 205 | 192 | 132 | 115 | 102 |
| 37 | 28 | 236 | 210 | 197 | 135 | 118 | 115 |
| 37 | 25 | 258 | 230 | 215 | 148 | 129 | 115 |
| 45 | 28 | 287 | 255 | 239 | 164 | 144 | 128 |
| 25 | 15 | 298 | 265 | 248 | 170 | 149 | 132 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 45 | 25 | 316 | 281 | 263 | 181 | 158 | 140 |
| 28 | 15 | 329 | 293 | 274 | 188 | 164 | 146 |
| 37 | 19 | 343 | 305 | 286 | 196 | 171 | 152 |
| 45 | 19 | 413 | 368 | 344 | 236 | 207 | 184 |
| 37 | 15 | 439 | 390 | 366 | 251 | 219 | 195 |
| 45 | 15 | 508 | 451 | 423 | 290 | 254 | 226 |

### *4.1.3. Seeds distribution system for field crops*

The issue with the seeder was that the conversion between field and row crop use was quite technical and time-consuming and may present a problem in regions with limited technical expertise. Roughly 1.5 days is required to convert row crop seeder into field crop seeder (Photo 6).

The usual range of available opener spacing is from 15 to 20 centimeters, which is the conventional spacing for wheat. Some farmers double-drill forages in two directions for a closer effective spacing. A few drills are available with spacing down to 10 cm for high-yielding wheat. This is a desirable spacing for forage, but presents problems in spacing no-till coulters. To get close spacing with planters and drills, the openers usually must be staggered by mounting on two or more parallel bars. Staggering ground-engaging components helps to negotiate trash (residue) without acting like a rake, in addition to allowing physical space for components.

Wheat seed metering is done by a gouged rotor, which can be moved sidewards allowing a larger or smaller amount of seeds to be distributed. Each row has one metering roller.

Photo 6: Field crop seeder from back and right side

The regulation procedure is done by the displacement of the axis increasing or decreasing the opening work of the rotors inside the distribution box, through the lever. After obtaining the desired seeds outlet, fasten the regulator lever through the fastening nut. The amount of seeds in kg $ha^{-1}$ can be according to Table 29.

The sowing depth of seeds is very important, and it is one of the factors that interferes in the emergence and germination of plants.

The limiting wheels copy the soil unevenness, which allows keeping great uniformity in the depth. The wheels set is mounted in a strategic position, right behind the seed dephased double disks. Besides the limiting function, the wheel mounted in a "v" replaces the removed straw and does a lateral compacting of the seeds, avoiding the formation of air bubbles in the furrows.

## 4.2. Boom sprayers

The application of agro-chemicals is necessary to achieve higher and economical production, but it can bring risks to human beings, environment and the crops. So a concern is always present to ensure the proper use of a boom sprayer in an efficient and safe way (Photo 28).

A successful spray application does not depend only on a good sprayer or correct use of the chemicals but also on factors to be determined in the field under specialized orientation. Among these factors, some concepts should be part of a criterion for evaluation so that positive results may be attained within the pest control program.

Photo 7: Boom sprayer for broad field

Ideal time: The ideal time for spraying should be chosen according to the chemical product characteristics as well as to the field conditions:

- Infestation level of pests, diseases and weeds
- Infection level of diseases
- Growing stage of weeds
- Weather conditions.

Correct application rate: Any type of application requires that a correct rate be maintained during the whole spraying work. This will be possible only with a good sprayer which is properly calibrated.

Calibration is a precondition to:

- ensure that mixed volume suits area to be treated

- be able to add correct amount of pesticide

Calibration will check if:

- nozzles are worn a little and pressure needs to be adjusted
- nozzles are worn and need to be changed
- speed in correct
- high pressure drop or faulty gauge
- damaged or blocked nozzles
- sprayer in good shape with no leakages

Table 29**: Planting rate table – wheat, oat, black oat and rice**

| Crops | Distance between rows | 0 | | | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wheat | 170 mm | 32 | 48 | 63 | 82 | 100 | 113 | 126 | 144 | 163 | 181 | 199 | 209 | 219 | 240 | 261 | 276 | 291 | 309 | 327 | 338 | 345 | 1 |
| | | 37 | 55 | 72 | 94 | 115 | 130 | 145 | 166 | 187 | 208 | 229 | 240 | 252 | 276 | 300 | 317 | 335 | 355 | 376 | 388 | 397 | 2 |
| | | 48 | 72 | 94 | 122 | 150 | 169 | 188 | 216 | 243 | 270 | 298 | 312 | 328 | 359 | 390 | 412 | 435 | 461 | 489 | 504 | 516 | 3 |
| Wheat | 220/ 250mm | 22 | 33 | 43 | 56 | 68 | 77 | 86 | 98 | 110 | 123 | 135 | 142 | 149 | 163 | 178 | 188 | 198 | 210 | 223 | 230 | 235 | 1 |
| | | 25 | 37 | 49 | 64 | 78 | 89 | 99 | 113 | 127 | 142 | 156 | 163 | 172 | 188 | 204 | 216 | 228 | 242 | 256 | 264 | 270 | 2 |
| | | 33 | 49 | 64 | 83 | 102 | 115 | 128 | 147 | 165 | 184 | 203 | 212 | 223 | 244 | 266 | 280 | 296 | 314 | 333 | 343 | 351 | 3 |
| Oat | 170 mm | | | | | | | | | | | | | | | | | | | | | | 1 |
| | | 14 | 23 | 31 | 38 | 46 | 54 | 59 | 69 | 77 | 83 | 90 | 98 | 106 | 114 | 123 | 132 | 138 | 148 | 158 | 168 | 176 | 2 |
| | | 17 | 27 | 35 | 43 | 52 | 60 | 68 | 78 | 87 | 94 | 101 | 110 | 120 | 128 | 138 | 148 | 157 | 167 | 179 | 190 | 198 | 3 |
| Oat | 220/ 250mm | | | | | | | | | | | | | | | | | | | | | | 1 |
| | | 10 | 16 | 21 | 26 | 31 | 37 | 40 | 47 | 52 | 57 | 61 | 67 | 72 | 78 | 84 | 90 | 94 | 101 | 108 | 114 | 120 | 2 |
| | | 12 | 18 | 24 | 29 | 35 | 41 | 46 | 53 | 59 | 64 | 69 | 75 | 82 | 87 | 94 | 101 | 107 | 114 | 122 | 129 | 135 | 3 |
| Black oat | 170 mm | | | | | | | | | | | | | | | | | | | | | | 1 |
| | | 23 | 35 | 46 | 56 | 66 | 76 | 87 | 98 | 108 | 116 | 126 | 138 | 150 | 165 | 176 | 191 | 198 | 211 | 223 | 236 | 251 | 2 |
| | | 26 | 38 | 52 | 61 | 75 | 86 | 98 | 110 | 122 | 132 | 143 | 156 | 169 | 186 | 198 | 214 | 223 | 236 | 251 | 266 | 283 | 3 |
| Black oat | 220/250mm | | | | | | | | | | | | | | | | | | | | | | 1 |
| | | 16 | 24 | 31 | 38 | 45 | 52 | 59 | 67 | 74 | 79 | 86 | 94 | 102 | 112 | 120 | 130 | 135 | 144 | 152 | 160 | 170 | 2 |
| | | 18 | 26 | 35 | 42 | 51 | 59 | 67 | 75 | 83 | 90 | 98 | 106 | 115 | 127 | 135 | 146 | 152 | 161 | 170 | 181 | 193 | 3 |
| Ryegrass | 170 mm | 25 | 35 | 36 | 41 | 47 | 52 | 58 | 64 | 70 | 77 | 83 | 88 | 94 | 101 | 108 | 113 | 120 | 126 | 133 | 139 | 144 | 1 |
| | | | | | | | | | | | | | | | | | | | | | | | 2 |
| | | | | | | | | | | | | | | | | | | | | | | | 3 |
| Ryegrass | 220/ 250mm | 17 | 24 | 25 | 28 | 32 | 35 | 39 | 44 | 48 | 52 | 57 | 60 | 64 | 69 | 74 | 77 | 82 | 86 | 91 | 95 | 98 | 1 |
| | | | | | | | | | | | | | | | | | | | | | | | 2 |
| | | | | | | | | | | | | | | | | | | | | | | | 3 |
| Rice | 170 mm | | | | | | | | | | | | | | | | | | | | | | 1 |
| | | | | 36 | 50 | 62 | 78 | 91 | 107 | 120 | 137 | 153 | 167 | 178 | 196 | 220 | 234 | 245 | 261 | 285 | 304 | 319 | 2 |
| | | | | 41 | 58 | 71 | 89 | 105 | 124 | 137 | 157 | 177 | 191 | 205 | 226 | 254 | 269 | 282 | 301 | 328 | 350 | 368 | 3 |
| Rice | 220/ 250mm | | | | | | | | | | | | | | | | | | | | | | 1 |
| | | | | 25 | 34 | 42 | 53 | 62 | 73 | 82 | 93 | 104 | 114 | 121 | 133 | 150 | 159 | 167 | 178 | 194 | 207 | 217 | 2 |
| | | | | 28 | 39 | 48 | 60 | 71 | 84 | 93 | 107 | 120 | 130 | 140 | 154 | 173 | 183 | 192 | 205 | 223 | 238 | 250 | 3 |

