Food and Agriculture Organization of the United Nations

# PRACTICE OF CONSERVATION AGRICULTURE IN AZERBAIJAN, KAZAKHSTAN AND UZBEKISTAN

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**FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS**

**Ankara, 2016**

**ISBN 978-92-5-109247-7**



**Photo cover: Seymur Safarli**

**Printed in Turkey**

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## ABBREVIATION

| | |
|---|---|
| **ADB** | Asian Development Bank |
| **AZ** | Azerbaijan |
| **BP** | Bed-planting |
| **CA** | Conservation Agriculture |
| **CIS** | Commonwealth of Independent States |
| **CP** | Conventional planting |
| **CT** | Conventional till |
| **CIS** | Commonwealth Independent States |
| **EC** | Emulsifiable concentrate |
| **EU** | European Union |
| **FAO** | Food and Agriculture Organization |
| **FAO-SEC** | FAO Sub regional Office for Central Asia |
| **FTPP** | FAO-Turkey Partnership Program |
| **GoT** | Government of Turkey |
| **GPS** | Global Positioning Systems |
| **ICARDA** | International Center for Agricultural Research in the Dry Areas |
| **ICARDA-CAC** | ICARDA for Central Asia and the Caucasus |
| **KZ** | Kazakhstan |
| **L** | Left |
| **MARA** | Ministry of Agriculture and Rural Affairs of Turkey |
| **MT** | Metric Tonnes |
| **N** | Nitrogen |
| **NT** | No-Till |
| **PFU** | Project Facilitation Unit |
| **R** | Right |
| **S.C.** | Suspension Concentrate |
| **SK** | South Kazakhstan Province |
| **USD** | United States Dollars |
| **UZ** | Uzbekistan |
| **W.S.** | Water Solution |
| **WB** | World Bank |

## ACKNOWLEDGEMENTS

These Guidelines have been prepared based on the findings of GCP/RER/030/TUR, Conservation Agriculture for irrigated areas in Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan, which was implemented during 2011-2013. The project has been financed by the Partnership Programme of the Food and Agriculture Organization of the United Nations (FAO) and the Republic of Turkey and implemented by the FAO Subregional Office for Central Asia in cooperation with the International Centre for Agricultural Research in the Dry Areas (ICARDA).

The representatives of FAO, ICARDA and the co-authors extend their thanks to involved government officials and farmers for active role and support in undertaking the project activities. The project, in its turn, has contributed to enhancing the capacity of national information resources and strengthening the practical skills in introducing new technologies.

The co-authors are most grateful to Dr. Seimour Safarli (Azerbaijan), Dr. Adzhar Karabalaeva (Kazakhstan) and Dr. Ravshan Boirov (Uzbekistan) for providing information support in exercising raised-bed and water-saving technologies, and in validating the economic aspects of Conservation Agriculture (CA) in the relevant project countries. The contribution of these people has helped to make the main sections of the Guidelines more informative.

Special gratitude is reserved for Dr. Asad Musaev (Azerbaijan), Dr. Rakhimzhan Medeubaev (Kazakhstan) and Dr. Yormamat Khaliyarov (Uzbekistan) for supporting the timeliness of project activities and for providing technical and practical support that helped to prepare the information to write these Guidelines.

A significant contribution to researches that have formed the basis of this book and the invaluable assistance for the project have been provided by the national experts, Dr. Kamil Fataliev (Azerbaijan), Dr. Natalya Gritsenko (Kazakhstan) and Dr. Abdumalik Namozov (Uzbekistan).

Special thanks shall be given to Dr. Akmal Akramkhanov, whose distinct and important contribution as well as valuable comments and proposals concerning knowledge dissemination have set the basis for the draft Guidelines.

We also note here the hard work of Anton Krylov, who has translated this book from English to Russian and made it available to a broad reading audience. We also thank Tatiana Semenova for her help in editing the Guidelines.

In conclusion, the co-authors express their profound gratitude to all FAO and ICARDA staff for technical and administrative support provided to the project and these Guidelines.

# FOREWORD

Agriculture is an important part of the economy in Central Asia and contributes significantly to the food security of the majority of population. Sustainable development of agriculture, increase of production and improvement of population welfare largely depend on soil condition and its fertility. Over the past decade, the agricultural lands, however, have suffered from progressive degradation leading steadily to the loss of their fertility and eventually to a low yield and inefficiency of production as a whole.

Land degradation is the direct result of inefficient farming driven by conventional soil tillage that leads to intensive mechanical pressure on fertile soil layer. This is why the soil structure is severely disturbed, and living organisms in the soil ecosystem inflict tangible damages. Arid and rough topographic conditions, difference in altitudinal zonation and increasing impact of climate change will only worsen the situation in time. It is therefore necessary to take proactive measures for preserving the structure of soil cover, accumulating moisture and providing optimal conditions to support the vital functions of soil organisms. Such measures should primarily include: the reduction of mechanical pressure on soil through direct-seeding and zero-tillage practices; the protection of soil cover; the increase of moisture deposits and organic matter by keeping surface mulch; and the improvement of agricultural cultivation techniques and adoption of diversified crop rotation.

All measures listed above are the fundamental principles of Conservation Agriculture (CA), a modern approach to managing agricultural ecosystems in order to increase productivity and ensure their sustainability. CA can form the basis for further development of environmentally and economically sound crop production and can help to address the issues of food security, combat poverty, optimize livelihood in rural areas and reduce the cost of energy resources, etc.

The adoption of CA requires that a managed farming system be created incorporating local knowledge and capacity and that a number of relevant practical skills suitable for farms be developed. In terms of production, CA can provide opportunities for intensifying crop production in rainfed and irrigated farming. Such fundamental changes in the farming system require reassessment of priorities in: crop production; on-time and sufficient use of fertilizers; efficient use of water; weed control; and management of labour and energy resources.

Recognizing the importance of this issue, the Food and Agriculture Organization (FAO), the centres of the Consultative Group on International Agricultural Researches and international financial organizations have been assisting over several years in promoting CA in rainfed conditions in the Northern Kazakhstan, and this promotion

has produced excellent results. Consequently, the four countries of Central Asia requested FAO to support the promotion of CA principles and methods in irrigated agriculture. The request was responded by implementation of GCP/RER/030/TUR, Conservation Agriculture for irrigated areas in Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan. The project was funded by the Partnership Programme of FAO and the Government of Turkey and implemented from 2011 to 2013 in Azerbaijan, Kazakhstan and Uzbekistan by the FAO Subregional Office for Central Asia in cooperation with the International Center for Agricultural Researches in the Dry Areas.

The project enabled to accumulate invaluable and multifaceted experience in adopting CA approaches in various conditions of the neighboring countries. A large amount of analytical and practical information draws up these Guidelines, which compile general concepts, experiences and practical recommendations directly applicable for detecting gaps and obstacles in agricultural production and for identifying, undertaking and assessing the activities that increase productivity and sustainability, conserve water and soil in irrigated areas where farming systems include both irrigated and dryland crops.

The book summarizes and presents the information on possible ways to adopt CA approaches under the conditions of the countries mentioned above and makes recommendations for their further promotion. The Guidelines cover such topics as the significance and current state of agriculture in the project countries, permanent raised-bed planting technologies, zero-tillage technologies, weed varieties and main measures to control them, crop rotation, overview of CA machinery and equipment, and laser-assisted land levelling.

The Guidelines target agricultural scientists, specialists, trainers, extension consultants and interested farmers. We hope that the information in these Guidelines will contribute to the promotion of CA, increase of productivity and sustainability in irrigated areas of Azerbaijan, Kazakhstan, Uzbekistan and other countries of Central Asia.

***Yuriko Shoji,***
*FAO Subregional Coordinator*
*for Central Asia*

# 1. INTRODUCTION

## 1.1. Status of agricultural systems in the project countries

Agriculture in Central Asia region is diverse and has the potential to revitalize the economies of Central Asian countries. Kazakhstan, Uzbekistan and Azerbaijan have seen 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 needs and capacities of these new farmers, and impacted their access to agricultural machinery and other production inputs. Through intensive investment in strategic crops, Central Asian countries have continued to promote economic and agricultural development as a means to overcoming the challenges of food production and achieving national food security.

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

Azerbaijan has diverse agro-ecological and climatic conditions (Figure 2). Traditionally, agriculture in Azerbaijan has been based on high water consuming

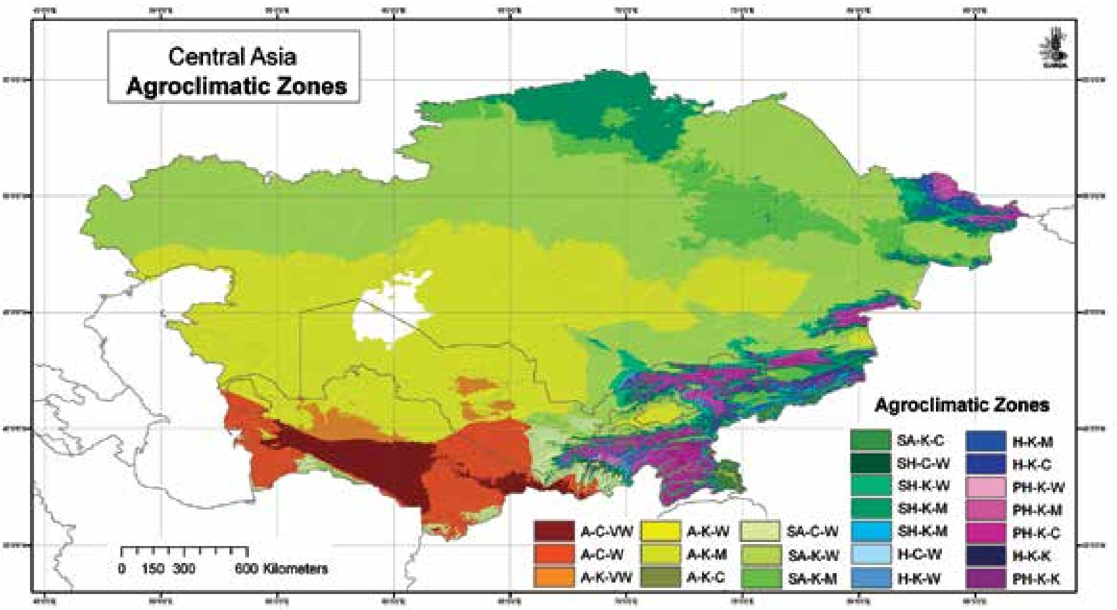


**Figure 1.** Agro-climatic zones of Central Asia (De Pauw, 2008)

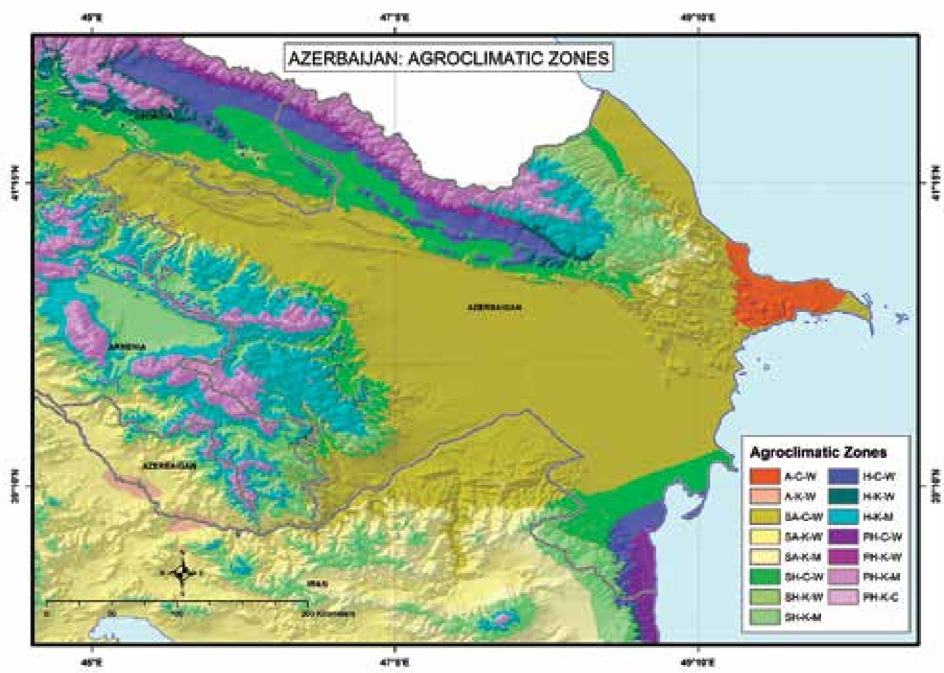


**Figure 2.** Azerbaijan agro-climatic zones (De Pauw, 2008)

crops, and thus water shortages are often recorded during the summer period in many regions including the Ter-Ter district where the project demonstration site is located. One of the main constraints to further increases in agricultural production is limited irrigation water. Therefore the adoption of improved irrigation technologies in conjunction with the practice of CA has become an increasingly important option for Azerbaijan to increase production with less water.

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 fields are flood irrigated, resulting in high crop kill due to highly mineralized ground water and soil crusting. An effective alternative approach to reducing the impact of salinity is the practice of bed-planting combined with furrow irrigation.

In Uzbekistan, the area under irrigated winter wheat has increased as a result of the policy intented to ensure national food security. This has resulted in a change in cropping systems where the former longer-cycle cropping system based on cotton and alfalfa has been largely replaced by a shorter crop rotation based on winter wheat and cotton. As a result, wheat production in Uzbekistan has increased by more than 600 percent, reaching 7.5 Million Metric Tonnes (MT) in 2013. In Kazakhstan, on the other hand, winter wheat production declined to 5 Million MT due to a reduction in the area planted under rainfed conditions.

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

| Country | Total territory (M ha) | Land area (M ha) | Cropland (M ha) | % cropland | % Agricul. GDP | Population (million) | Population density (km$^{-2}$) | % rural population | Per capita cropland (ha) |
|---|---|---|---|---|---|---|---|---|---|
| Azerbaijan | 8.60 | 8.20 | 1.77 | 20.0 | 5.5 | 9.3 | 104.0 | 45.0 | 0.19 |
| Kazakhstan | 272.49 | 269.70 | 24.00 | 8.8 | 5.2 | 15.7 | 6.0 | 42.8 | 1.52 |
| Uzbekistan | 44.74 | 42.54 | 4.90 | 10.9 | 18.5 | 30 | 65.0 | 63.5 | 0.16 |
| Total | 325.83 | 320.44 | 30.67 | 9.4 | 9.7 | 55 | 16.0 | 50.4 | 0.55 |
| *Source: National statistical books of Azerbaijan Kazakhstan and Uzbekistan, 2013* | | | | | | | | | |

The total land area of the three project countries covers 320.44 million hectars (M ha), roughly 98% of the total area, the rest being water bodies. Kazakhstan with 270 M ha is the largest of the three countries, comprising almost 81.2% of the entire area, followed by Uzbekistan 44.74 M ha (15.7%), while Azerbaijan is a smaller state, comprising 8.20 M ha (3.04%). The population is sparsely settled with the highest density (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) with lowest of 0.16 ha and 0.19 ha in Uzbekistan and Azerbaijan, respectively, to the highest (1.45 ha) reported in Kazakhstan.