There are four steps in calibration:

- Check driving speed
- Calculate required nozzle flow and choose nozzle size
- Check liquid system
- Check nozzle output

## 4.3. Development of no-till seeder in Uzbekistan

Findings from NT and BFS planting showed that savings in time and labour as well as the user-friendly machine construction and the simple technology appealed to farmers and researchers. The use of implements suitable for CA practices increased yields through an earlier establishment of the crops and decreased crop establishment costs through a reduction in tillage costs which was underlined by the participating farmers (Pulatov et al., 2001).

In Uzbekistan on tilled soils of rainfed area, most of farmers use conventional seeder model SZ-3.6. This commercially produced seeder is intended for sowing wheat, barley and other cereals. Use of this seeder requires preparation of fields for sowing, i.e. cleaning of field from residues, plowing, levelling, and harrowing. The sowing of winter wheat in rainfed areas requires number of field operations. This needs a lot of expenses to prepare fields for sowing winter wheat. To avoid the many field operations which are necessary for sowing winter cereals on rainfed areas farmers have modified existing SZ-3.6 seeder, the added a chisel. And this helps farmers to sow winter wheat or other cereals timely right after first rain falls which is very important in rainfed agriculture. Nowadays, total area under this conservation tillage reached up to 30,000 ha in rainfed areas.

**Photo 8. A signal variant of no-till drill in Uzbekistan**

World experience on adoption conservation agriculture shows that only countries with local production of no-till is adopting CA practices fastest compared to other countries where no-till manufacturer is not in place. The leading countries in the world with the biggest area under no-till are the Brazil, USA, Canada, Argentina, Australia, China and etc. All countries are having different kind of manufacturers with development of CA equipments. As a good example Brazilian no-till drills delivered to the project countries. The Brazilian no-till drill is expensive and total cost is about 38,000 USD including transportation. Not all farmers can afford to buy such expensive equipment. But, there is a need to ensure availability of more raised bed planters and no-till drills for covering large areas under conservation agriculture in

the project countries. In general, a suitable chisel can be mounted to front line of seeder to plant winter wheat. But this is not enough to properly manage seeding of any cereal crop. Taking this into account National consultants from Uzbekistan modified existing conventional planter into no-till drill. A signal variant of this planter has been produced in a factory located in Karshi, near the Uzbekistan project site (please see picture 8). The newly developed no-till drill in this case is an own development, modifying a disc type seeder to a no-till drill, with the advantage over the models from Turkey seen in other parts of the project, that the tine type can handle residues and that they follow the contour for each row independently and are not fixed. Weight of the no-till seeder is 1500 kg. Box capacity for seed is 300 kg and box capacity for fertilizer is 400 kg. Working wide width for wheat is 3600 mm and distance between row is 15 cm.
Thanks to project on "CA for irrigated areas in Azerbaijan, Kazakhstan and Uzbekistan" area under CA reached 1800 ha in Azerbaijan, 1100 ha in Kazakhstan and 2050 ha in Uzbekistan in 2013, under irrigated conditions. The results of this project convinced policy makers to start adoption of CA in the irrigated areas in the respective project countries.

# 5. Confidence of farmers, extension people and other stakeholders on practicing principles of CA increased.

## *5.1. Socio economic survey*

### *5.1.1. Introduction*

In 2011 socio-economic research was focused on rural livelihood analysis and economic assessment of technologies being tested by the Project. Rural livelihood analysis was implemented by conducting structured farm-level surveys with the sample size of 40 farming household units per site. E-database per site has been developed and available for further use. Descriptive data analysis has been applied and addressed the followings: (i) production characteristics of farming units based on irrigated agriculture, (ii) management of land use and irrigation water use practices, including crop diversification issues, and (iii) farm property issues and access to credits.

### *5.1.2. Methodology*

### *5.1.2. Creating database and data analysis.*

We developed e-database. All data generated were entered into computer and e-database was developed in MS Excel. Data analysis was done using descriptive statistics (frequency distribution, central tendency, variability, etc.). Data were analyzed using MS Excel.
Semi-structured questionnaire was developed based on the general objective of the Project, which is to improve rural livelihoods through applying efficient soil and water technologies.
Therefore, the main target of the survey was to assess soil and water issues on the farm level in light with general farming issues as expenditures and marketing and farm property rights. In order to cover all these issues it was discussed and agreed to divide questionnaire into three sections: Section A) Household characteristics and activities, Section B) Soil and water issues, Section C) Farm property rights and land tenure. Developed questionnaire was discussed with all the enumerators in each country and each site. Questionnaire has been tested in the field conditions with the following objectives in mind:

- To further select or reduce the number of main sections and questions to be included in the final version of the questionnaire.
- To test and verify survey methodology in such a way that will be suitable for specificities of all countries and sites involved.
- To take into account all remarks and suggestions from the farmers and consider them while developing final version of the questionnaire.
- To develop a survey methodology applicable for all sites in Uzbekistan.