## 1.2. Conservation Agriculture in the region

Agricultural croplands in Azerbaijan, Kazakhstan and Uzbekistan include both rain-fed and irrigated areas and consequently, the adoption and adaptation of CA practices should be considered according to the farming systems in the different agro-climatic zones (Figure 1 and Figure 2). For example, raised beds[1], which are suitable in the irrigated systems of Central Asia, are less appropriate in rainfed systems.

Conservation Agriculture is based on three linked principles: (i) no or minimal mechanical disturbance of the soil (No-Till seeding), the health and productivity of which is the basis of farming operation; (ii) maintenance of permanent soil cover with plant residues or living cover crops including green manure legume crops in order to reduce water loss and erosion, protect the soil from harsh climate extremes, and provide substrate for soil micro-organism; and (iii) crop diversification in time and space through rotations, sequences and associations, involving annual and perennial crops (FAO, 2008).

Conservation Agriculture is defined as a concept for resource - saving agricultural crop production that strives to achieve acceptable profits, high and sustained production levels while concurrently conserving the environment. CA is based on enhancing

[1] We define permanent raised beds as raised beds that were prepared and used during a previous season but subsequently used also for growing the next crop on the same beds. Therefore, we differentiate between raised beds that are not permanent (fresh beds prepared every season) and those that are permanent.

natural biological processes both above and below the ground. Interventions such as mechanical soil tillage are reduced to an absolute minimum or avoided altogether, and the use of external inputs such as agrochemicals, nutrients of mineral or organic origin are applied at an optimum level and in ways and quantities that do not interfere with or disrupt the biological processes (FAO, 2008).

Also, Conservation Agriculture can contribute to mitigating climate change, at least as far as the release of greenhouse gases is concerned. With increasing soil organic matter, soils under CA can retain carbon from carbon dioxide and store it safely for long periods of time. This carbon sequestration in the soil will continue for 25 to 50 years before reaching a new plateau level of soil carbon saturation (Reicosky, 2001). The consumption of fossil fuel for agricultural production is significantly reduced under CA and the burning of crop residues is completely eliminated, which also contributes to reduction in greenhouse gas emissions. In addition, soils under a No-Till system, depending on the management practise, may also emit less nitrous oxide (Izaurralde *et al.*, 2001).

Improving soil physical and chemical properties is important characteristic of both the conventional and CA system, but the improvement of biological properties is particularly significant under CA, as the biological environment of soil is greatly degraded by the type and degree of tillage, whereas CA provides a more conducive environment for improving the biological health and function of soil. For example, improving the biological capacity of soils under CA management impacts nutrient release through the decomposition of plant and animal residues, and increases the population of beetles, insects, worms, fungi, and bacteria, all of which are involved in the decomposition and humification processes.

In Conservation Agriculture, crop rotation is an integral part of the crop production system. A benefit of a good crop rotation is improved yield and a reduction in inputs. A well-planned crop rotation can improve insect, disease and weed control and will aid in maintaining, or improving, soil structure and organic matter levels. Using a variety of crops can reduce weed pressure, spread the workload, protect against soil erosion and reduce biotic and abiotic stress, as well as economic risks. Legume crops in the rotation reduce subsequent nitrogen input needs and have become more valuable with the increased cost of mineral nitrogen. Research and experience has proven that a good crop rotation will provide more consistent and stable yields, build soil productivity and increase the profit potential.

Over the last decade, the term CA has made its way into research and development communities of Central Asian countries. For example, since 2006 the Kustanay Research Institute of Agriculture, located in the north-west of Kazakhstan, has gradually moved away from conservation tillage and towards No-Till[2]. Similarly, FAO Sub-Regional Office for Central Asia (FAO-SEC) has made a systematic effort to promote a regional strategiuc framework for the promotion of CA in Central Asia, and has been providing technical support to countries in Central Asia to adopt and scale CA (FAO, 2012). In the early 20th century, the area under irrigation in Central Asia expanded rapidly from 1930s through until the 1990s (Figure 3), totalling 8.5 M ha in 1990. The expansion of irrigated

[2] No-Till consisting of direct drilling as the only mechanical operation disturbing the soil surface. All other operations usually employed under "conservation tillage" in the rainfed areas of Kazakhstan such as for instance sweep tillage, disking and harrowing are thus not included.

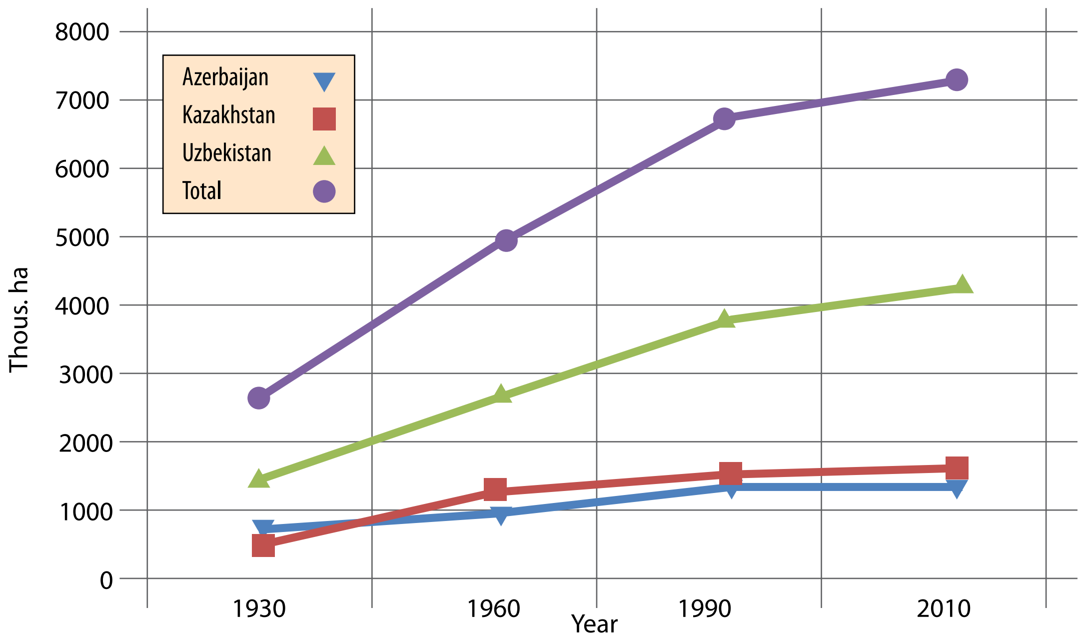


**Figure 3.** Development of irrigated areas in project countries during 1930-2010

farmland combined with poor water management resulted in several environmental problems and the devastation of the Aral Sea. After 1990, the growth of irrigated areas slowed significantly in all countries, and over the last 20 years (1990-2010) increased by only 1 M ha (Nurbekov *et al.*, 2013).

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, and EU funded research projects. All shared their resources and experiences with the 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 strengthen the sustainability of farming mainly through improvement in soil structure and health; 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 2 421.5 ha in 2013. The results of the FAO project on CA also convinced policy makers to begin the introduction and adoption of CA in Azerbaijan. Today the country has taken measures to implement programs on resource saving technologies, as envisaged in the national agriculture development plan.

According to the Ministry of Agriculture of Kazakhstan, in 2011, the area covered by reduced tillage, including No-Till was 11.7 M ha, which was 70% of all the area sown to wheat. Consequently, in 2011, the country harvested record gross output of grain (20 Mt) corresponding to a yield of 1.7 t $ha^{-1}$. The area under strict CA in Kazakhstan in 2011 was 1.7 M ha (Karabayev *et al.*, 2012).

Qilichev and Khalilov (2008) reported that over the previous 20 years, Uzbekistan has been researching ways of introducing grain crops into a crop rotation that consisted mainly of cotton and alfalfa. Long-term research has shown that broadcasting seed

into standing cotton crop that was sown earlier had a large advantage over delayed sowing following deep tillage. However, sowing at the same time with different tillage methods resulted in similar grain yields, compared to deep tillage. The reality is that in order for wheat to be sown following a cotton crop, sowing cannot be delayed until the cotton harvest is completed. Research has confirmed that planting winter wheat in standing cotton crop is a promising practice. According to information from the Uzbekkistan Ministry of Agriculture and Water Management, 600 000 ha of wheat was broadcasted into standing cotton in 2012.

# 2. PERMANENT-BED PLANTING TECHNOLOGIES

## 2.1. Bed planted winter wheat management

The bed-planting technology involves growing crops on raised beds and using the beds permanently with consecutive crops without tillage which incorporates the benefits of zero-till to bed-planting, and 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 mulch from the residues of the previous crop. There is 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 and disease pressure. Currently, bed-planting systems for wheat production are gaining importance in other parts of the world. The introduction of this technique in North Mexico improved wheat grain yield by at least 10% and water economy by up to 35% compared to conventional systems (Aquino, 1998).

Raised-beds are particularly favourable for seed multiplication and crop production systems using hybrid seeds, as they significantly reduce seeding rates. Therefore, a CA system combined with bed-planting should lower production costs.

In Azerbaijan and in South Kazakhstan province, yield of winter wheat under irrigation is still low, in the range of 1.8-2.7 t $ha^{-1}$. One reason for the low productivity is poor management such as delayed planting, poor irrigation practises, suboptimal seeding rates, incorrect selection of varieties, to name a few.

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

The project evaluated raised beds having three rows of wheat per bed. It was determined the beds having two rows per raised bed had yields equal to beds having three rows and had the additional advantage in that the weeds under the two row per bed system could be managed mechanically, fertilizer could be applied as a top dress application between the rows (increasing efficiency) and there was a reduction in lodging due to larger (thicker) stems. Bed-planting also had the advantage of allowing lower seed rates, and produced a larger, heavier seed, an important issue in hybrid seed production. For this trial, all planting was done using a new no-till drill adjusted to allow for bed-planting.

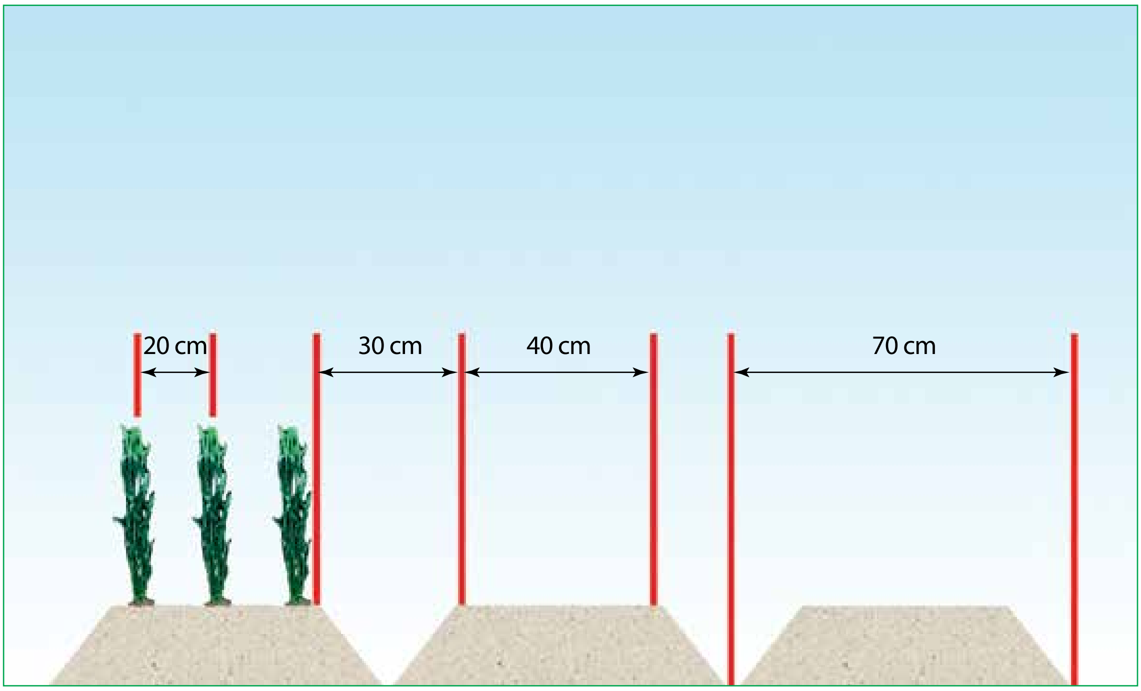


**Figure 4.** Configuration of raised beds and planting arrangements for irrigated wheat

### 2.1.1. Seeding date and rate

Optimal seeding dates and timely pre-sowing irrigation pre-defines the yield potential of agricultural crop in bed-planting. In South Kazakhstan, optimal dates for bed-planted winter wheat range between September 25 and October 15-20; in Kashkadarya province of Uzbekistan optimal planting date is during mid October while in Azerbaijan the optimal planting date is from late October to the beginning of November. Autumn vegetative period vary between 25 and 45 days, and impacts the efficient of use soil moisture reserves and the rate of crop growth when vegetative growth resumes in the spring. Timely planting in the fall stimulates the plants' rapid growth with more effective use of precipitation in the early spring. In the spring, raised-beds warm up faster and growth of winter wheat occured earlier compared with the conventional seeding practice.

The winter wheat varieties Azamatli-95 and Tale in Azerbaijan, Almaly and Zhetysu in Kazakhstan, and Turkiston and Jayhun in Uzbekistan were each sown at a rate of 130 kg $ha^{-1}$ on raised beds, and compared to the same varieties sown by broadcasting the seed at a rate of 200 kg $ha^{-1}$. Grain yield was higher under the raised bed system, utilizing a lower seed rate (Figure 5).

Depending on seeding method, higher sowing rates do not always result in a yield increase; on the contrary, at lower seeding rate, the number of productive tillers, spike size, grains per spike and 1 000 kernel weight all increase and contribute to higher yields. It is important to understand the importance of timeliness of seeding combined with the use of high-quality seeds of locally adapted varieties as a component in increasing crop productivity.

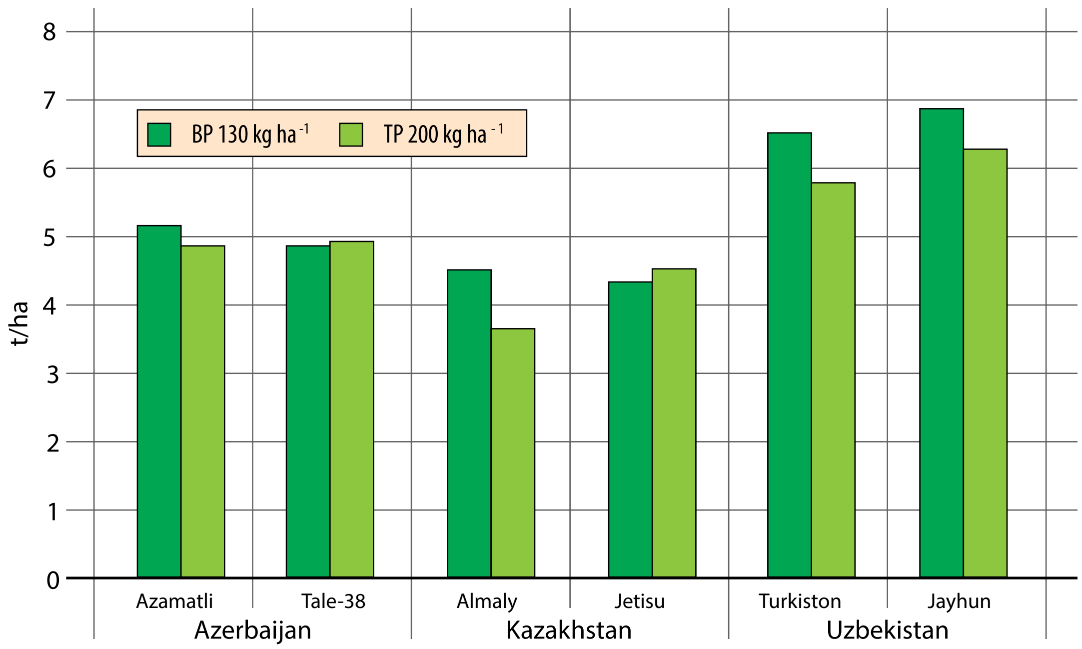


**Figure 5.** Effect of planting method and seed rate on productivity of winter wheat 2012-2013

Seeding rates for raised bed-planting of winter wheat varys with a rate at 1.5-3.0 million live seeds in South Kazakhstan (Sydyk *et al.*, 2008), 2.0-3.0 million live seeds in both Azerbaijan (Jumshudov *et al.*, 2012) and Uzbekistan (Qilichev and Khalilov, 2008). Seeding rate will depend on the biological characteristic of a variety, planting dates, land preparation, soil water and fertilizer application.

### 2.1.2. Fertilizer application under bed-planting

Nutrient deficiency at any time during a wheat plant's life will reduce yield, but if the nitrogen deficiency occurs during its rapid vegeta¬tive 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. In the demonstration sites, nitrogen was managed for intensive production with 1/3 of the N rate applied at tillering stage and the remainder at booting stage. 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 kg $ha^{-1}$ which produced an additional yield increase that was statistically significant across the two 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 (5.88 t $ha^{-1}$) was recorded in the treatment where nitrogen rate was 160 kg $ha^{-1}$ (Figure 6) 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 tended to lead to higher winter wheat yield.

In order to optimize nutrient uptake when cultivating winter wheat, it is important to apply rational rates of phosphorous fertilizers at the rate of P90 kg $ha^{-1}$ of ac-

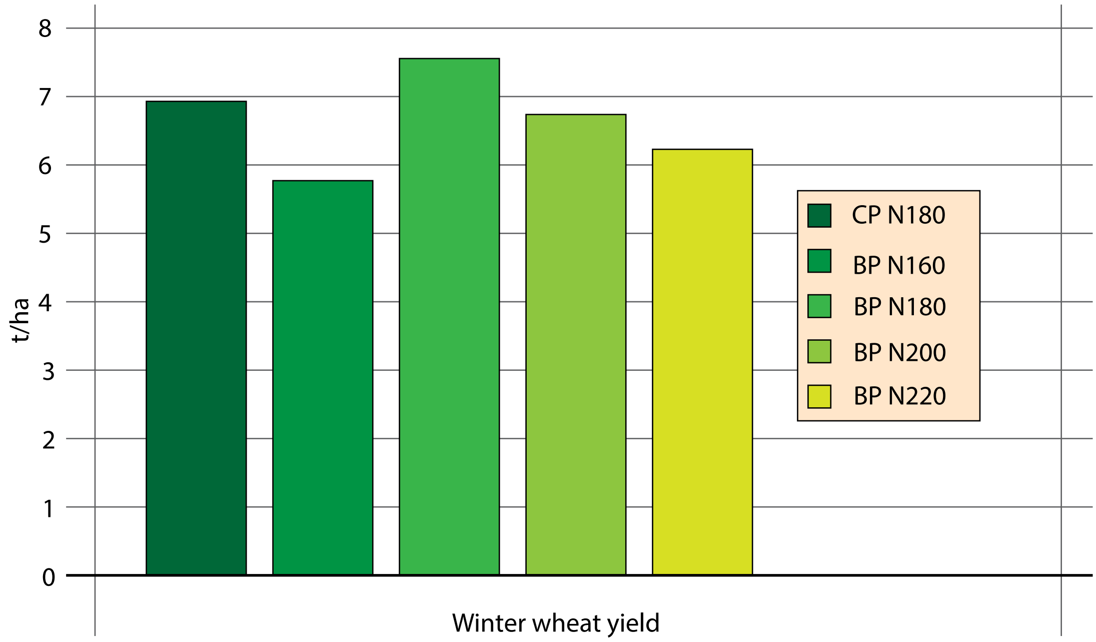


**Figure 6.** Winter wheat yield as affected by planting method and nitrogen rates (2012-2013)

tive substance at the time of seeding. Bed-planting with winter wheat provides high grain yield, when fertilizer application is managed efficiently.

### 2.1.3. Irrigation

It is important to provide timely supplementary irrigation at the rate of 700-800 m$^3$ ha$^{-1}$ (at the beginning) because during planting, moisture reserves of topsoil layers are not sufficient to obtain good seed germination. It is worthwhile mentioning that supplementary irrigation quality, i.e., even distribution of water through the furrows and its absorption to the required depth (70 cm), to a great extent, determines good seedlings of winter wheat with optimal plant density, which, eventually, determines its yield potential.

During the vegetative period in winter wheat, irrigation through an intermittent supply to every furrow with soil moisture saturation to the depth of 0.6-0.7 m is important in order to maintain pre-irrigation moisture at the level of 70-75% of field capacity:

- In humid years – without irrigation or one-time irrigation at grain filling stage (600-700 m$^3$ ha$^{-1}$);
- In moderately humid years – one-time irrigation at the end of 1$^{st}$ decade of May (May 7-10) at the end of booting stage and beginning of ear formation (700-800 m$^3$ ha$^{-1}$);
- In extremely dry years – two-time irrigation: first irrigation – at the beginning of the 1$^{st}$ half of April at winter wheat booting stage; second irrigation – in mid-May at grain formation stage (800 m$^3$ ha$^{-1}$).

One of the main benefits of bed-planting is water savings as well as greater water use efficiency. Therefore, in high-production cases, bed-planting allows for

**Table 2.** Effect of traditional and bed-planting on winter wheat yield and water use efficiency in Azerbaijan (Jumshudov et al., 2012)

| Farmers | Planting method | 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 | 1 900 | 1.67 |
| | Bed-planting | 5.23 | 5.10 | 1 600 | 2.36 |
| Farm 2 | Traditional planting | 2.57 | 2.53 | 1 950 | 1.85 |
| | Bed-planting | 3.42 | 2.52 | 1 600 | 2.11 |

*Note: Traditional planting means crop planted in tilled field*

yields higher than those possible on flat bed (Nurbekov, 2008). An increase of water use efficiency by 21–30% combined with an approximate saving of 17% in applied irrigation was observed with bed-planting (2.36 and 2.11 kg m$^{-3}$) compared with conventional planting (1.67 and 1.85 kg m$^{-3}$) (Table 4).

Depending on soil moisture content, irrigation rates vary within the range of 600-800 m$^3$ ha$^{-1}$. In this case, irrigation rates and total water consumption for Almaly and Zhetysu (Figure 7) varieties at intermittent irrigation in every furrow amounts to an average of 1 400-1 500 m$^3$ ha$^{-1}$ and 1 500-1 800 m$^3$ ha$^{-1}$ respectively (Karabalayeva and Sydyk, 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 3. 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, 4.45 t ha$^{-1}$, was recorded in South Kazakhstan. 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,

**Table 3.** Wheat Yield Response to planting method (2011-2013)

| Planting method | Wheat grain yields (t ha$^{-1}$)* | | | 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 % |

**Fertilizer rate for all planting methods were 90 kg ha$^{-1}$ of N and 60 kg ha$^{-1}$ P.*

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**Figure 7.** Bed-planted winter wheat variety Zhetysu in Kazakhstan (L) and Azamatli-95 variety in Azerbaijan (R)

Intensivnaya, Steklovidnaya 24 and Yuzhnaya 12 in Kazakhstan (Sydyk *et al.*, 2008), Azamatli-95 (Figure 7), 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 varieties, especially with high tillering capacity, for bed-planting.

### 2.1.4. Economics of permanent bed planted winter wheat

Labor and resource inputs are the most important indicators for economic evaluation of agricultural practices in question. Thus, for conventional farming, direct costs per 1 ha amount to an average of USD 230, whereas for the raised-bed-furrow technology with low seeding rates (2.0-3.0 million live seeds), the costs are lower or amount to USD 200 (Sydyk and Karabalayeva, 2010).

The highest net benefits (USD 745 $ha^{-1}$) were obtained with bed-planting while the conventional method achieved the lowest net benefits (Table 4). 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 (Jumshudov *et al.*, 2012).

**Table 4.** Economics of planting methods on winter wheat productivity in Azerbaijan

| Planting methods and seeding rates | Grain yield, t $ha^{-1}$ | Production cost USD $ha^{-1}$ | Production value USD $ha^{-1}$ | Net benefits, $ | Profitability rate,% |
|---|---|---|---|---|---|
| Conventional – 220 kg $ha^{-1}$ | 3.02 | 465 | 960 | 495 | 106 |
| Bed – 130 kg $ha^{-1}$ | 4.29 | 535 | 1 280 | 745 | 139 |





**Figure 8.** Bed-planted winter wheat at milky (L) and full maturity stage (R)

Sydyk et al. (2008) reported that cost-benefit analysis for bed-planting of winter wheat indicated that lower seeding rates were needed in Kazakhstan. For example, at a seeding rate of 2.0-3.0 million live seeds, the highest production cost per ha ranged between USD 866 and USD 933 where fertilizer applied to bed in early spring at the rate of N60 kg $ha^{-1}$. This helps to achieve the highest net operating revenue of about USD 733 and lower the production cost per kg of grain to about USD 1.50. While in conventional planting net operating revenue was between USD 466 and USD 500 (Figure 8).

The model of winter wheat production under permanent bed-planting technology on irrigated areas in Azerbaijan, South Kazakhstan and Uzbekistan is given in Appendix 9.1.

## 2.2. Permanent bed planted maize

Maize (*Zea mays* L.) is a second important cereal crop after winter wheat in the irrigated conditions of Azerbaijan, South Kazakhstan and Uzbekistan, and it is a dual-purpose crop for grain and fodder.

### 2.2.1. Planting period and rate

The planting period of grain maize is mid-April in South Kazakhstan while in Uzbekistan it is the beginning of April, when the soil temperature is about 10-12°C at the depth of seeding, 6-8 cm deep, with 70 cm width between rows with simultaneous packing of soil to ensure uniform sealing of the seeds.

The following density of maize varieties and hybrids should be observed:

- Late–maturing – 55 000-60 000 plants ha$^{-1}$;
- Medium–late–maturing – 60 000-65 000 plants ha$^{-1}$;
- Medium–maturing – 65 000-70 000 plants ha$^{-1}$;
- Early–maturing – 80 000 plants ha$^{-1}$.

### 2.2.2. Water management in maize production for grain

One of the key factors in obtaining high and stable maize yields, in Azerbaijan, South Kazakhstan and Uzbekistan which are 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 and hybrids of maize.

The most crucial period in ensuring the availability of water for maize - is 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 in all regions with irrigated agriculture are obtained by ensuring persistently high soil

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**Figure 9.** The technology of furrow irrigation with siphon tubes (L) and the use of small-scale implements of surface irrigation (R)

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. 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 800-1 000 $m^3$ $ha^{-1}$ for heavy-textured soils.

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.

There are more advanced methods of supplying irrigation to the water furrow: using flexible hoses of nylon fabric, detachable pipelines, reinforced by adjustable water ejectors from enclosed piping embedded in the soil at the depth of 40 cm (Figure 9).

Recommended furrow length should be from 60-100 to 250-400 m, depending on the slope, soil permeability, the size of furrow stream, and field relief conditions.

The model of permanent bed-planted maize production in the irrigated conditions of Azerbaijan, South Kazakhstan and Uzbekistan is given in Appendix 9.2.

For rational use of irrigation water on gray soils of South Kazakhstan in the production of maize for grain, and to maintain pre-irrigation field capacity at 70-80-70% during the growing season, it is recommended to conduct watering with moistening the soil ground at the optimal depth (0.5-0.7-0.6 m) as follows:

- For late-maturing hybrids with 132-136 days of growing period duration at 149-153 days: in wet years with irrigation rate at 2 120 $m^3$ $ha^{-1}$, in dry years with irrigation rate at 3 300 $m^3$ $ha^{-1}$;
- For more late-maturing varieties with vegetation: wet years with irrigation rate at 2 630 $m^3$ $ha^{-1}$ and in dry years with irrigation rate at 3 930 $m^3$ $ha^{-1}$.

It is an established fact that grain yield of maize is closely linked with the length of the growing season and the development of assimilation surface. The more late-maturing is the hybrid or variety, the greater assimilation surface is developed by the plants and the higher is the grain yield.

# 3. NO-TILL TECHNOLOGY

## 3.1. No-Till irrigated winter wheat

Conservation Agriculture is good for farmers and the environment. CA 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.

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. Winter wheat productivity was higher in the treatment with No-Till method compared to other treatments (Table 5). The absolute highest yield of 6.71 t $ha^{-1}$ was recorded in the No-Till treatment in 2013 while in conventional tillage the maximum yield was 6.54 t $ha^{-1}$. This is in line with Nurbekov *et al.* (2012) where they report that No-Till winter wheat yield was higher compared to conventional and minimum till. There are also a number of changes which take place in the No-Till soil.

The winter of 2013 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 2012 (Table 5).

## 3.2. No-Till winter wheat under rainfed conditions

Depending on availability of precipitation, hydrological and hydrothermal conditions and the administrative division, rainfed areas in South Kazakhstan and Uzbekistan are grouped into the following three rainfed zones:

**Table 5.** Effect of different tillage methods and seed rate on winter wheat yield, t $ha^{-1}$

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

*Note: CT – conventional tillage; MT- minimum tillage; NT- No-Till.*

- Rainfed areas well-provided with moisture (at altitude of 600-1 500 meters above sea level, precipitation level exceeds 600 mm);
- Rainfed areas half-provided with moisture (at altitude of 350-600 meters above sea level, precipitation ranges between 300 and 600 mm);
- Rainfed areas poorly provided with moisture (at altitude of 200-300 meters above sea level, precipitation amounts to 200-300 mm).

Sydyk *et al.* (2009) and Yusupov *et al.* (2004) studied the possibility of No-Till direct seeding, and ways of reducing tillage in cultivating winter wheat. They showed that it was possible to produce No-Till winter wheat in rainfed areas of South-Kazakhstan and Uzbekistan through direct seeding with mandatory application of mineral fertilizers and herbicides. Several varieties proved to be most suitable for direct seeding in rainfed areas of South Kazakhstan and Uzbekistan (Sydyk and Isabekov, 2011; Yusupov *et al.*, 2004).

In rainfed areas under conventional tillage, the biggest problem is with open fallow when multiple tillage operations are conducted to control weeds, causing substantial soil erosion and degradation. It is established that through application of No-Till practices soil moisture can be increased and conserved compared with conventional tillage. Crop rotation and relevant structure of areas under crop should be conducive to fully-fledged use of soil moisture reserves during the vegetative period and draw maximum benefit from production factors that are under management control. These include: optimal plant density, seeding methods, application of optimal amounts of fertilizers, use of locally adapted varieties, and water-saving technologies for cereal crop production. In general, in crop rotation, winter wheat comes after perennial forage legumes (alfalfa), pulses, melon and safflower.