Survey was launched in June 2011 and completed by the end of August 2011.

### *5.1.3. Double cropping after harvest of winter wheat*

In 2011, in Qashqadaryo province, economics of double cropped mung bean after winter wheat harvest was tested where mung bean planted on beds. Winter wheat yield was 5.94 t $ha^{-1}$ and that of mash was 1.73 t $ha^{-1}$. Average price across year was: for wheat grain 650 uzs $kg^{-1}$, for mash 1750 uzs $kg^{-1}$. The net income amounted to 3,861,000 and 3,027,500 uzs $ha^{-1}$ for wheat and mash, respectively. This data also indicates that farmers' incomes could be doubled easily through double cropping even under rather low market prices for alternative crops.

## *5.2. Site characterization*

### *5.2.1. Qovchin village, Karshi district site*

By administrative division the territory is located in Karshi district, Kashkadarya Province.

Researched area by its physical resources is characterized as a homogeneous. The area is irrigated and represented as a flat lands located in the Qarshi district. The site is characterized as arid zone, where climate is strong continental. R-19-KBK canal has the capacity to irrigate 10 thousand ha of land. About 70% of water from the canal is used by Karshi district for agriculture purposes. Project's experimental plot is fed by KX-3 sub-canal, which is used to irrigate 545 ha of land.

Farming units and population characteristics: There are over 1,520 households, out of which about 1,100 are farming households. Production system is based on cotton production. The closest market is in a 10 km. Livestock contributes significantly to farm and family budgets, the need to strengthen fodder base is important for the farmers and rural population. There are about 19 farming households that have official right to cultivate land.

### *5.2.2. Farm head and gender issues*

According to our estimations schooling of farm heads ranges from 8 years to 17 years, which means that education of farm heads varies from uncompleted 8 classes at secondary school to high University degree. Average years of formal schooling made 11 years (range 8-17), which means that in average farm heads at least finished secondary school (high school).

As it is indicated in the Table 30 in average up to 90% of farm heads at all surveyed sites are men. However, at QATAGON use site, Kashkadarya province there are cases, where women are the heads of the farm. At Qatagon use site farms managed by women is more than that at Qovchin site. This situation is explained by the cultural and traditional differences between these two sites. At Qovchin site ethnical population is mainly (<95%) is represented by Uzbeks, who are considered to be more traditional and conservative in their daily life styles. According to the local people at Qovchin farming in general, and leading a farm in particular, are the jobs for the men.

Table 30: General characteristics of farm head

| Site | Gender | Head of a farm (%) | Age (Years) | | |
|---|---|---|---|---|---|
| | | | Mean | Range | SD |
| QOVCHIN (40 cases) | Men | 97 | 49 | 26-70 | 10.6 |
| | Women | 3 | 52 | 49-70 | 11.6 |
| QATAGON (40 cases) | Men | 88 | 50 | 25-76 | 11.4 |
| | Women | 13 | 50 | 41-60 | 11.3 |

General literacy rate in former Soviet countries makes up to 95%. This was proved by our survey results also (Table 31).

Table 31: Education of farm heads (%)

| Education level | QOVCHIN (120 cases) | | QATAGON (80 cases) | |
|---|---|---|---|---|
| | M* | W** | M | W |
| University | 13 | 33 | 33 | 40 |
| Technical/ vocational training | 7 | 0 | 9 | 10 |
| Secondary school | 63 | 67 | 51 | 50 |
| Uncompleted secondary school | 2 | 0 | 7 | 0 |
| No answer | 15 | 0 | 0 | 0 |
| Not educated | 0 | 0 | 0 | 0 |

*M – Men
**W – Women

Attending secondary school at all the sites are regular, except one case at QATAGON site, when school is not attended because a child was disabled.

### *5.2.3. Housing issues*

In average about 58% of houses at QOVCHIN site have wells used for drinking and other domestic purposes and about 61% of houses at QATAGON site have houses with central running water. Average number of rooms at QOVCHIN made 4 (range 2-11) and at QATAGON site 4 rooms (range 2-8).

At QOVCHIN 81% and QATAGON 71% of houses have places for keeping domestic livestock with the average size of 34 $m^2$ and 160 $m^2$, correspondingly. The most prevailing types of animal house are simple shelter for summer time and houses constructed from bricks for wintertime at both sites. These kinds of houses to keep domestic animals are common in Uzbekistan.
In average 80% of surveyed farms at QOVCHIN have winter and summer storing houses that are used for keeping vegetables, cereals and fodder for livestock.

Land resources and cropping practices

Farmers were asked to indicate number of land parcels they have. The purpose of this question was to observe what kinds of additional managerial efforts farmers have to have in order to maintain several land parcels located at different places.

Currently in Uzbekistan small farms (less than 15 ha) are getting merged into bigger farms and new types of collective farming is being emerged, especially in the southern parts of the country (observations from the surveyed areas).

### *5.2.4. Cropping pattern*

At QOVCHIN site cotton is the major crop and 62% of farmers grow cotton. Vegetables prevail in the cropping structure at QATAGON use site as second crop after winter wheat. Comparative cropping pattern at QOVCHIN and QATAGON sites is shown in the Table 32.

Table 32: Average cropping pattern in Kashkadarya, 2011

| Crop | QOVCHIN | | | | QATAGON | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean (ha) | Range | SD | %* | Mean (ha) | Range | SD | %* |
| Wheat | 35 | 12-51 | 2.2 | 45 | 40.5 | 34-60 | 15.7 | 39 |
| Barley | 12 | 3-19 | | | 4 | 2-5 | 12 | 2 |
| Maize | 1** | 1-1 | | 1 | 8** | 6-18 | 13.6 | 6 |
| Alfalfa | 1 | 0.5-1.8 | 1 | 2 | 1 | 0.2-1.1 | 1.2 | 7 |
| Cotton | 46 | 23-55 | 3.1 | 42 | 56 | 28-75 | | |
| Potato | | | | | 4 | 2-8 | 4.8 | 2 |
| Vegetables | 3 | 1-6 | 3.3 | 2 | 6.8** | 2-11.2 | 12.2 | 41 |

*% of farmers growing certain kind of crop
** maize and vegetable growing as second crop in 2011

Data from Table 4 reveals that at QOVCHIN cotton is the major crop followed by wheat and alfalfa. These three crops are cultivated for earning income and used for running farm activities, while vegetables are mainly cultivated for home consumption. Importance of vegetables produced at backyards is significant, since these vegetables (potatoes, tomatoes, cucumbers, carrots and other green stuffs) are used for everyday diet of rural population.

### *5.2.5. Farm input and output sources and marketing issues*

Survey results revealed that input market for all the surveyed sites is located relatively far from the farms. The main source farm inputs is the central markets, normally located close to the big cities.

### *5.3.5.1. Marketing constraints*

Farmers were asked to rank four major problems, while marketing vegetable crops because for cotton and wheat there is state quota which means government buy the product. Farmers surveyed at QOVCHIN indicated the following as the major marketing problems: 1. high transportation costs associated with high prices for fuel (42%); 2. middleman, who lowers the price for vegetable and market for vegetable is occupied by them (22%); 3. lack of own machinery and transportation (26%); 4. Storing of crops, especially of carrot is difficult, spring prices much more higher than summer because farmers have to sell carrot directly from the to middleman, that is it affects the price (10%).

All the farmers surveyed at QATAGON use site stated only 1 problem that they face during marketing their crops. They did not “range” problems as the most significant, less significant and least significant ones. Out of one problem that each farmer indicated the most prevailing

constraint during marketing of crops was: 1). absence of special marketing points (3%), i.e. absence of well-developed marketing channel; 2). low prices because of middleman (1; 3). majority (20%) of farmers implied that they do not face any problem and 4). 76% of farmers did not provide any answer for this question.

### *5.3.5.2. Labor resources and migration of labor*

Labor resources issue was studied in order to learn if there are any labor migrations in rural settlement within the surveyed villages.

Table 33: **General characteristics of permanent labor resources, Uzbekistan**

| Types of work and average wages | QOVCHIN | | | | QATAGON | | | |
|---|---|---|---|---|---|---|---|---|
| | Winter | Spring | Summer | Fall | Winter | Spring | Summer | Fall |
| Occurrence of certain type of work, %: | | | | | | | | |
| - shepherd | 11 | 32 | 32 | 32 | 28 | 29 | 30 | 28 |
| - complex work [1] | 89 | 68 | 68 | 68 | 72 | 71 | 70 | 72 |
| - do not hire | | | | | | | | |
| Average no. of hired person per day | 1 | | 1 | 1 | 2 | 2 | 2 | 2 |
| Average wage (soum/month) | 344,346 | 455,740 | 545,740 | 615,740 | 524,150 | 631,880 | 691,760 | 622,000 |
| Average wage (US$/month[2]) | 172.9 | 228.9 | 274.1 | 309.2 | 263.2 | 317.3 | 347.4 | 312.4 |
| Method of payment [3] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

[1] Complex work: combination of several types of work at farm
[2] Exchange rate: 1 USD=1991 Uzbek soum
[3] Method of payment: 1 = cash; 2 = in kind

As it can be learned from the above table farmers do not hire any labor in winter times since any significant farming activities take place in winter and outsource labor is not needed.

### *5.2.5.3. Sources of family income*

Source of family income was studies to identify contributions of different sources to income generation.

## *5.3. Issues of irrigation water and soil resources management*

### *5.3.1. QOVCHIN and QATAGON sites*

At QOVCHIN all farmers use traditional furrow irrigation method. And they are satisfied with this irrigation method. Irrigation water is not measured by farmers because farmers do not have any irrigation water measuring device. According to farmers' responds 82% are not willing to change anything in their current irrigation practices, 18% expressed that they face frequent shortage of irrigation water and poor management of irrigation water distribution was stressed as the major reason of that. At QOVCHIN irrigation water is physically available but due to reorganization in the management system of irrigation water distribution, water delivery into farmers field is very often a problematic issue.

Local people are not willing to change anything in their irrigation practices because of a number of reasons as: lack of finances (50%), lack of knowledge and skills (22%), current institutional constraints (1%), low land quality (2%), distrust to new technologies (25%). All the surveyed farmers at QOVCHIN use canal water for irrigation purposes. Average distance between main irrigation canal and farmers fields makes about 1 km. The main irrigation canal is served as a distribution source of irrigation water into small canals that are directly linked to the fields. Quality of irrigation water according to farmers' evaluation was characterized as a good (43%), normal (30%) and bad (6%) ones; 21% did not give any answer. 94% of farmers at QOVCHIN said that they reduce number of irrigations in order to find out ways of managing frequent water shortages and 6% stated that they pump groundwater for irrigation purposes. 47% of farmers indicated soil salinization as the major problem faced by them during the last few years, 4% indicated high water table as the cause of problems for faming, 27% indicated several generalized problems as poor quality of land and shortage of irrigation water and poor condition of irrigation canals, 12 said that they do not have any problems, and 10% did not give any replies. Also, the issue of pricing of irrigation water is not well regulated and this very causes conflicts between farmers and local authorities responsible for irrigation water management.

Crop cultivation practices were studied with the purpose to identify what kind of agronomic practices are prevailed in the area and compare those practices with the options offered by the Project. Namely, tillage and sowing methods and correspondingly seed and fertilizer rates were studied. 87% out of surveyed farmers use deep ploughing and use broadcasting sowing method, 10% minimum tillage and 3% did not give any answers. Average seed rate for cotton is 50 kg $ha^{-1}$ (range 30-70) and nitrogen fertilizer is used at a rate of 450 kg/ha (range 240-550) and ammophous 150 kg $ha^{-1}$ (120-250). None of the surveyed farmers indicated usage of any other kinds of fertilizers as potassium fertilizers.

Cultivation practices for wheat and cotton were homogeneous among surveyed farms. 45% of farmers do not grow wheat. 95% of surveyed farmers, who cultivate wheat, use deep ploughing and it was revealed that 10% of farmers apply "minimum" tillage while preparing land for wheat production on standing cotton and 85% farmers use broadcasting method of sowing while 15% of farmers use seeding with cereal planters. Average seed rate for wheat made 200 kg $ha^{-1}$ (range 180-250).

Crop rotation practices were studied in order to reveal whether farmers use fallows and if any crop sequence is followed, and if not what are the reasons of that. Also issues of soil fertility in light with fallow practices were studied. Out of surveyed farmers none of them adopted any new crops. Farmers said that their land is very suitable for growing cotton and they do not need to adopt any other new crop. Moreover, cotton, according to farmers, is the most

beneficial crop at the moment. Another reason for not adopting new crop is the uncertainty with the market. Farmers said they are not sure if a newly adopted crop would have well-established market as for cotton.

According to farmers from QOVCHIN site, next season they are planning to grow the following crops: cotton (42%), wheat (43%); and they did want to introduce soybean (6%), and mung bean. 3% did not want to adopt any new crops. Farmers believe that introducing these legume crops will help them to improve soil quality, serve as a good source for livestock feeding, and beneficial in terms of getting higher incomes. 90% out of all surveyed farmers replied that cotton is the most beneficial crop, which brings immediate cash income for them and they would like to expand the area under this crop.

### *5.4. Conclusions*

Irrigation method applied at the farms is not water saving one. Around 90 % of farmers use float irrigation which requires high irrigation rate, sometimes excessive rate of irrigation water.
Seed rate is also high in comparison to Project recommendations that proved to be applicable on the on-farm level without negatively affecting crop yields.
Policy regulations regarding maintenance of irrigation system needs to be applied for better irrigation water management.
Crop marketing and transportation costs associated with delivery of agricultural produce to the market are one of biggest constraints for income generation.

## 6. Farmer-oriented brochures and guidelines on applying CA practices in irrigated and rainfed areas in the selected countries produced and printed.