### 3.2.1. Timelines, standards and seed depth

In spring, as early as fieldwork is possible, winter wheat planting density and winter survival risk should be assessed. It is important to provide extra nutrition with nitrogen fertilizer when winter wheat begins its vegetative growth because during winter, wheat plants can be weakened due to severe conditions, so they require a top dressing of nitrogen fertilizer. Application rate of nitrogen fertilizer should be determined according to the demand considering the difference in soil and climatic conditions and zonality in South Kazakhstan Province and Uzbekistan. Application rate may change (decrease) as soil health improves over time under CA system.

According to long-term meteorological data, precipitation is scarce in summer, with little or no precipitation in June, July, August, and September. Long-term climatic data shows that beginning in October, precipitation amounts to 39 mm in Azerbaijan, 37 mm in Kazakhstan, 23 mm in Uzbekistan, 49 mm, 52 mm, 34 mm in November in Ter-ter, South Kazakhstan and Uzbekistan respectively and 64 mm in December.

Due to global warming, weather- and climate-related factors are changing under conditions of Azerbaijan, South Kazakhstan and Uzbekistan. As mentioned above, climatic conditions in summer and early autumn turn out to be very dry, thus complicating the main pre-sowing soil tillage operation which results in the delay in planting dates, from its optimum date, of winter wheat under rainfed conditions. In addition,

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**Figure 10.** Local stubble seeder SZS-2.1 (L) and FANKHAUSER 2115 No-Till seeder (R)

rising prices of fuels, oils, lubricants and financial capacities of manufacturers are altering production practices of some crops. If autumn is dry, despite seeding during the optimal planting period (1st and 2nd ten days of October in Uzbekistan and South Kazakhstan), even obtaining field emergency becomes problematic.

By planting certified seeds into dry soil, farmers expect to get full germination rate in case of precipitation. However, under the current conditions of dry autumn (seeds planted on optimal dates and remaining in dry soil for more than 30 days begin to lose their germination strength, which explains the occurrence of lower germination), field germination rate drops to 45-55%. Therefore, it is important to attain uniform emergence of winter crops to ensure good and strong seedlings because this determines their yield potential at crop establishment stage (see Appendix 9.3).

In case of No-Till direct seeding of winter wheat using stubble seeder SZS-2.1 (Figure 10) or FANKHAUSER 2115 seeder (Figure 10), soil moisture level should be taken into consideration. Planting should begin when topsoil is moist down to 12-18 cm deep and the seeding machine is moving freely without resistance from soil. This is very important in order to obtain uniform crop establishment.

It is an established fact that varieties Steklovidnaya 24, Pamyat 47, Intensivnaya, Krasnovodopadskaya 210, Surkhak, Tezpishar, Ko'kbuloq are the most adapted for direct seeding under rainfed conditions in South Kazakhstan and Uzbekistan.

### 3.2.2. Planting dates and seed rates

According to long-term weather observations, planting time for winter wheat in humid years (at early precipitation in the 1st and 2nd ten days of October) in South Kazakhstan province and Kashkadarya province, Uzbekistan, come at the beginning of the 3rd ten days of October, in moderately humid years – early in the 1st ten days of November, while in dry years - during 1st and 2nd ten days of November.

Depending on zonality, and based on biological traits of cultivated varieties, differentiated approach needs to be adopted in direct seeding rate of winter wheat:

- 3.5-4.0 mln live seeds $ha^{-1}$ are recommended for rainfed areas where precipitation execeeds 600 mm per year;
- 3.0-3.5 mln live seeds $ha^{-1}$ for rainfed areas precipitation between 300 and 600 mm per year;
- 2.5-3.0 mln live seeds $ha^{-1}$ for rainfed areas precipitation ranges 200-300 mm.

These seeding rates are recommended for optimal planting dates (2$^{nd}$ and 3$^{rd}$ ten days of October and 1$^{st}$ ten days of November). When planting in late November and early December, these seeding rates should be increased by 10-15 %. At later planting dates, varieties Pamyat 47 (facultative wheat) and Intensivnaya (facultative wheat), Sanzar-4, Tezpishar are recommended because these varieties have proved to be the most productive, when planted late.

### 3.2.3. Fertilizer application and crop management

Ammophos should be applied at the time of seeding at the rate of P20-30 kg $ha^{-1}$, which facilitates the development of the root system and increases resistance of winter wheat to severe winter conditions and increases kernel weight.

Findings show that in South Kazakhstan, an optimal application rate of nitrogen fertilizers for rainfed areas poorly and half-provided with moisture are N35-50 kg $ha^{-1}$. On rainfed areas well-provided with moisture, application rate of nitrogen fertilizers should be increased by 1.5-2.0 times or up to N70 kg $ha^{-1}$ (Sydyk *et al,* 2009, Yusupov and Abdukhaliqova, 2009). Again, these rates may decrease over time as soil health and fertility builds up under CA system.

A pattern of Recommended Models for No-Till Winter Wheat on Rainfed Areas in South Kazakhstan and Uzbekistan is given in Appendix 9.3.

Nitrogen fertilizer application in early spring is an important operation in No-Till winter wheat on sierozems. Thus, timely application of nitrogen can increase grain yield up to 2.0 t $ha^{-1}$ on average, which is 0.4-0.5 t $ha^{-1}$ higher than the yield under conventional agriculture.

It has been found that consistent and timely crop management is essential. Thus, early spring nitrogen application, followed by application of herbicide and using a combination of herbicides to manage dicotyledon and grain-bearing weeds (Dialen super 480 water solution – 0.6 l $ha^{-1}$ + Topik 080 EC– 0.4 l $ha^{-1}$) can ensure quite high grain yield, amounting to 2.5-2.7 t $ha^{-1}$.

Harvesting of cereals should be done with combine-harvesters that have adjustable high stubble cutting capacity and are equipped with straw chopper and spreader. Windrow harvesting is undesirable as it tends to leave surface residues in piled rows that are not evenly distributed. Stubble help to trap snow during winter and facilitates more uniform snow melt in the spring, thus increasing infiltration and soil moisture content and reducing runoff.

### 3.2.4. Economic and energy analysis of No-Till winter wheat

Economic analysis is a criterion of efficiency of a certain crop management practice. Labor and input costs are the most important indicators for economic assessment of crop management practice.

Analysis of cost-effectiveness of No-Till direct seeded winter wheat shows the economic feasibility of nitrogen application and herbicide use in crops in Kazakhstan (Sydyk and Karabalayeva, 2010). Thus, under conventional practice direct costs per ha amounted to USD 170, while under No-Till direct seeding, costs reduced down to USD 100. In this case, net operating income increased 1.9 times and amounted to an average of about USD 300-320 with relatively low costs per 100 kg of production at USD 6, which is almost 1.7 times lower compared to conventional technology (USD 10 -11).

## 3.3. No-Till maize

### 3.3.1. Seeding date and rate

Abendroth and Elmore (2007) reported that the optimum plant population within a field can vary from 15 000 to 36 000 plants per hectare in a given year based on the environmental conditions unique to that season. Thus, using variable seeding rates within fields at this time will not likely result in significant savings given current technology and the year-to-year variability that exists. In No-Till cropping system, maize should be placed into crop rotation after winter wheat or alfalfa. After harvesting winter wheat, or the first hay crop of third year alfalfa on raised beds in the 1st ten days of July, direct seeding of maize is carried out at the depth of 6-7 cm with a seed rate of 23-25 kg $ha^{-1}$ (Figure 11), leading to a density of 60 000 plants $ha^{-1}$.

### 3.3.2. Fertilizer and herbicide application

Maize is very sensitive to plant nutrient deficiency and is considered to be a test plant for identifying the availability of many nutrients in the soil. Maize crop should





**Figure 11.** No-Till maize planted after winter wheat in Azerbaijan (L) and No-Till maize planted after alfalfa in Kazakhstan (R)

have a continuous supply of nitrogen at all stages of growth untill grain formation. Nitrogen deficiency in maize plants in the early stages of growth will reduce grain yield substantially. Recommended rate of nitrogen application is 160 kg $ha^{-1}$ and 90 kg $ha^{-1}$ of phosphorus. Young maize plants need higher amounts of phosphorus in the early stages. It is necessary to apply phosphorus 90 kg $ha^{-1}$ while Nitrogen is applied in 3 equal splits. The first application of nitrogen is applied at sowing along with phosphorus. The second dose of nitrogen is applied after 30 days of sowing and the third dose at tasseling stage of the crop.

At 3-5 leaf development stage, weed control with herbicide can be done with working fluid consumption of 250-300 l $ha^{-1}$. Herbicides reduce the mass of weeds on average by 80-82%, which enables the elimination of a number of operations, i.e., post-emergence harrowing and one inter-rowtillage as well as hand weeding.

### 3.3.3. Water management in No-Till maize production

It is necessary to carry out pre-sowing irrigation at a low rate of 350-450 $m^3$ $ha^{-1}$, depending on soil type and structure, after previous crop harvest. For rational use of irrigation water on different types of soil in South Kazakhstan in No-Till maize production, to maintain soil moisture during the growing season at the level of 70-80% of field capacity, it is recommended to provide irrigation with soil moistening at the optimum depth (0.5-0.7 meters) according to the following schemes:

For maize production in South Kazakhstan to maintain soil moisture at 70-80% of field capacity, it is recommended to provide irrigation according to the following schemes: in moderately moist years, irrigate 2-3 times with total volume of 2 400 $m^3$ $ha^{-1}$; in dry years, irrigate 3-4 times with total volume of 3 200 $m^3$ $ha^{-1}$.

Research has established that production under No-Till CA practices ensures a reduction in total water use by 25-26% (4 374 $m^3$ $ha^{-1}$) compared to the conventional practice of production (5 914 $m^3$ $ha^{-1}$).

The main benefit of bed-planting is water savings. Almost all farmers have reported 30-35% less irrigation time. Therefore, in high production situations, bed-planting exceeds the yields possible on flat bed (Nurbekov, 2008). These results are in accordance with those of Fahong *et al.* (2004) in China. These authors observed an improvement in water use efficiency by 21–30% combined with an approximate savings of 17% in applied irrigation water. Water use efficiency was significantly higher with bed-planting (2.36 $m^{-3}$) compared to conventional planting (1.85 kg $m^{-3}$).

### 3.3.4. No-Till maize yield

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). The results show that No-Till practices are feasible for the production of maize green biomass yield. Maize harvesting is carried out at the milky-waxy grain ripeness stage.

No-Till maize provided higher (7.82 t $ha^{-1}$) grain yield compared to minimum till (7.38 t $ha^{-1}$) and conventional till (7.51 t $ha^{-1}$) in Uzbekistan. In 2012 a significantly

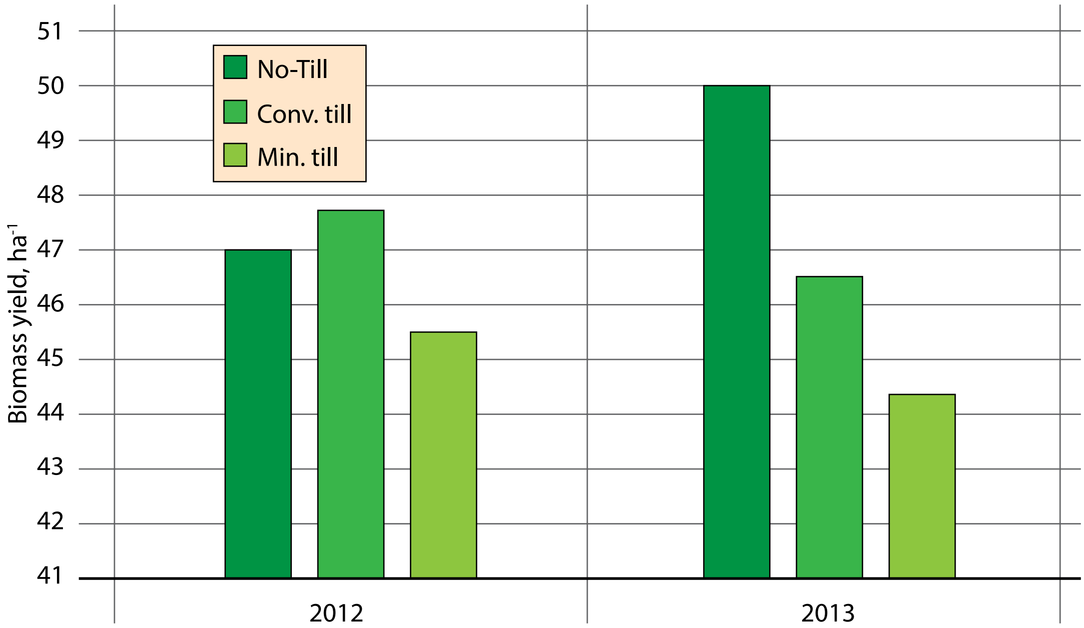


**Figure 12.** Maize green biomass yield affected by tillage method (Kazakhstan) 2012-2013

higher grain yield was observed with No-Till and conventional till while there was little difference across the treatments. In 2012 there was significant difference between the treatments. In 2013 there was a little difference across the treatments (Table 6). Maize for grain yield was harvested at full maturity stage.

**Table 6.** Effect of tillage on maize grain yield in Uzbekistan (2012-2013)

| Planting method | Years | | Mean Yield, t $ha^{-1}$ | Yield difference, % |
|---|---|---|---|---|
| | 2012 | 2013 | | |
| CT | 7.64 | 7.38 | 7.51 | 0 |
| MT | 7.32 | 7.44 | 7.38 | 98.2 |
| NT | 8.13 | 7.51 | 7.82 | 104.1 |

### 3.3.5. Cost-effectiveness of No-Till maize production

Recent introduction of new technology such as the No-Till system offers an opportunity to increase farmers' income. Fuel for producing agricultural products has become expensive in all project countries. 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 USD 736.5 $ha^{-1}$ and USD 641.9 respectively, which was 123.7 % and 107.8 % higher than from conventional till (CT) with USD 595.3 $ha^{-1}$. The benefit-cost ratio varied from 45.9 % in CT to 57.3% in NT (Table 7). These results show that introduction of CA with No-Till maize forage crop will help livestock producers to have access to low-cost forage resources and thus improve the efficiencyof livestock production in Kazakhstan,and perhaps in other Central Asian countries as well.

**Table 7.** Benefit-cost ratio for forage production from No-Till and conventional maize in Kazakhstan

| Planting method | Green mass yield, t $ha^{-1}$ | Total production cost, USD $ha^{-1}$ | Total income, USD | Net benefit USD $ha^{-1}$ | Benefit-cost ratio |
|---|---|---|---|---|---|
| NT | 48.5 | 548.6 | 1 285.1 | 736.5 | 57.3 |
| CT | 47 | 701.4 | 1 296.6 | 595.3 | 45.9 |
| MT | 44.8 | 647.3 | 1 289.2 | 641.9 | 49.7 |

## 3.4. No-Till alfalfa growing in rainfed and irrigated conditions

In Uzbekistan and Kazakhstan, alfalfa (*Medicago sativa*) is one of the important forage crops, providing high-protein fodder as herbage, haylage, hay and vitamin-enriched flour. Alfalfa stimulates recovery of soil fertility and structure, protects sloping land from water erosion and prevents soil salinization on irrigated areas. Yield of alfalfa under rainfed production depends mainly on the soil moisture available from rainfall (Figure 13). Most of the crop is planted in rainfed areas with precipitation more than 600 mm and between 350-600 mm and the smaller part – on rainfed areas precipitation less than 300 mm per year.