To ensure wide and effective dissemination and adoption of the improved technologies, 12 recommendation leaflets, poster and other publications have been brought out for farmers and also a guidelines on conservation agriculture is under preparation.
Also consultants of the project have produced and published 15 scientific papers based on the results achieved under the project. Following is a list of publications throughout the Project period:

**Journal Paper**

Nurbekov Aziz, M. Suleimenov, T. Friedrich, F.Taher, R. Ikramov, N.Nurjanov, 2012. Effect of tillage methods on productivity of winter wheat in the Aral Sea Basin of Uzbekistan. J Arid Land Studies Vol.22-1.

**Seminars and Conferences**

Nurbekov Aziz, M. Suleimenov, T. Friedrich, F.Taher, R. Ikramov, N.Nurjanov, 2011. Effect of tillage methods on productivity of winter wheat in the Aral Sea Basin of Uzbekistan. The 1st International Conference on Arid Land "Desert Technology X" Abstracts. May 24-28, 2011. Narita-Tokyo, Japan. p. 106.
Nurbekov Aziz, M. Suleimenov, T. Friedrich, F.Taher, R. Ikramov, N.Nurjanov. No-till practices in the drought and salt-affected region of Uzbekistan. 5th World Congress of Conservation Agriculture incorporating 3rd Farming Design Conference, September 2011 Brisbane, Australia. pp. 410-412.

Nurbekov Aziz, T. Friedrich, F.Taher, R. Ikramov, Z.Ziyadullaev. Conservation Agriculture Practices in Karakalpakstan. International Conference on 20 Years of Conservation Agriculture in China. Nov. 19-21, 2012. Beijing, China. Pp.59-65.
Nurbekov A., T. Friedrich, H.Muminjanov, R. Ikramov, Z.Ziyadullaev. Effect of fertilizer rate on productivity of winter wheat in the Aral Sea Basin of Uzbekistan. 3rd International Agronomy Congress on Agriculture Diversification, Climate Change Management and Livelihoods, 26-30 November 2012. New Dehli, India. Pp
Nurbekov A., T. Friedrich, H.Muminjanov, R. Ikramov, Z.Ziyadullaev. 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. 10th - 15th December 2012 Hanoi, Vietnam. Pp.272-274.
Jumshudov I., A. Nurbekov, H.Muminjanov, A.Musaev, S.Safarli. 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. 10th - 15th December 2012 Hanoi, Vietnam. Pp.250-252
Sydyk D., A.Karabalayeva, A.Nurbekov. 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. Pp96-101.
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Nurbekov A. Effect of soil salinity and tillage on productivity of winter wheat in the irrigated conditions of Uzbekistan. International Conference on Scientific bases of Grain Production and its perspectives in Uzbekistan. 23-24 May, 2013, Djizakh, Uzbekistan. Pp. 266-269.
Sydyk D.A., Karabalayeva A., Nurbekov A.I. Irrigation regime of winter wheat under raised bed planting. International Conference on Scientific bases of Grain Production and its perspectives in Uzbekistan. 23-24 May, 2013, Djizakh, Uzbekistan. Pp. 269-271.
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**Book chapter**
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# 7. Capacity building activities in the area of CA designed and carried out at the benefit of farm households and national partners

## *7.1. Inception workshop*

A two day Inception Workshop was held from January 31 - 1 February, 2011 in Tashkent under the FAO/Turkey Partnership Programme (FTPP), in which ICARDA Regional Office in Tashkent is providing technical backstopping. The Inception Workshop was held at the premises of the La Grande Plaza hotel located Tashkent.
In the Inception Workshop experts from FAO, ICARDA, JIRCAS, ZEF-project, Vice rectors of Agricultural Universities of Uzbekistan and National project coordinators and consultants from Azerbaijan, Kazakhstan and Uzbekistan participated. A total number of 40 participants from 3 countries of Central Asia and including Azerbaijan participated to the workshop. The participating institutions are the Ministries of Agriculture and the institutions under the Ministries of the all countries. The participants were nominated by Ministries of Agriculture of the respective countries in the project with high academic qualifications including PhD degree in agricultural sciences especially in crop production, mechanization, water management and economics subjects.
The following objectives were set:
a) Discuss the detailed national and regional work plans of the project
b) Obtain valuable inputs and suggestions from the distinguished participants regarding for the conservation agriculture in the project countries
c) Proposals and options for the none expendable equipment.
Various resource persons made presentations during the second session of the Inception Workshop. The first presentation was delivered by Dr. Theodore Friedrich, Senior Officer,

Plant Production and Protection Division, FAO, "Status, challenges and perspectives of conservation agriculture in Central Asian countries". This was followed by the presentations on the topics – "ICARDA's research strategy on sustainable intensification in the dry areas" by Dr. Rachid Serraj, Program Director, ICARDA, "Conservation Agriculture in Wheat-based systems in CWANA" by Ravi Gopal Singh, Agronomist (ICARDA), "ICARDA's approach to implementing Conservation Agriculture in Central Asia" by Dr. Jozef Turok, Regional Coordinator ICARDA-CAC, and "No-till wheat yield as related to soil moisture content and manure application at different rates" by Dr. Aziz Nurbekov, Project Regional Coordinator (ICARDA-CAC). Three national project coordinators from Azerbaijan, Kazakhstan and Uzbekistan were made country presentations included suggested project sites. Dr. Hafiz Muminjanov, Plant Production and Protection Officer, FAO/SEC, Ankara, Turkey, made an introductory presentation to the project on the topic "Conservation Agriculture for Irrigated Areas in Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan".
Dr. Theodore Friedrich, Senior Officer, Plant Production and Protection Division, FAO, chaired the closing session. The course was closed by Dr. Zakir Khalikulov, Deputy Regional Coordinator, ICARDA-CAC, Dr. Hafiz Muminjanov, Plant Production and Protection officer, Sub-regional Coordinator for Central Asia, FAO, and Prof. Laziza Gafurova, Vice Rector, Tashkent State Agrarian University, Uzbekistan. They made closing remarks in the closing session and gave the vote of thanks to all the participants for coming to the inception workshop, for their active participation, for valuable inputs and suggestions.
The workshop was successful in the sense that regional and national work plan of the project successfully introduced and examined during the discussions. The participants provided critical and valuable inputs for the national work plan of the project. It should be also mentioned here that the participants realized the need of the conservation agriculture practices in the region. This was well reflected during the discussion sessions after each presentation. The workshop accomplished the objectives as planned.
The workshop was participated by diverse group of specialists from the region. The interaction during the discussion sessions was very lively. The participants appreciated FAO and ICARDA efforts in conservation agriculture in Central Asia and Azerbaijan. The conducive atmosphere of the inception workshop helped participants to take active part. However, absence of participants particularly the Members of Farmers' Association from the respective countries was greatly felt during the workshop.

## *7.2. Field days*

In 2013 ICARDA scientists continued their efforts on capacity-building in Central Asia and the Caucasus. Many local researchers and farmers were trained in a variety of best practices in agriculture. A lot of effort was focused on conservation agriculture practices like no-till and bed planting, crop residue retention and crop rotation. Twelve field days, involving about 187 in Azerbaijan, 183 in Kazakhstan and in Uzbekistan 208 farmers and representatives of local authorities were organized (please see **List of Field Days organized in the project countries (2011-2013)**Table 34). During these field days, improved technologies of irrigation, conservation agriculture and crop diversification have been 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 June, 2012. During these field days, CA technologies, improved water management and crop diversification methods were demonstrated by ICARDA staff and project national consultants in the

respective project countries. The field days showed farmers the benefits of adopting conservation agriculture in the irrigated areas.

Table 34: **List of Field Days organized in the project countries (2011-2013)**

| # | Title | Date | Number of attendees | Country |
|---|---|---|---|---|
| 1 | Introduction of bed planting technologies in the project demo site in Azerbaijan | 21 May, 2011 | 33 | Azerbaijan |
| 2 | Bed planting technologies for agricultural crops in the South-Kazakhstan Province | 16 June, 2011 | 35 | Kazakhstan |
| 3 | Improving current conservation agriculture practices in the project demo site | 24 August, 2011 | 40 | Uzbekistan |
| 4 | Demonstration of no-till winter wheat cultivation in Azerbaijan | 13 March, 2012 | 40 | Azerbaijan |
| 5 | Introduce no-till drill in Uzbekistan | 27 March, 2012 | 52 | Uzbekistan |
| 6 | No-till alfalfa and winter wheat planting under irrigated conditions of South Kazakhstan province | 06 April, 2012 | 55 | Kazakhstan |
| 7 | Demonstration of the capability of the no-till seeder to seed maize directly behind the combining of wheat | 04 June, 2012 | 70 | Azerbaijan |
| 8 | Installation of no-till drill in Kazakhstan | 12 June, 2012 | 50 | Kazakhstan |
| 9 | Mung bean planting after winter harvest in Uzbekistan | 08 June, 2012 | 70 | Uzbekistan |
| 10 | Bed planting and its environmental impact | 27 March, 2013 | 44 | Azerbaijan |
| 11 | The system of crop rotation under conservation agriculture | 16 March, 2013 | 43 | Kazakhstan |
| 12 | No-till practice and succeeding crops (multi-cropping) | 25-Apr, 2013 | 46 | Uzbekistan |

### *7.3. Field training courses*

A series of training courses on CA practices were conducted in Azerbaijan, Kazakhstan and Uzbekistan. In all, 540 participants (Azerbaijan 170, Kazakhstan 172 and Uzbekistan 198) attended the course, including policy makers, delegates from Ministry of Agriculture, researchers, national consultants of the project, and farmers. The list of training courses conducted according to the approved project work plan is presented in the Table 35. The main objectives of the courses were to train the scientists and farmers on the required skills and tools to be used in better targeting of conservation agricultural research in order to increase adoption of conservation agriculture technologies in the respective countries. At formal training courses, officials, national consultants, researchers and farmers joined to discuss promotion of conservation agriculture in the project countries. They described their great enthusiastic interest to promote conservation agriculture in the respective project countries and do research on conservation agriculture in the Research Institutes of Azerbaijan, Kazakhstan and Uzbekistan.

### *7.4. Closing workshop*

Final Workshop of the FAO-supported project GCP/RER/030/TUR '**Conservation Agriculture for Irrigated Areas in Azerbaijan, Kazakhstan and Uzbekistan'** was held in Tashkent, Uzbekistan, on 10-11 December 2013. The main objective of the Final Workshop was to highlight and review the most important technical results generated in the project during the last three years and to promote conservation agriculture in the project countries.

Table 35**: List of Trainings courses organized in Azerbaijan, Kazakhstan and Uzbekistan (2012-2013)**

| # | Title | Date | Number of trainees | Country |
|---|---|---|---|---|
| 1 | Promotion of conservation agriculture in South-Kazakhstan province | 01 March, 2012 | 47 | Kazakhstan |
| 2 | Soil fertility improvement training course in Azerbaijan | 12-13 March, 2012 | 40 | Azerbaijan |
| 3 | Bed planting and no-till practices in Uzbekistan | 26-27 March, 2012 | 52 | Uzbekistan |
| 4 | Exploitation of boom sprayer and herbicide application in conservation agriculture | 19-20 July, 2012 | 40 | Azerbaijan |
| 5 | A training course on conservation agriculture in South Kazakhstan province | 11-12 July, 2012 | 35 | Kazakhstan |
| 6 | Concepts of practices of no-till and the technical aspects of double cropping in Uzbekistan | July 27-28, 2012 | 52 | Uzbekistan |
| 7 | Laser land leveling reintroduced in Azerbaijan under Conservation Agriculture project | 03 October, 2012 | 45 | Azerbaijan |
| 8 | Adoption of Conservation Agriculture started in the irrigated areas of Kazakhstan | 10-11 October 2012 | 47 | Kazakhstan |
| 9 | Conservation agriculture awareness comes to the farmers through field training course in Uzbekistan | 24-25 October 2012 | 45 | Uzbekistan |
| 10 | Training course on soil fertility improvement in Uzbekistan | 18-19 February 2013 | 49 | Uzbekistan |
| 11 | Soil fertility Management under conservation agriculture | 01-02 February 2013 | 45 | Azerbaijan |
| 12 | Training course on soil fertility improvement in Kazakhstan | 07-08 February 2013 | 43 | Kazakhstan |

This workshop brought together representatives of FAO, GIZ-Tajikistan, UNDP-Uzbekistan, ICARDA as the implementing organization and the National consultants on economics, irrigation, mechanization and agronomy from Azerbaijan, Kazakhstan, Tajikistan and Uzbekistan. Overall, about 30 participants attended the regional event. It is worth to note that almost all participants had experience on conservation agriculture (CA) while some of them had a little knowledge of CA practices.

The opening session was chaired by Dr. Jozef Turok, Head PFU and Regional Coordinator ICARDA-CAC. Dr. Abdumalik Namozov, Head, Department of Innovation, Ministry of

Agriculture and Water Resources of the Republic of Uzbekistan welcomed all participants. Dr. Hafiz Muminjanov Plant Production and Protection Officer, FAO-SEC, Ankara, Turkey and Dr. Turok, Head PFU and ICARDA-CAC Regional Coordinator made introductory remarks in the opening session on importance of conservation agriculture Central Asian countries and Azerbaijan.

Various resource persons made presentations during the second session of the Workshop. The first presentation was delivered by Dr. Hafiz Muminjanov, "Global and Regional Adoption and Promotion of Conservation Agriculture." This was followed by the presentations on the topics "Natural resources management in Dryland Systems and other CGIAR Research Programs in Central Asia and the Caucasus" by Dr. Jozef Turok, "ICARDA's research strategy on sustainable intensification in the dry areas" by Dr. David Feindel, Acting Director DSIPS Program, ICARDA, and "Promoting conservation agriculture in Central Asia and the Caucasus" by Dr. Aziz Nurbekov, Project Regional Coordinator, ICARDA-CAC. These presentations gave a comprehensive overview of CA and highlighted some key constraints for the introduction and adoption of conservation agriculture practices. At the end of the presentations participants put questions and made comments concerning the breeding of crop varieties suitable for CA, development and production of CA equipment, comparative advantage of wheat growing under zero-till, weed management in conservation agriculture and figures about agricultural production and yields in Central Asia and Azerbaijan.