Alfalfa is one of the best preceding cover crop in a crop sequence for all crops and is included in all types of crop rotations recommended for rainfed areas in Uzbekistan and South Kazakhstan Province. In rainfed areas with sufficient amount of precipitation, and where a ten-field cereal-grass crop rotation is applied, it covers 40% of the area.





**Figure 13.** No-Till alfalfa under rainfed (L) and irrigation systems (R)

Hay harvest from alfalfa in rainfed areas well-provided with moisture reaches 6.0 t $ha^{-1}$, on rainfed areas half-provided with moisture about 3.5 t $ha^{-1}$, and on rainfed areas poorly provided with moisture about 1.5-2.0 t $ha^{-1}$, which is still significantly higher than yields of natural hayfields.

In choosing a field for alfalfa production, high sensitivity of alfalfa to weed infestation should be taken into account. Rootstock weed is especially harmful to alfalfa because as it spreads it leads to a reduction in green matter from alfalfa. In the areas with insufficient soil moisture, it is advised to allocate lowland areas with lowest weed infestation and highest natural moisture levels to alfalfa production.

Alfalfa gives rich harvest of hay and seeds for four years of its life-cycle, followed by a decrease in yields caused by strong thinning of herbage and infestation from ephemeral weeds. Therefore, standing of alfalfa in cereal-fodder crop rotations should be for 3-4 years but sometimes it can be up to 5-6 years. Expansion of seeding areas under alfalfa on rainfed lands through outscaling CA technologies is instrumental for building solid fodder reserves for livestock production.

A time frame for No-Till alfalfa production in rainfed conditions has been developed on the basis of field experiments conducted in South West Kazakhstan Research Institute of Livestock and Plant Production and FAO project on CA (see Appendix 9.4).

### 3.4.1. No-Till alfalfa seeding date and rate

Alfalfa is planted using No-Till planter FANKHAUSER 2115 adapted for No-Till direct seeding with inter-row spacing of 30 cm to the depth of 1-2 cm, but not deeper than 3 cm. Recommended seeding rate are: 12 kg $ha^{-1}$ for rainfed production well-provided with moisture, and 8-10 kg $ha^{-1}$ for rainfed production half-provided or poorly provided with moisture. The following released varieties are used for planting: "Krasnovodopadskaya skorospelaya", "Krasnovodopadskaya 8" in South Kazakhstan and "Aridnaya" in Uzbekistan.

The optimal planting dates under rainfed conditions poorly or half-provided with moisture are the end of February and the first ten days of March, while in rainfed areas well-provided with moisture these are the first ten days of April. The planting date of alfalfa should be adjusted so as to obtain the full seedling germination prior to any soil crust formation, which is typical for spring-time rainfed areas where the top soil has not yet developed a good structure and covered by a layer of mulch.

No-Till excludes any mechanical soil tillage. Improvement of hydrophysical, soil texture and biological soil properties is achieved through leaving high-standing stubble, chopping and even spreading of straw on the field surface. This creates a mulch layer of plant residue which is exposed to biological decomposition and enhances soil health and fertility while protecting the soil surface from extreme temperatures (Sydyk *et al.*, 2008).

### 3.4.2. Fertilizer application

In South Kazakhstan and Uzbekistan, alfalafa is an important forage crop in irrigated and rainfed areas. Alfalfa is a high-yielding, high-quality perennial forage that removes

plant nutrients from soil in large quantities. For optimal production, the nutrients must be available at the appropriate level and time (Lanyon and Griffith, 1988). It is common practice to not to apply fertilizer in the first year of alfalfa, which results in relatively low yields but newly planted alfalfa needs a readily available supply of phosphorus, potassium and other plant nutrients immediately after emergence. A well-planned fertilizer program is necessary for alfalfa forage production. Berg *et al.* (2003) reported that to meet the total seasonal nutritional requirements, an adequate nutrient supply must be available for uptake by the crop to meet periods of peak demand. In South Kazakhstan and Uzbekistan this peak demand time for nutrients will be the late-bud stage when the crop is fully covering the ground and when intensive plant growth is going on. Applying 33 kg $ha^{-1}$ of P during seeding has been shown to increase seedling size by four times compared to no phosphorus application. Although alfalfa usually obtains a high percentage of its required N via symbiotic N fixation, additional fertilizer N applied once in the spring can increase forage yields (Raun *et al.*, 1999). However, this may not be necessary once soil health has improved and there is increased level of organic matter in the soil. After review of literature on alfalfa production in irrigated and rainfed areas and considering critical issues on fertilizer applications, it is recommend applying nitrogen at the rate 20 kg $ha^{-1}$ of at the time of No-Till direct seeding. Further, the use of mineral fertilizers should be based on the soil's agrochemical survey, taking into account the nutrient content of the soil.

### 3.4.3. Harvesting

Harvesting alfalfa for hay should be done during the period when the plants have their maxium amount of foliage. Therefore, alfalfa needs to be cut in early bloom.

Harvesting alfalfa for seeds should begin when 80-85% of the seeds are brown. On sparse vegetation direct combine-harvesting is recommended, while at normal fodder density and height, it is more effective to use swath harvesting.

### 3.4.4. No-Till alfalfa under irrigation

Crop management in No-Till alfalfa production in irrigated areas is similar to that in rainfed production, though the timing of each farming operation is dependent on the soil and climatic conditions (Figure 13).

Sydyk *et al.* (2008) reported that the highest yields under irrigation are achieved when nitrogen fertilizer and herbicide treatment are applied. The yield of 6.41 t $ha^{-1}$ was achieved in production under conventional technology, and 6.73 t $ha^{-1}$ under pre-planting disking and No-Till seeding, i.e., 8.9-11.5% higher.

It is well-known that alfalfa does not produce high yields in the first year of its life-cycle. However, in the second and third years, alfalfa can give quite high yields of herbage and hay.

# 4. WEED CONTROL

## 4.1. Weed management in No-Till winter wheat

Weed control has been shown to be effective in No-Till system (Sydyk *et al.*, 2008). Central Asian farmers mention the ability of cover crops and herbicides to reduce the number of weeding required in a cropping season. The overall weed infestation observed in conventionally tilled spring wheat is generally equal to that found in No-Till wheat. Soil covered with crop residue can suppress weed growth and reduce problems experienced in direct seeding under zero tillage (Sydyk *et al.*, 2008).

Inter-row cultivation during irrigation fails to achieve a desired impact on weed control. In this regard, depending on the weed species, herbicides should be applied to the winter wheat field at tillering stage.

In recent years, after agricultural reforms which led to establishment of many small and medium- sized farming enterprises, phytosanitary status of cereal crop production has deteriorated due to failure to follow recommended farming practices (technically appropriate crop rotation patterns, a system of pre-planting land preparation, crop management practices, etc).

The current circumstances require a new approach to fieldwork and production of leguminous crops in the rotation because weed management is becoming a primary challenge for a farmer in the conventional tillage system. In this regard, observation of weed infestation, weed species involved and quantity of weeds will determine the integrated weed management strategies and crop management activities to be adopted.

### 4.1.1. Most common weed species

With direct seeding on No-Till soil, it has been shown that the number of weeds is much more intense compared to conventional practices. In south Kazakhstan and Uzbekistan, more than 33 species of weed plants (see Appendix 9.5) were found in winter cereal crop fields (Hamraev *et al.*, 1999; Amanov *et al.*, 2004; Sydyk *et al.*, 2008).

Wild oats (Avena fatua), locally referred to as “karasuli” in Kazakh and “yavvoisuli” in Uzbek, is one of the most harmful weeds that grows in areas under cereal crops (e.g., wheat, barley) and causes a sharp decrease in yield and deterioration of grain quality. Wild oats look like cultivated oats at the early growth stages, but they are taller with loose panicle and jointed awn at the later grain stage. In general, it grows on heavier soil and mainly in lowlands. Seeds of the wild oats emerge at the temperature of 8-10°C. Maximum germination depth is 15-18 cm, though the shoots are weak. The most viable shoots emerge from seeds located within 10 cm from soil surface. The seeds of wild oats grow unevenly and for a long time. Seeds maintain their viability

in soil for 3-4 years. Quantity of wild oat seed in the soil is huge and can reach several millions per hectare.

Not only do wild oats reduce overall crop yield but the contamination of commercial grain with wild oats significantly reduces quality of bread and imposes extra costs on grading and transportation. The main reasons causing an increase in cereal crop contamination with wild oats include:

- Failure to follow zone-specific requirements of crop management in cereal production (failure to comply with planting dates, lack of fallow lands, low quality of farming operations, failure to provide pre-planting);
- Planting seeds contaminated with wild oat grains, which do not comply with seeding requirements due to lack/insufficient supply of grain-cleaning machines installed with indented separator cylinders;
- Insufficient herbicide used to manage wild oats during pre-planting and post-planting periods;
- Use of wasteland areas, which serve as a reserve stock of wild oats.

The need to manage wild oats is pre-conditioned by its extreme harmfulness. One culm of wild oats per square meter reduces spring wheat yield by 10 kg $ha^{-1}$. Key control measures for wild oats include crop management activities and chemicals. Crop management activities to control wild oats are aimed at diminishing the stocks of weed seed in the soil through the promotion of its emergence followed by extermination of all of its shoots and preventing seeds from falling into the crops. However, crop management activities are insufficient to completely control wild oats (Amanov *et al.*, 2004). Therefore, it is necessary to apply herbicides to control such a pestilent weed plant. The following types of herbicides are recommended: Topik – 080 EC – 0.3-0.5 l $ha^{-1}$, Dialen Super 480 s.c. Suspension Concentrate+, Topic 080 EC – 0.6 l $ha^{-1}$ + 0.35 l $ha^{-1}$.

**Wild barley** (*Hordeum spontaneum c. Koch*), locally referred to as “tak-tak” in Uzbek or “Karakyltyk” in Kazakh, is the progenitor of the cultivated barley. In recent years, wild barley has easily become adapted through a natural selection process to grow with winter wheat and barley in South Kazakhstan and Uzbekistan. With respect to its biological characteristics, wild barley is close to cereal crops, whereby the weed seedlings emerge simultaneously with those of the cultivated crops and further development stages in both are almost identical. However, wild barley ripens 10-14 days earlier than winter crops and intensively shatters its seeds before harvest of winter barley and wheat. This weed is distributed as seeds.

The following types of herbicides are recommended: Topik 080 EC – 0.3-0.5 l $ha^{-1}$, Dialen Super 480 s.c. + Topik 080 EC – 0.6 l $ha^{-1}$+0.35 l $ha^{-1}$.

**Clingy bedstraw** (*Jaliumaparine*), locally known as “Jabyskakqyzylboyau” in Kazakh or “Yopishqoqqyzylpoya” in Uzbek, is an annual plant belonging to the Madder family in a category of winter weeds. It propagates by seeds. This plant is dwarf, clingy and very fertile. Clingy weed seeds strongly contaminate the soil. The plant flowers in the first ten days of April and bears fruit in May (Amanov *et al.*, 2004).

The following herbicides are recommended: Dialen Super 480 w.s. at the rate of 0.5-0.7 l $ha^{-1}$, Diamin, 72% w.s. – 1.0-1.2 l $ha^{-1}$, Esteron EC – 0.4-0.8 l $ha^{-1}$.

**Russian centaury** (*Acroptilon repens*) is a root-sucker perennial plant belonging to Aster family (Compositae). This plant has a strong root system. Its straw is straight, spiderweb-like and fallen, 25-50 cm tall. It reproduces by seeds and root suckers. Seedlings appear in early spring, it flowers in the first year of its life, though does not produce seeds, bears fruit in the second year of life. It is highly fertile. In the safflower plantings, the Russian centaury strongly suppresses safflower in initial stage of growth by generating thick tangles (Hamrayev, 1999).

The following herbicides are recommended: Dialen Super 480 w.s. at the rate of 0.5-0.7 l $ha^{-1}$, Diamin, 72% w.s. – 1.0-1.2 l $ha^{-1}$, Esteron EC – 0.4-0.8 l $ha^{-1}$.

**Field cabbage** (*Brassica campestris*), locally known as "Tuyekaryn" in Kazakh and "Tuyaqorin" in Uzbek, is a rootstock weed. It reproduces not only by seeds, but also by roots located deep underground in the soil, and cannot be reached through mechanical soil tillage. In summer, the wind can easily disperse fully formed field cabbage seeds to long distances in any direction from the point of growth. Naturally, the fully formed seeds continuously scatter along their movement in soil, which leads to its intensive contamination. This weed is very fertile (Hamrayev *et al.*, 1999).

### 4.1.2. Herbicide application date and rate

Selection of herbicides based on number of weeds per square meter requires creative approach and competency, which in return, ensures feasibility and this is a very important issue during the first years of No-Till cultivation of any agricultural crop in both irrigated and rainfed conditions (Table 8).

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%).



**Figure 14.** After three days of treating crops with Dialen Super 480 water solution at the rate of 0.7 l $ha^{-1}$

**Table 8.** Recommended rates and dates of herbicide application on cereal crops

| Herbicide | Application Rate | Crop | Weed | Application Date |
|---|---|---|---|---|
| Dialen super 480 water solution | 0.5-0.7 l $ha^{-1}$ | winter wheat, spring wheat, spring and winter barley | perennial and annual dicotyledon weeds including those that have resistance to 2.4D | beginning at 3-leaves stage until the end of tillering stage of cereal crops |
| Topik 080 EC | 0.4-0.5 l $ha^{-1}$ | winter wheat, spring wheat, spring and winter barley | wild barley, wild oats, barnyard grass, bristle grass and etc. | beginningat 2-3- leaves stage of weeds until tillering stage |
| Dialen super 480 water solution+ Topik 080 EC | 0.6 l $ha^{-1}$ + 0.35 l $ha^{-1}$ | winter wheat, spring wheat, spring and winter barley | perennial and annual dicotyledon weeds including those that have resistance to 2.4D: wild barley, oatgrass, barnyard grass, bristle grass and etc. | until the end of tillering stage of winter wheat |
| Istrebitelactive substance (tribenuron-methyl 750 g/kg) + Efiram EC | 15 g/ha + 0.4 l $ha^{-1}$ | winter wheat, spring wheat, spring and winter barley | perennial and annual dicotyledon weeds including those that have resistance to 2.4D, Canadian thistle | spraying in spring at the crop tillering stage until booting stage |
| Diamin 72% water solution | 1.25 l $ha^{-1}$ | winter wheat, spring wheat, spring and winter barley | annual weeds (redroot, burdock, different types of wormseed and etc.) and perennial (corn lily, sow thistle types) | from the very beginning of tillering stage until crop booting stage |
| Valsamin | 1.20-1.30 l $ha^{-1}$ | winter wheat, spring wheat, spring and winter barley | annual (redroot, burdock, different types of wormseed and etc.) and perennial (corn lily, sow thistle types) | from the very beginning of tillering stage until crop booting stage |

Before booting stage of winter wheat and at the beginning of development stages of perennial and annual dicotyledon weeds, the use of Dialen Super 480 water solution at the rate of 0.5-0.7 l $ha^{-1}$ is recommended (Figure 14).

Weather and climate conditions need to be taken into account (wind speed no more than 5 m $s^{-1}$, air temperature above 14-160C), during herbicide application, and treatment should be applied in the mornings and evenings.

Conditions of the sprayers and spray nozzles are crucial in herbicide application. Topic 080 EC is the most effective at rate 0.4-0.5 l $ha^{-1}$ against "wild barley". This weed plant emerges in late autumn after cereal crops, so it is very difficult to manage. Firstly, biologically, "wild barley" requires more moisture before sprouting (germination of seeds consumes 10 times more moisture that its own volume), which explains late emergence. Besides, this weed is good at overwintering and tillering.

In order to determine a weed management strategy using herbicides, it is necessary to be efficient in early spring; in other words, plots infested with wild barley must be treated before the tillering stage.

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 $ha^{-1}$ is recommended. Treatment

of winter wheat with the indicated combinations of herbicides and application rates ensures high efficiency. It should be noted that Dialen Super 480 water solution at the rate of 0.6-0.7 l ha$^{-1}$ is very effective against field pea, wild cabbage, bindweed, bur, Russian knapweed and other types of dicotyledon weeds.

Using Diamin 72% water solution at the rate of 1.25 l ha$^{-1}$ as operating fluid in the amount of 250-350 l ha$^{-1}$ at tillering stage of winter wheat and early stages of weed development produces a considerable impact on the weeds with notably benign effect on the crop.

## 4.2. Weed management under No-Till maize

It is well known that the critical period of damage for maize, sunflower and sorghum is estimated to be about 40 days after crop emergence. The presence of weeds during this period reduces the yield of maize by 10-13%. Extension of the period affects the quality of the harvest, storage of moisture and nutrients in soil is reduced, accumulation of weed seeds in the soil increases and the infestation by perennial weeds increases, and its cleaning and drying is complicated at harvest, etc.

Some small farmers and all households use manual weeding in all three project countries. Manual weeding does not provide for successful weed control. Thus, it is advised to combine manual weeding with herbicides application, which provides the same yield as in the manual weeding in the rows. Proper application of herbicides can reduce labor and input costs for production of maize and can reduce the production costs versus manual weeding. Machinery maintenance operations in CA-system are minimized compared to traditional production systems. In this case, the most effective method of weed control is chemical application, providing the same yield of maize as in manual weeding in rows (4.7 t ha$^{-1}$). Over time, as CA cropping system is established with mulch cover and diversified rotation, it is expected that herbicide use would reduce.

### 4.2.1. Herbicide application date and rate

Several herbicides used in maize production are Dialen-Super 480, w.s. (1.25-1.5 l ha$^{-1}$), Diamine, 72% w.s. (1.0-1.2 l ha$^{-1}$), Dikopur ® Top, EC (1.0-1.5 l ha$^{-1}$), Bazagaran, 48% w.s. (2.0-4.0 l ha$^{-1}$), Efiram, EC (0.8-0.9 l ha$^{-1}$). All chemicals must be used according to the type and degree of weed infestation of maize fields, regional growing features, as well as chemical and toxic properties of individual herbicides. Among herbicides applied at 3-5 leaf stage of the maize crop, the most effective are Dialen-Super (1.25-1.50 l ha$^{-1}$) and Valsamin w.s. (1.2-1.4 l ha$^{-1}$).

To protect the harvest, maize weeding should be carried out at the early stages of crop development – at 3-5 leaf stage. The delay with the use of herbicides will lead to significant losses.

This implies the need to incorporate herbicides into an integrated pest management system. In case of mixed types of weeds, relevant number of weeds which justifies the use of herbicides is 20 species m$^{-2}$.

Effective use of herbicides ensures a significant reduction in weed infestation and allows efficient use of energy and labor resources (Figure 15).

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**Figure 15.** Maize treated with herbicide (L) and untreated field (R)

## 4.3. Weed management in No-Till alfalfa

### 4.3.1. Common weeds in alfalfa fields

Since alfalfa occupies the field for three or more years, there is a risk of infestation by weeds. Management of alfalfa crops in the planting year consists of regular cutting of weeds before flowering and protecting crops from damage by cattle.

The study of the phytosanitary status of alfalfa crops in rainfed and irrigated areas showed the following common weeds:

- Perennials: Russian centaury, field sow thistle, field cabbage, couch grass, Sophóraalopecuroídes, camel thorn, etc.
- Annuals – wild barley, field dodder, Austrian winter pea, redweed, false carrot, cleavers, etc.

The greatest damage inflicted to the crop is by annuals – field dodder, cleavers, and by perennials – Russian centaury (pink), and Aleppo grass.

**Field dodder** (*Cuscuta campestris*), locally known as "chirmavuq" in Uzbek or "Sary-shoep" in Kazakh, is a parasitic weed. Dodder falls into a group of parasitic angiosperms, completely fed at the expense of the host plants. Dodder predominantly multiplies by seeds and partly by vegetative stems, and is very fertile.

**Cleavers** (*Galium aparine*), locally known as "Zhabysqaqqyzylboyau" iin Kazakh and "Yopishqoqqyzylpoya" in Uzbek – an annual of the Madder family, belon gs to winter weeds. It multiplies by seeds, and is a low-growing plant, clingy and very fertile. Cleavers' seeds heavily contaminate the soil. It flowers in the first ten days of April and bears fruit in May.

**Wild barley** (*Hordeum spontaneum c. Koch*), locally known as "tak-tak" or "Qaraqyltyq" is the progenitor of cultivated barley.This weed heavily contaminates and suppresses the growth of alfalfa. In the south of Kazakhstan, in the process of natural breeding in recent years, wild barley has easily adapted to growing alongside winter wheat and barley, the weed heavily contaminates alfalfa and strongly suppresses it (Hamrayev *et al.*, 1999). In terms of biological traits, it is close to cereals.

**Field cabbage** (*Brassica campestris*), locally known as "Tuyaqorin", is a rootstock weed. It propagates not only by seeds, but also by roots that stay in the top soil and are not affected bytillage. In the summer, mature seeds of field cabbage are easily carried by the wind, away from the place of growth in any direction. Naturally, mature seeds are constantly dispersed in the soil along the course, which leads to intensive infestation of the fields. The weed is very fertile.

**Aleppo grass** or **Johnson's grass** (*Sorghum halepense*) is a perennial weed. It has two types of rootstock: one is short, situated close to the soil surface, in the 1$^{st}$ year; the other one is longer and thicker, goes deep into the soil and gives seedlings after wintering. It can multiply both by seeds and by rootstock. Aleppo grass seeds can be transferred to other fields through irrigation channels. Often, this way, the newly reclaimed lands become infested within a very short time. Aleppo is very similar to Sudan grass; the seeds of Aleppo are indistinguishable from Sudan seeds.

### 4.3.2. Herbicide application date and rate

Research has revealed that in No-Till alfalfa, the use of Fusilade Forte 150% EC and Pivot, 10% w.d.g. herbicides provides the greatest impact in weed management and creates best conditions for the growth and development of alfalfa (Sydyk *et al.*, 2008).

It was found that treatment of alfalfa crops with herbicides considerably reduces both the number of weeds, and their mass compared to standard practice. Thus, under irrigation, with the application of Fusilade Forte 150% EC herbicide, the reduction in weed number and mass was within the range of 77.9-80.4% and 78.5-83.0%.

Pivot herbicide, 10% w.d.g. was found to be more effective as infestation reduction by number and weight was higher, up to 81.0-83.0% and 82.4-84.1% respectively.

Field observations showed that Fusilade forte 150% EC herbicide had an impact on all types of annual and perennial cereal weeds except for dodder. The three or four years alfalfa fields should be treated with Fuzilade – Super herbicides. As mentioned above, Pivot 10% w.d.g. herbicide is characterized by the highest efficiency, having had an impact on all types of annuals, including one of the worst weeds – dodder.

## 5. CROP ROTATION UNDER NO-TILL

Research and experience have shown that good crop rotation will provide more consistent yields, build soil structure and increase profit potential (Nurbekov, 2008). Crop rotations for selected farms were developed taking into account farmers' interest and also marketability of the selected crops of the project in the project countries.

During the time of the Soviet Union, farm area was planted with cotton in rotation with alfalfa in Azerbaijan and Uzbekistan while in South Kazakhstan wheat was rotated with vegetable crops. Cotton occupied up to 80% of the cropland in Ganja and Kashkadarya provinces of Azerbaijan and Uzbekistan respectively. The rest of the cropland was dedicated to alfalfa and other forages. As cotton and wheat are main contracted crops by the Government of Uzbekistan, the farmers in this area switched to cotton and wheat crops relying on supply of inputs through governmental channels. Nowadays in Ganja, winter wheat, barley and cotton occupy 80% of the total arable area. In order to attain food security, wheat became the most important crop in the region.

The demand for food and fodder is expected to continue to grow in countries of Central Asia. A model was proposed by Suleymenov *et al.* (2004, 2006) that grouped the rainfed and irrigated-based zones into three main crop-based production systems zones: (1) the northern Kazakh steppes; (2) the warmer foothills of Kyrgyzstan and southern Kazakhstan where a mixture of rainfed and irrigated agriculture is practiced; and (3) Tajikistan, Turkmenistan and Uzbekistan where irrigated bed and, furrow or basin systems are used. Wheat, cotton and livestock are the most important commodities in the region. However, with a trend towards diversification, oil crops such as sunflower could also become important (Figure 16). The results of research on adaptive cropping systems and CA conducted since 2003 have been introduced across 230-347 ha in southern Kazakhstan region.

Rainfed farming is a system of using non-irrigated land for farming that has historically developed in southern Kazakhstan. It is closely tied with local soil and climate properties, which strongly influenced the crop management practices and the botanical composition of crops cultivated there.

As mentioned already in the previous sections, rainfed area was divided into three sections by rainfall as: well-provided precipitation level exceeding 600 mm; semi-provided with moisture precipitation ranging between 300 and 600 mm; and poorly rainfed area with precipitation in the range of 200-300 mm.

South Kazakhstan and Uzbekistan are distinguished by sharply continental climate, which is prone to adverse natural phenomena that can drastically reduce the productivity of winter cereal crops. These include air and soil droughts, hot dry winds, designated as "capture" or "igniting fuse". These phenomena occur due to long dry pe-

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**Figure 16.** Crop diversification with No-Till maize for livestock feed in Kazakhstan and Sunflower for oil extraction in Azerbaijan

riods without precipitation and high air temperatures, with each of them reducing yield of agricultural crops. In order to manage these negative weather phenomena, it is important to know about the nature and times of drought and the onset of hot dry winds and associated effects on the specific crops to decide which crop management practice(s) to apply.

The following useful patterns have been identified as a result of research (Sydyk *et al.*, 2008; Lavronov, 1969, 1979; and Nurbekov 2008) on the nature of these harmful weather phenomena that undermine productivity of rainfed lands:

- Any type(s) of soil disturbance at any time of the year should follow one rule aimed at accumulation, preservation and rational use of soil moisture;
- Agricultural crops should be cultivated only within crop rotations. This facilitates higher yield of cultivated crops and augments soils fertility from rotation to rotation;
- Rainfed areas under winter cereal crops should be increased to the maximum;
- All crops should be sown using good quality certified seeds.

Observing these rules helps to achieve a relatively stable yield regardless of adverse weather phenomena (Sydyk *et al.*, 2008).

Raising awareness about farming standards and increasing productivity is significantly facilitated by: adoption of effective crop rotation and specifically dedicated No-Till, as they represent connecting links in the set of crop management practices facilitating soil fertility and soil moisture conservation.

## 5.1. Recommended crop rotation for irrigated production under CA

### 5.1.1. Recommended short-term cereal crop rotations for irrigated zones

**Table 9.** Examples of six-field cereal based crop rotation under irrigated conditions

| Option I | | Option II | |
|---|---|---|---|
| 1. | Winter wheat + Alfalfa 1st year | 1. | Maize |
| 2. | Alfalfa, 2nd year | 2. | Winter wheat |
| 3. | Alfalfa, 3rd year | 3. | Soybean |
| 4. | Winter wheat | 4. | Winter wheat |
| 5. | Winter wheat | 5. | Potato |
| 6. | Grain maize | 6. | Winter wheat |
| **Option III** | | **Option IV** | |
| 1. | Maize | 1. | Winter wheat |
| 2. | Winter wheat | 2. | Maize |
| 3. | Kidney bean | 3. | Field pea |
| 4. | Oilseed rape | 4. | Sunflower |
| 5. | Winter wheat | 5. | Winter wheat |
| 6. | Soybean | 6. | Mung bean |

Over the period of agricultural reforms, more private farms (in Azerbaijan and South Kazakhstan) and, dekhkan farms and small-scale farms (Uzbekistan), were created. Under current circumstances in Azerbaijan and South Kazakhstan, it has become difficult to introduce and adopt long-term crop rotations while in Uzbekistan it may be relatively easy to adopt long-term crop rotations because small-scale farms are changing into larger-scale farms.

In irrigated agriculture, winter wheat is cultivated with legume crops in specialized cereal crop rotation. Developed and recommended crop rotation options for soil and climatic zones in the project countries are also characterized as being methods for soil fertility rehabilitation.

### 5.1.2. Recommended fodder crop rotation for irrigated production

**Table 10.** Examples of six-field crop rotations under irrigated conditions

| Option I | | Option II | |
|---|---|---|---|
| 1. | Alfalfa, 1st year of life | 1. | Winter wheat+maize |
| 2. | Alfalfa, 2nd year of life | 2. | Winter field pea+Sorghum |
| 3. | Alfalfa, 3rd year of life | 3. | Winter barley+fodder bean |
| 4. | Maize | 4. | Winter Triticale+maize |
| 5. | Co-sowing Maize &Sorghum | 5. | Winter Rye+Sorghum |
| 6. | Winter Rye + Winter Field Pea, Second crop+ co-sowing Maize and Sunflower | 6. | Winter barley+Alfalfa |

### 5.1.3. Crop rotation for rainfed production

Based on the current reality in the agricultural sector where a lot of private and medium-sized farms are established in South Kazakhstan and Uzbekistan, the following locally adapted short crop rotation options for South Kazakhstan and Uzbekistan for the rainfed conditions are recommended:

**Table 11.** For rainfed area (precipitation exceeds 600 mm)

| Option I | | Option II | |
|---|---|---|---|
| 1. | Alfalfa, 1st year of life +Safflower | 1. | Sainfoin 1st year of life +Barley |
| 2. | Alfalfa, 2nd year of life | 2. | Sainfoin 2nd year of life |
| 3. | Alfalfa, 3rd year of life | 3. | Sainfoin 3rd year of life |
| 4. | Winter wheat | 4. | Winter wheat |
| 5. | Safflower | 5. | Winter wheat |
| 6. | Winter wheat | 6. | Winter barley or Triticale |

**Table 12.** For rainfed area (precipitation 350-600 mm)

| Option I | | Option II | |
|---|---|---|---|
| 1. | Winter wheat | 1. | Winter wheat |
| 2. | Safflower | 2. | Melon |
| 3. | Winter wheat | 3. | Safflower, Barley or Triticale |
| 4. | Alfalfa | 4. | Sainfoin |

**Table 13.** For rainfed area (precipitation 200-350 mm):

| Option I | | Option II | |
|---|---|---|---|
| 1. | Winter wheat | 1. | Winter wheat |
| 2. | Safflower | 2. | Winter barley |
| 3. | Alfalfa | 3. | Chickpea |

Crop rotation creates a more resilient production system from the viewpoint of pest infestation, and also serves as a source of organic matter for the soil which improves soil structure, while other CA practices improve soil nutrition regime and hydrophysical soil properties.