The research partners from the participating countries showed a wide diversity of experiences on conservation practices and appreciated the opportunity for sharing them. There were fruitful discussions after each presentation. The participants exchanged their views on promotion of conservation agriculture in the region. The Governments of some countries in the region have invested more on CA equipment, as observed in Kazakhstan.

During the final session of the workshop the participants shared their impression about the workshop and provided critical and valuable inputs to the recommendations of the workshop. There are a number of challenges that CA faces throughout the largely agricultural region of Central Asia and the Caucasus, including lack of crop diversification on small-size farming areas, knowledge about CA systems among extension and technical staff, knowledge about CA at decision-making levels, farmers' ability to decide on diversified crop rotations, and CA equipment. Participants once again stressed the need for and importance of conservation agriculture practices for achieving the balance between agro-ecosystems' sustainability and increased crop production in the region.

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The final session of the workshop was chaired by Dr. Hafiz Muminjanov. The workshop was successful in the sense that national consultants successfully reported results of the project and made useful recommendations. It should be also mentioned that the participants supported the need for further promotion of the conservation agriculture practices in the region.

### *7.6. Adoption of CA in the project countries*

During the last decade, the term CA has made its way into research communities of Central Asian countries. Adoption of no-till technologies differed from country to country. The fastest adoption was observed in northern Kazakhstan in rainfed conditions while under irrigated conditions is very slow. According to the Ministry of Agriculture of Kazakhstan, in 2011, no-till and conservation tillage practice were introduced on an area of 11.7 M ha (**Error! Reference source not found.**), which is 70% of all the area sown to wheat in Kazakhstan (Sydyk *et al*., 2008). Consequently, in 2011, the country harvested record gross output of grain of 20 M t corresponding to a yield of 1.7 t $ha^{-1}$ (Sydyk *et al*., 2008). These results were achieved due to the introduction of CA related practices, although the area under full CA in Kazakhstan is only 1.7 M ha. CA is still not widely practiced among the farming population in the irrigated areas of the lower half of Central Asia. Current activities are mainly concentrated in research institutes to integrate CA principles and practices into existing production systems.

In the project countries, no-till and bed planting cultivation has been tried in case of wheat, barley, sunflower, mung bean, soybean kidney bean, alfalfa, maize and sorghum and the results had been quite encouraging. The lodging of sunflower was less under no-till planting as compared to the conventional planting, which is an important factor for higher yield. Similarly, raised bed planting of winter wheat and provides higher yields than conventional planting and also saves seed (about 50%) and water (about 30%).

The results of this project provided convincing farmers and policy makers to start adoption of conservation agriculture in respective project countries. As of 2013, thanks to the project, irrigated areas under conservation agriculture reached 1800 ha in Azerbaijan, 1100 ha in Kazakhstan and 2050 ha in Uzbekistan.

## Conclusions

**Azerbaijan**

- Water use efficiency is important in Azerbaijan in view of the limited water resources in the country. The results have to be considered as preliminary. More detailed studies of the factors influencing farmers' choices and preferences are required. The results are useful for identifying suitable varieties for bed planting method in Azerbaijan.
- Grain yield in continuous wheat (4.50 t $ha^{-1}$) was the lowest because plants were less supplied with moisture and were competing with large number of weeds. Winter wheat grain yield was 10.8 % higher compared to continuous wheat yield (4.99 t $ha^{-1}$). However when wheat was rotated with legumes its yield was also high: 5.88 t ha-1 or 25.1 %.
- The main benefit of bed planting is water savings. Therefore, under high production situations, bed planting exceeds the yields possible on the flat bed. We observed an improvement of the water use efficiency by 21–30% combined with an approximate 17% savings in applied irrigation water use efficiency was significantly higher with the bed planting (2.36 and 2.11 kg $m^{-3}$) compared to conventional planting (1.67 and 1.85 kg $m^{-3}$).
- The high tillering winter wheat variety Azamatli-95 had maximum grain yield (5.88 t $ha^{-1}$) in 2012 in bed planting while winter variety Tale-38 had the lowest grain yield (3.82 t $ha^{-1}$) in 2012 in conventional planting.

- Economic assessment of this research showed that that bed planting is more profitable than conventional planting for growing winter wheat thanks to higher yields and savings in planting costs obtained under raised bed planting.
- In discussion about continuous wheat, it has been emphasized about soil intoxication which was not proved by any data. In further studies one should control weeds in continuous wheat by efficient herbicides which may change assessment of continuous wheat growing. Also weed control is very important to change attitude to replacement of cereals with legumes. As per this research the wheat–legume rotation seemed to be the best practice in the irrigated conditions of Azerbaijan. Also this short term crop rotation can improve land use efficiency in the irrigated areas which is extremely important in the country. Short term wheat-legume crop rotation under no-till practices can be recommended to the farms of the country. Many aspects of crop rotation and second cropping are compatible with current crop rotation in the country and could become more accessible to farmers if government policies are restructured to reflect the true environmental costs of agricultural production.
- Overall, the results of this study indicate that tillage system and double cropping practices are compatible and need to be more investigated in irrigated conditions of Azerbaijan. Best tillage option was assessed and recommended to be adopted in Karabakh low lands and introduced to the farms of the country. These investigations can be included following: planting and seeding date, fertilizer rate and application date, irrigation date and rate.

**Kazakhstan**

- In conclusion, 60000 seeding rate had the highest plant height (226 cm) while 40000 seeding rate had the lowest plant height and there was no significant difference between the plant height and seeding rate.
- The higher seeding rates gave almost similar yields while the low seeding rate frequently reduced grain yield of bed planted maize.
- On the basis of our experiment it was found that the maize crop grew the tallest (291 cm) and a high biomass yield when the plant is planted on May 15. There were significant differences in maize plant height within years, treatments and farms. There was also close interaction between year and treatment on maize plant height.
- It should be mentioned here that the higher seeding rates gave almost similar yields while the low seeding rate frequently reduced grain yield of bed planted maize. In our experiment four planting dates showed a relatively small trend of seed germination. The seed germination ranged from 64.9 to 82.6 % across treatments, farms and years.
- Number of plants was significantly affected by treatment i.e. planting dates while year and farm were not significant. Effect of planting date on maize grain yield was significant. Analysis of variance showed that grain yield had significant difference within treatments (<.001) while number of plants within farms was unrelated to biomass yield. The planting date analysis showed that the best sowing date was April 30, and grain yields of other three dates were relatively lower.
- The results of this study proves that planting dates have significant effects on number of plants and grain yield in maize.
- Bed planting system tested in Southern Kazakhstan reduced seed rates by almost half and provided higher winter wheat yields. At the same time, effective weed management appeared to be critical for the success of this technology.