## 5.2. Recommended legumes for CA

There is a need for crop diversification with legumes to improve sustainability as well as to provide protein-rich grains. Technologies to save seed, water, fertilizer, etc. should be identified and disseminated to the farmers on a large scale. Food legumes enrich the soil with nitrogen and are very important for sustainable production intensification. In addition to providing nitrogen, legume crops also improve soil quality, thus positively affecting the performance of the ensuing crop. Nitrogen fertilizer requirement for the succeeding crop is reduced in a cropping system that includes legumes, which results in lower cost of production.

Legumes - chickpeas, peas and beans – in Azerbaijan, Kazakhstan and Uzbekistan are produced for grain and green biomass. Great interest in the production of leguminous crops in the project countries is due to the volatility in grain prices and demand for pulse crops in foreign markets. As it is known, modern varieties of leguminous crops grow well both on fertile and on poor soils having a pH from 5.0 to 7.5. In addition, legume crops are high-performance bio-plants for the fixation of atmospheric nitrogen.

Legumes improve soil fertility and, accordingly, are excellent as preceding crops to many other crops in rotations. Additionally, leguminous grain crops produce more protein per unit area, and its quality and digestibility is much higher.

The rising cost of mineral nitrogen fertilizers has revived interest in nitrogen-fixing legumes. Organic growers often include this type of cover crop in order to produce nitrogen for the rest of the crop rotation. Deep-rooted cover crops can bring nutrients up from deeper layer in the soil profile and contribute to the development of a network of soil biopores which improves aeration, drainage and moisture holding capacity.

### 5.2.1. Soybean

Soybean pods, stems and leaves are covered with fine brown or grey hairs. The leaves are trifoliolate, having three to four leaflets per leaf, and the leaflets are 6–15 cm long and 2–7 cm broad. The leaves fall before the seeds are mature. The inconspicuous, self-fertile flowers are borne in the axil of the leaf and are white, pink or purple. Modern crop varieties generally reach a height of around 1 m, and take 80–120 days from sowing to harvest (Figure 17).

Nurbekov and Ziyadullayev (2012) studied effect of Rhizobium with combination of Potassium and Phosphorus on productivity bed-planted soybean in irrigated





**Figure 17.** Bed-planted soybean field in Uzbekistan and No-Till soybean at full maturity stage in Azerbaijan

conditions of Kashkadarya province. Significant findings of this study were: soybean appeared to have high response to Rizobium application in all treatments, especially Control + Rizobium + $K_{60}$+$P_{120}$; the response was lowest in treatments where Rizobium was not applied.

Soybean consists of more than 36% protein, 30% carbohydrates, and excellent amounts of dietary fiber, vitamins, and minerals. It also consists of 20% oil, which makes it the most important crop for producing edible oil http://www.iita.org/soybean.

The USA, Argentina, Brazil, China and India are the world's largest soybean producers and represent more than 90% of global soybean production (FAOSTAT, 2013). Soybean can be used for human food and animal nutrition and will increase soil fertility for the succeeding crop in the crop rotation and wider adaptability across different climatic zones. Despite the above-mentioned characters and its ability to grow well with no added N fertilizer, soybean production in Uzbekistan has not been substantial and the crop is not widely grown in Azerbaijan, South Kazakhstan and Uzbekistan because cotton and winter wheat are the important crops. However, demand for soybean is growing in the region.

### 5.2.2. Kidney bean

Beans are one of the most important legume crops used for food supply. According to FAOSTAT (2013), sown area under beans has been growing year by year and in the world it now accounts for 19-20 million hectares. The main producers of beans are India, China, Brazil, USA, and Mexico. The lion's share is the growing of vegetable beans.

In the CIS, vegetable beans are grown primarily in Ukraine, Moldova and the Caucasus. In countries such as Portugal, Bulgaria, Romania beans are grown in large quantities for export only. Despite the advantages in growing vegetable beans, they are not as yet widely distributed in the CIS. However, there is no doubt about its development potential in the future.

In terms of the nutritional qualities, vegetable beans take one of the top spots among other plant foods. In practice, they are used as seeds (as dry grain) as well as immature beans and unripe seeds (as green vegetable).

Vegetable bean contains (in %) 90.0 of water, proteins – 4.0, 4.3 of carbohydrates, including sugar 1.0, 0.25 of fat, dietary fiber 1.0, 0.7 of ash. Bean protein is one of the full plant proteins contained in vegetables. In the bean there are also carotene and vitamin C, B1, B2, K. In terms of minerals, green beans are rich in phosphorus (44 mg %) and iron (1.1 mg %). Double cropped kidney beans can help solve food security challenges in Central Asian countries (Figure 18).

### 5.2.3. Mung bean *(Vigna radiata)*

The Mung bean, Wilczek has been grown in India since ancient times. Mung bean originates from South West Asia, where it was introduced into agriculture of 5-6 thousands years ago. It is still widely grown in southeast India, Pakistan, Afghanistan, Iran, Burma, China, Vietnam, Japan, and African countries, South American countries and also in Australia. The crop is also grown in Uzbekistan, Turkmenistan, Tajikistan, the





**Figure 18.** Bed-planted kidney bean in Uzbekistan

Caucasus and south Kazakhstan (in small areas) as main crop or second crop after winter wheat. The most common mung bean varieties are Pobeda 104 in Kazakhstan, and Orzu in Uzbekistan. Mung bean grain can be used as food while its stem can be used as fodder to feed animals. The crop can also be used as green manure cover crop to improve soil fertility.

Place in the rotation: Mung bean in the rotation can be grown as main crop in the spring as well as second crop in the summer period of sowing after cereal crops, vegetables, oil crops in rotation. Mung bean is a perfect preceding crop for many crops.

Mung bean is a warmer season crop requiring 90-120 days of frost free conditions from planting to maturity (depending on variety). Adequate rainfall and available soil moisture is required from flowering to late pod filling stage in order to ensure good yields.

Mung bean does best on fertile sandy, loam soils with good internal drainage. They do poorly on heavy clay soils with poor drainage and low carbon content. Performance is best on soils with a pH between 6.2 and 7.2. Mung bean plants can show severe iron chlorosis symptoms and certain micronutrient deficiencies on more alkaline soils. Mung bean has phosphorus, potassium, calcium,magnesium and sulfur requirements similar to other legumes which must be met by mineral and/or organic fertilizer additions if the soil is deficient in these elements.

Seeds should be planted 3-4 cm deep into the soil with good moisture content. If the surface layers are dry this depth can be increased to 5 cm, if the soil does not crust easily. The seeds of Mung bean can have a hard time breaking through a thick crust and stands will be reduced and uneven. Crusting and soil surface sealing is the result of low soil organic matter content and mechanical destructuring. Under No-Till/CA system, soil crusting reduces as soil health builds over time. Planting dates of mung

bean are as follows: in the spring, in the beginning of May, in the summer,in the 1st and 2nd ten days of July, after the harvest of cereal crops and early vegetables. Sowing is carried out by No-Till direct seeders such as FANKHAUSER 2115 and other modified seed drills designed for direct sowing in No-Till soils.

Seed rate should be 16-20 kg $ha^{-1}$, corresponding to plant density of 150 000-200 000 plants $ha^{-1}$. Sowing should be on beds 70 cm in width, at row spacing of 17-20 cm, and 10-20 cm between plants within the rows.

Irrigation: Pre-sowing irrigation is very important to obtain even seed germination of mung bean and the rate of water application is 800-1 000 $m^3$ $ha^{-1}$. The second irrigation of mung bean crop should be done during the flowering period at the application rate of 800-900 $m^3$ $ha^{-1}$.

Fertilizers: Sowing is followed by the application of 60-70 kg $ha^{-1}$ of phosphorus and 40 kg $ha^{-1}$ of potash fertilizers in active substances. Application of nitrogen fertilizer during the growing season of mung bean is not recommended, as legumes with Rhizobium bacteria are able to fix atmospheric nitrogen.

There are many herbicides available for control of later emerging weeds in mung bean field in the irrigated conditions. After field emergence of seedlings at 2-3 trifoliate leaf stage, mung bean crops should be treated with herbicides Pivolt – 0.6-0.8 l $ha^{-1}$ and Pivot – 0.8-1.0 l $ha^{-1}$.

Pod maturity in mung bean is not uniform because the vine type plants flower over an extended period (Figure 19). This makes it difficult to decide when to harvest. Generally harvest should begin when one half to two-thirds of the pods are mature. Seeds might be between 13% and 15% moist at this time. Some growers swath the plants to allow further maturity of the pods and then combine using a pick-up header on a small





**Figure 19.** Pod maturity in mung bean in different stages as the plants flower over an extended period

grain combine. This is a especially useful harvest system for the vine type varieties or when there is delayed maturity or when problem weeds are present. Swathing should be done earlier in the day to prevent severe shattering losses.

## 5.3. Double cropping

There is an urgent need to increase cropping intensity. More needs to be produced from less land. It is time for growing two crops in a year as against the current practice of growing either cotton or winter wheat in a year. Many crops can be used for double cropping after wheat harvest in the irrigated conditions of Central Asia and Azerbaijan. In this context maize, mung bean, pearl millet, kidney bean, and sorghum are used as summer crops after the wheat harvest in the project demonstration sites.

In Azerbaijan corn, sunflower, soybean and millet, in Kazakhstan maize, mung bean, soybean and kidney bean while in Uzbekistan mung bean, corn, kidney bean were studied as compared to summer fallow after winter wheat and barley harvest.

Multiple cropping (growing two or more crops in sequence in one growing season) offers an opportunity to provide additional output from the same land. Multiple cropping may be the most important of today's modern agricultural developments.

- No-Till system, herbicides and residue management leads to increase in the possibility of double-cropping;
- Two crops can be planted with the same fuel required for one conventional crop;
- Output is increased, while the overall cost of production is reduced;
- Equipment is used more fully and labour requirements are spread more evenly through the year.

In double-cropping, timing of planting the second crop becomes limited along with pressures of harvesting the mature crop. No-Till system reduces the time element while retaining soil moisture that is already present, and reducing run-off, soil erosion and soil evaporation.

In No-Till system, herbicides and residue management offer an opportunity to increase double-cropping. Fuel for producing agricultural products has become expensive and no longer is available in unlimited supply. By using No-Tillage and multiple 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 extra harvest. Farmers and researchers agree that double cropping can add grain or forage production in the project countries.

### 5.3.1. Double cropping with mung bean

Mung bean was studied under irrigated wheat–cotton rotation in Uzbekistan for double cropping after the harvest of winter wheat. It was found that food legumes are the best crops for diversification under CA system in irrigated conditions.

The results for grain yields show that No-Till mung bean (2.24 t ha$^{-1}$) had significantly higher yields than conventionally planted mung bean (1.85 t ha$^{-1}$) (see Table 14 and Figure 20).

**Table 14.** Mung bean grown as a catch crop with retention of surface residues in Karshi (2011-2013)

| Planting method | Spent fuel for planting, l ha$^{-1}$ | Root length, cm | Plant height, cm | Yield, t ha$^{-1}$ |
|---|---|---|---|---|
| Conventional | 53.6 | 25.4 | 67.17 | 1.85 |
| No-Till with 1 cultivation | 13.6 | 23.5 | 68.83 | 1.97 |
| No-Till | 5.9 | 23.8 | 65.35 | 2.24 |



**Figure 20.** Planting l mung bean with No-Till planter (L) and field performance of No-Till mung bean in Uzbekistan (R)

### 5.3.2. Double cropped maize

No-Till technologies provide opportunity for double cropping with maize after harvest of winter wheat. Maize is the most widely adopted second (double) crop by the farmers in the irrigated conditions of Azerbaijan, South Kazakhstan and Uzbekistan. Experiments were conducted to identify best tillage options, namely: conventional, minimal tillage and No-Till. Plant height was significantly affected by tillage methods (<.001). Plants in the No-Till treatment were taller than control plots. The tallest plant height was recorded (226 cm) in the No-Till treatment. The effect of tillage practices was significant on grain yield of maize (Table 15). No-Till treatment recorded higher grain yield (4.96 t ha$^{-1}$) compared to minimum tillage (4.77 t ha$^{-1}$) and conventional tillage (4.85 t ha$^{-1}$).

**Table 15.** Effect of tillage on productivity of double cropped maize in Azerbaijan (2011-2013)

| Planting method | Plant height, cm | Grain yield, t ha$^{-1}$ |
|---|---|---|
| Control (Conventional tillage) | 225 | 4.85 |
| Minimum till | 222 | 4.77 |
| No-Till | 226 | 4.96 |

# 6. EQUIPMENT AND MACHINERY FOR CONSERVATION AGRICULTURE

## 6.1. No-Till planter

New machinery for Conservation Agriculture 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 uniform 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 1 800 kg. Box capacity for wheat is 190 kg and box capacity for fertilizer is 505 kg. Working wide width for wheat is 2 380 mm while for row crops it is 2 400 mm. Traction is pull type which is very easy to transport from one place to another place. The Fankhauser 2115 is universial No-Till seeder can be converted to plant either field or row crops.

### 6.1.1. Row unit for large grains

Precision planter for large grains: It is a four or five row planter spaced at 40-90 cm (Figure 21). 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 (Figure 21). The operating depth adjustment of the coulter is obtained with adjustments on the frame leveler of the machine.

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 is 7.5 mm, number of holes is 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 local market.

In this planter, number of seeds per meter can be varied between 2.2 through 63.1 depending on crops (Table 16). For row crops the speed should be maintained at a maximum of 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.



**Figure 21.** Four row No-Till planter with disc opener (L), gauge wheel, and double disc closing wheels (R)

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 $ha^{-1}$. The planter can accommodate 5 row crop units in total. Good seed placement and soil contact is important to achieve healthy crop development and uniform 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 16.

**Table 16.** 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 |

### 6.1.2. 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 Table 17). There are two augers for fertilize metering: low-rate application auger and high rate application auger.

**Table 17.** 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 |

## 6.2. Seeds distribution system for field crops

The issue with the seeder is that the conversion between field and row crop use is 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 (Figure 22).

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.

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 18.

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

The limiting wheels copy the soil unevenness, which allows keeping the uniformity in the seeding 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

**Table 18.** 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/ 250 mm | 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/ 250 mm | | | | | | | | | | | | | | | | | | | | | | 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 |
| | | | 38 | 52 | 61 | 75 | 86 | 98 | 110 | 122 | 132 | 143 | 156 | 169 | 186 | 198 | 214 | 223 | 236 | 251 | 266 | 283 | 3 |

**Table 18.** Planting rate table – wheat, oat, black oat and rice

| Crops | Distance between rows | 0 | | | 1 | | | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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/ 250 mm | 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/ 250 mm | | | | | | | | | | | | | | | | | | | | | | 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 |

a "v" replaces the removed straw and does a lateral compacting of the seeds, avoiding the formation of air bubbles in the furrows.



**Figure 22.** Field crop No-Till seeder from back and right side

## 6.3. Sprayers

### 6.3.1 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 (Figure 23). In this regard FAO has developed the specifications described in the guidelines on testing, certification and registration of pesticide applying equipment that is also available in Russian (FAO, 2013).

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.