- There were some on-farm research in the country has shown that bed planted crops have yielded better and consumed less irrigation water (about 40%) with lower seed rate, soil tillage and fuel expenses than flood irrigated crops. The soil is improved, especially on the top of the beds. Bed planting combined with reduced/zero tillage technologies looks promising to improve farming profitability, introduce better diversified rotations, reduce the turn-around period between harvesting and planting of the following crop to a minimum with a goal to produce two and more crops per year.
- Benefits of planting winter wheat on beds in irrigated systems in terms of yield and water savings from project demonstration site were significantly and ranged from 24-32%. Irrigation farmers must realize that seed rate decrease will be essential if they attempt to adopt permanent bed planting systems even though their primary goal may be simply to realize lower production costs.
- Maize green forage yield was higher in the treatment involving the no-till method compared to the other treatments. Further investigations of the effect of NT are needed to assess its effects in the longer term, specifically to monitor long-term effect of conservation agriculture.
- These results show that introduction of conservation agriculture as a no-till maize forage crop will help livestock producers to have access to low-cost forage resources and thus improve the efficiency of livestock production in Kazakhstan, and perhaps in other Central Asian countries as well.
- It is an established fact that grain yield of maize is closely linked with the irrigation rate which is proved by the results of this experiment. Irrigation rates should stay in the range of 500-600 $m^3$ $ha^{-1}$ for light, 600-800 $m^3$ $ha^{-1}$for medium and 800-1000 $m^3$ $ha^{-1}$ for heavy-textured soils.

**Uzbekistan**

- Based on the experiments performed in the framework of this project it is concluded that treatments with 60000 and 70000 live seeds had taller plants than other treatments and performed excellent for grain yield potential.
- Across the two years grain yield production of treatments 60000 and 70000 live seeds were higher than rest of the treatments. On the basis of the performance, 60000 and 70000 live seeds can be considered as best seeding rates for permanent bed planted maize cultivation in the irrigated conditions of Uzbekistan.
- The two-year average data showed that bed planting with nitrogen 180 kg $ha^{-1}$ application treatments tended to lead to higher winter wheat yield. Above stated findings shows that fertilizer use efficiency will be increased under bed planting in the region while fertilizer rate will be decreased in the this system.
- Significant findings of this study were; soy bean was appeared high response to *Rizobium* application at all treatments, especially Control+ Rizobium+ K60+P120 then; the response was lowest in treatments where *Rizobium* was not applied.
- No-till winter wheat results in an increase in crop production and higher grain yield as compared to conventional and minimum till.
- The results also indicate that retention of crop residues may be essential to ensure the required enrichment of critical levels of the chemical, physical and biological soil parameters that are crucial to ensure and achieve sustainable long-term production. Farmers must clearly realize that some residue retention will be essential before they attempt to adopt permanent raised-bed planting systems even though the primary goal

may be to simply realize lower production costs which is common with tillage reductions.

- The results presented in this study have shown that adopting cereal-legume rotation can increase winter wheat crop productivity.
- Crop rotations play an important role in the success of most crop production enterprises, but rotations are will be important for no-till crop production. With carefully planned crop rotations, the advantages of no-till crop production can be extended to soil types or situations where success is difficult. This should be further studied in no-till system.
- The results presented in this experiment with double cropped mung bean cultivation indicate that tillage reduction for surface irrigated production systems reverberate in the same positive way in terms of production profitability and sustainability total grain production. It should be mentioned here that that retention of crop residues will be essential to ensure that the required enrichment of critical levels of the chemical, physical and biological soil parameters, that are crucial to ensure long-term production sustainability, can be achieved. And also land use efficiency will be increased with double cropping of no-till mung bean.
- Improved furrow irrigation technologies (raised bed planting) provide significant increase in WUE and good net returns due to increased crop yields.
- It was also observed that by improving water coverage, plant populations could be reduced by up to 40%, which resulted in less time spent on weeding operations, from 21 down to 5 labor-days per hectare. This represented a reduction of up to 16 person-days per hectare, a 75% decrease in the traditional labor requirement for weeding.
- Similarly, cost-benefit analyses of improved technologies to assess the economic viability of useful options for better livelihood of farming communities in three participating countries under this project are completed. The cost benefit analyses of technologies revealed that many of the technologies developed and disseminated under the Project have considerable advantage than those currently practiced by the farmers in Central Asian countries. The economic assessment of technologies was based both in quantitative and qualitative methods of analysis. Among those technologies, the application of no-till practices and bed planting of winter wheat, new crop rotation options with inclusion of legumes in cropping systems, etc. were found to be useful for increasing farmers' income and improving their livelihoods.
- A signal variant of no-till drill has been produced in a factory located in Karshi, near the Uzbekistan project site. The newly developed no-till drill in this case is project product, modifying a disc type conventional seeder to a no-till drill, with the advantage over the models from Turkey seen in other parts of the project, that the tine type can handle residues and that they follow the contour for each row independently and are fixed.

## Recommendations

Recognizing the importance given to the development of the agricultural sector by the Governments of the region, and after reviewing the conservation agriculture project country reports and considering critical issues, raised during the final workshop of the project, the key conclusions and recommendations are summarized and presented below:

- Local no-till drill development is absolutely essential for up-scaling of conservation agriculture practices in the region and manufacturing of no-till drill should be

organized. The project proposal on development of no-till drill in the region to be formulated and implemented.

- Another crucial factor is the availability of affordable and appropriate CA equipment for the specific farming conditions.
- Both types of crop diversification as single crops and double cropping systems will be essential to improve sustainability of farming and income generation at the local, regional and national levels. Prepare a project proposal on crop diversification under CA for each country in the region.
- It will be helpful if the Government would encourage the CA practices to enhance agricultural production of salt- and drought-affected regions, which are extremely important issues in the region.
- Assist the Governments of the countries in the region in formulation and implementation of the national strategies on adoption and promotion of conservation agriculture. Prioritize the training programs and focus on no-till, raised-bed practices and their development and improvement.
- Carry out awareness raising campaigns, establish and arrange demonstration sites, filed days, workshops and seminars for wide adoption and promotion of CA.
- Close collaboration of all stakeholders for introduction and up-scaling of CA, particularly farmers, farmer's communities, NGOs, Machinery industry, Government offices and institutions, universities, and also higher ministry levels is suggested
- Make a Special State decree on "Support the development of the zero till and direct planting practices" for wider adoption and increased effectiveness of CA.
- One of the key areas requiring immediate attention is the organizing training courses on CA machinery.

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# Annex 1 Pictures

Topographic survey in Kazakhstan

Laser land leveling in Azerbaijan

Bed planted soy bean in Uzbekistan

Bed planted winter wheat in Azerbaijan

No-till triticale in Kazakhstan

Herbicide application into no-till corn in Azerbaijan

Direct planting of corn in Azerbaijan

No-till mung bean in Uzbekistan

Field day in Uzbekistan, 08 Jun. 2012

Formal training course in Kazakhstan, 12 Jun. 2012

National Coordinator Dr. Asad Musaev interviewed by local media

Newly developed no-till planter in Uzbekistan