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 operation. This will be possible only with a good sprayer which is properly calibrated.





**Figure 23.** Boom sprayer transportable position and for broad field

**Calibration is a preconditon 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.

**There are four steps in calibration:**

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

### 6.3.2. Knapsack sprayers

Knapsack sprayers are widely used on small farms and households in Central Asia and Azerbaijan. In local markets there are three types of knapsack sprayers, namely: pressure sprayers (Figure 24), manual operated knapsack sprayers, and powered (petrol or electrical) but the basic components and requirements for use are the same for all. The components of a knapsack sprayer are similar as for boom sprayers.These components are:

- Tank to hold chemical;
- Hand pump to create pressure;
- Filtration system behind the nozzle tip to reduce blockages;
- Control Valve to control pressure and turn of the sprayer;
- Nozzle tip to control application rate and produce the correct size droplets.


**Figure 24.** Knapsack sprayers for small farmers

# 7. 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 operation, the soil surface should be loosened with a surface ripper equipment (Figure 25) to make leveling process easier, and a topographic survey should be carried out to determine the optimal slope and slope direction for the site (Figure 25). An example of a topographic survey is provided in Table 14. The topographic map was developed for the project demonstration site at Karshi in Uzbekistan and based on the map the tractor operator was able to accurately level the field (Table 15). 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).





**Figure 25.** Ploughed field (L) and conducting topographic survey (R)

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 (Figure 26). A "receiver" is mounted on the leveling equipment and connected hydraulically to the earthmoving blade. When activated, the receiver (and the blade) will "lock on" to the laser source, and 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.

The on-farm project showed that laser leveling operations lead to increase water use efficiency at the project demonstartion 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.



**Figure 26.** A rotating laser and a receiver mounted to the land leveler

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 19.** Measurements of uneven field areas within 1 ha obtained using laser device with a 20x20 meter measurement points*

| | | 100 m | | | | | Average, cm |
|---|---|---|---|---|---|---|---|
| | | 20 m | 20 m | 20 m | 20 m | 20 m | |
| 100 m | 20 m | 322 | 325 | 316 | 316 | 318 | 319 |
| | 20 m | 323 | 326 | 317 | 316 | 318 | 320 |
| | 20 m | 321 | 327 | 315 | 320 | 320 | 320 |
| | 20 m | 325 | 327 | 316 | 317 | 310 | 319 |
| | 20 m | 326 | 327 | 310 | 320 | 320 | 320 |
| | Average, cm | 323 | 326 | 315 | 317 | 318 | 320 |
| *Red – cut, blue – fill and green – equal to average.* | | | | | | | |

**Table 20.** Map and calculated depth and volume of cut and fill for each cell

| | | | | |
|---|---|---|---|---|
| 2 cm ($8 m^3$) | 5 cm ($20 m^3$) | -4 cm ($16 m^3$) | -4 cm ($16 m^3$) | -2 cm ($8 m^3$) |
| 3 cm ($12 m^3$) | 6 cm ($24 m^3$) | -3 ($12 cm^3$) | -4 cm ($16 m^3$) | -2 cm ($8 m^3$) |
| 1 cm ($4 m^3$) | 7 cm ($28 m^3$) | -5 cm ($20 cm^3$) | 0 cm | 0 cm |
| 5 cm ($20 m^3$) | 7 cm ($28 m^3$) | -4 cm ($16 m^3$) | -3 ($12 cm^3$) | -10 cm ($40 m^3$) |
| 6 cm ($24 m^3$) | 7 cm ($28 m^3$) | -10 cm ($40 m^3$) | 0 cm | 0 cm |

Fill up to 2 cm | Fill from 3-5 cm | Cut up to 5 см

Fill>6 cm | Cut > 5 cm | ± projected

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# 9. Appendices

**Appendix 9.1.** The model of winter wheat production under permanent bed planting technology on irrigated areas in Azerbaijan, South Kazakhstan and Uzbekistan

| | | | | |
|---|---|---|---|---|
|  | Full tillage | September | Magnum,<br>K-700 and | Plough |
|  | Leveling with laser device and scraper | It is depending land availability | MTZ-80/Magnum | Laser device and scraper |
| Disking after laser leveling |  | September | MTZ-80,<br>и T-150,<br>K-700 | |
| Reshaping* furrows for irrigation |  | September– early October | MTZ-80 | Furrow opener |
| Seed treatments: | Raksil 6% w.s.<br>- 0.4-0.5 l t$^{-1}$<br>Dividend Extreme<br>- 1.0 l/t<br>Kolfugo super 20 %<br>- 2.0-2.5 l/t | September– early October |  | |
| Seeding cum application of P-90 kg ha$^{-1}$ on permanent beds. | Raised-bed-furrow with row-spacing of 70 cm (distance between lines is 20 cm) in depth of 4-5 cm. |  | 1$^{st}$ and 2$^{nd}$ decades of October in South Kazakhstan and Uzbekistan while in Azerbaijan October end | |
| Pre-sowing or supplementary irrigation | Where possible, it should be done before sowing (along furrows) at the rate of 700-800 m$^{3}$ ha$^{-1}$ | October | Manually | Elastic polyethylene pipes |
| Nitrogen application in spring | Row-space application at tillering stage with simultaneous nutrition with N60-90-30 kg ha$^{-1}$ to beds |  | 1$^{st}$ and 3$^{rd}$ decades of March, 1$^{st}$ decade of April, | MTZ-80 |

| | | | | |
|---|---|---|---|---|
| Vegetative irrigation | Humid years – without irrigation or single irrigation in grain filling stage (600-700 $m^3$ $ha^{-1}$); – moderately humid years - single irrigation, at the end of booting stage and beginning of ear forming (700-800 $m^3$ $ha^{-1}$); – in extremely dry years – double irrigation: first irrigation –during winter wheat booting stage; second irrigation –during the grain forming stage (800 $m^3$ $ha^{-1}$). | $1^{st}$ and $2^{nd}$ decades of May End of $1^{st}$ decade in May<br><br>First irrigation – in the $1^{st}$ half of April; Second irrigation – in mid-May | Discrete irrigation in every furrow | |
| Treatment with herbicides at tillering stage of winter wheat | Herbicide application rate Dialen super 480 water solution – 0.5-0.7 l $ha^{-1}$; |  | $2^{nd}$ and $3^{rd}$ decades of March $1^{st}$ decade of April | MTZ -80 and boom sprayer |
| Harvesting | In the stage of full maturity | $3^{rd}$ decade of June, or early July |  | Niva, Case, New Holland and others |
| Grain transportation from field to threshing | By vehicle with tight body | 2nd decade of June, beginning of July | | GAZ-53 KAMAZ |

** If there is a need to reshape*

**Appendix 9.2.** The model of permanent bed planted maize for grain

| Farming Operation | Farming Operation Parameters | Farming Operation Timeline | Machinery Type | |
|---|---|---|---|---|
| | | | Tractor | Motor Vehicle |
| 1. Disking | Disking is carried out using heavy weight disk implements | October – November | T-150 DT-75 | BDT-7.0 |
| 2. Seedbed preparation | Seed bed is prepared using chisels and cultivators (at the depth of 8-10 cm) | April | DT-75 MTZ-80 | ChKU-4.0 KPS-4.0 |
| 3. Seeding and fertilizer application | Together with seeding nitrogen fertilizer at the rate of 40 kg $ha^{-1}$ and phosphor 90 kg $ha^{-1}$. | April | MTZ-80 | Bed planter |
| 4. Application of herbicides | In case there is no crusted soil and weed infestation of crops, for best results herbicide 2.4-D (amine salt) 40 % water soluble concentrate -2.0-2.5 l $ha^{-1}$ 50% water soluble concentrate –1.5-2.0 l $ha^{-1}$ or Dialen Super, 48% water soluble concentrate –1.25-1.5 l $ha^{-1}$ | At 3-5 leaf stage | MTZ-80 | OVT-1A POU OPSh-5 |
| 5.First irrigation during the vegetation period | When reducing pre-irrigation soil moisture threshold down to 70% from field capacity. Irrigation rate is 520-570 $m^3$ $ha^{-1}$. Estimated soil moistening layer is 0-50 cm. | At 6-7 leaf stage in dry years; At 9-10 leaf stage in moderately moisture years; At 13-14 leaf stage in moist years | Manually | Intermittent furrow irrigation |
| ** Only first year* | | | | |
| 6. Second irrigation | At soil moisture of 70% of field capacity until development of 13-14 leaves (530-550 $m^3$ $ha^{-1}$), 80% of field capacity after development of the indicated number of leaves(500-540 $m^3$ $ha^{-1}$). The depth of soil moistening in the first case is 0-50 cm and 0-70 cm in the second case. | At 12-13 leaf stage in dry years (beginning of the 2nd decade of June); At 15-16 leaf stage in moderately moist years | Manually | Intermittent furrow irrigation |
| 7. Third irrigation | At pre-irrigation soil moisture at 80% of field capacity (480-590 $m^3$ $ha^{-1}$). Soil moistening depth is 0-70 cm. | At 16-17 leaf stage in dry years; Period when tassels enter flowering stage in moderately moist years; At corn silk emergence in moist years | Manually | Intermittent furrow irrigation |
| 8. Fourth irrigation | At pre-irrigation soil moisture at 80% of field capacity (550-620 $m^3$ $ha^{-1}$). Soil moistening depth is at 0-70 cm. | At paniculation (tassel emergence) in dry years; At grain formation in moderately moist years; At milky ripeness stage in moist years | Manually | Intermittent furrow irrigation |
| 9. Fifth irrigation | To be done in case of reduced pre-irrigation soil moisture and 70% of field capacity (630-690 $m^3$ $ha^{-1}$). Depth of soil moistening is 0-60 cm | In dry years – for very late maturing corn – at milky-waxy grain ripeness stage | Manually | discrete furrow irrigation |
| 10. Grain harvesting | | At full maturity stage | | |

**Appendix 9.3.** Recommended Models for No-Till Winter Wheat on Rainfed Areas in the South Kazakhstan and Uzbekistan

| Crop management operations | Technological Parameters | Farming Operation Date | Вид техники | |
|---|---|---|---|---|
| | | | Трактор | Инструментарий |
| 1.Seed Treatment | Raksil–0.4-0.5 l $ha^{-1}$<br>Dividend extreme –1.0 l $t^{-1}$ | 2-3 weeks before planting | Electricity | PS-10<br>PSSh-5 mobitoks |
| 2. No-Till seeding | Kolfugo Super, 20% – 2.0-2.5 l $t^{-1}$ | 3rd decade of October,<br>3rd decade of November | MTZ-80 | SZS-2.1<br>FANKHAUSER2115<br>Seeder (Brazil) |
| 3.Early Spring Nitrogen application* | Direct winter wheat seeding using stubble seeders SZS- 2.1 or FANKHAUSER 2115 seeder (Brazil) at the depth of 4-5 cm | Sometimes in February if weather is favourable,<br>1st and 2nd decades of March | MTZ-80 | NRU-0.5<br>or aviation |
| 4.Treatment with herbicides at tillering stage of winter wheat | In resuming vegetation of winter wheat in spring, application of Nitrogen fertilizer to frozen-thawed soil: | 2nd and 3rd decades<br>of March 1st decade of April | MTZ-80 | OVG-1aOPSh-1.5<br>POU |
| 5.Winter wheat harvest | N35-50 kg $ha^{-1}$ – rainfed area both poorly and half provided with moisture, | 3rd decade of June<br>and 1st decade of July | Niva,<br>Laverd<br>and<br>others | Straw<br>chopper |
| 6.Grain transportation | N70 kg $ha^{-1}$ of active substances - rainfed area well-provided with moisture | June-July | Trucks<br>ZIL 130; Kamaz | |

**It depends on rainfall*

**Appendix 9.4.** No-Till alfalfa production under rainfed condition

| Preceding crops | Farming operation | Agricultural machines and implements | Dates | Crop management standards | Notes |
|---|---|---|---|---|---|
| | Seed treatment | Magnetic seed cleaner | No earlier than 10-15 days before planting, treatment 0.5…1.0 t/hour | Trifluralin 4 kg/t | |
| Wheat, Safflower, Barley, Oats, Rye | Planting and fertilizer application | T-90, MT3-80+ FANKHAUSER 2115 | Before 1.04 on rainfed areas well provided with moisture<br>Before 1.03 on rainfed areas half-provided with moisture<br>Before.03 on rainfed areas poorly provided with moisture | At the depth of 1…2 cm, no deeper than 3 cm | |
| - | Weed management | MTZ-80+ ОП-2000 OBT-1, OREN Raduga, QF Braunt and hang glider; | April. Against cereal weeds | Fuzilade Super at 0.5…1.0 l $ha^{-1}$ Fuzilade Forte – at 1.5 l $ha^{-1}$ | |
| - | Pest management | MTZ-80+ ОП-2000 OBT-1, OREN Raduga, QF Braunt and hang glider; | April-May | Actellic at 1.0, Karate 050 EC – at 0.15 l $ha^{-1}$ and others | If 1-2 weeds per 1 $m^2$ |
| - | Alfalfa cut for hay | KSK 100, JRK-6, PPS Kirghiziya | May. During alfalfa flowering phase | | |
| - | Harvesting alfalfa for seeds: -two-phase harvesting, or -direct combining | SK-5 Niva, Yenisey 1200HM, John Deere, New Holland. | June | Treatment 7…12 t/hr | If 80-85% of the beans grow brown |
| - | Barn-floor cleaning of the grain | Petkus-Gigant | - | Treatment 2…8 t/hr | |

**Appendix 9.5.** Species Composition of Weed Plants on Cereal Crop Fields in South Kazakhstan and Uzbekistan

| Weed Plant | | Biotype | Biogroup |
|---|---|---|---|
| Whild Barley | *Hordeum spontaneum* | annual | winter plant |
| Austrian Winter Pea | *Pisum arvense* | annual | spring plant |
| Black Bindweed | *Poliygonum convolvulus* | annual | spring plant |
| Field Mustard | *Sinapis arvensis* | annual | spring plant |
| Self-seed Poppy | *Papave rrhoeas* | annual | winter plant |
| Blindweed | *Capsella bursa- pastoris* | annual | winter plant |
| Scratchweed | *Galium aparine* | annual | winter plant |
| Caucalislappula (Weber) Grande | *Caucalisl appula (Weber) Grande* | annual | spring plant |
| Mayweed | *Matricariainodora* | annual | spring plant |
| Field Penny-Cress | *Thlaspiarvense* | annual | winter plant |
| Caltrop | *Tribulusterrestris* | annual | spring plant |
| Camel's-Thorn | *Alhagicamelorum* | perennial | root sucker |
| Corn Lily | *Convolvulus arvensis* | perennial | root sucker |
| Russian Centaury | *Acroptylon repens* | perennial | root sucker |
| Pink Russian Knapweed | *Acroptylon repens* | perennial | root sucker |
| Field Sow Thistle | *Sonchusarvensis* | perennial | root sucker |
| Bergaman's Cabbage | *Brassica campestris* | perennial | root-stock |
| Couch Grass | *Agropyron repens* | perennial | root-stock |
| Bermuda Grass | *Cynodondactylon* | perennial | root-stock |
| Russian Thistle | *Salsolapestife* | perennial | root-stock |
| Sophora | *Sophoradifolia* | perennial | root-stock |
| Thick-Fruited Sophora | *Sophorapachycarpa* | perennial | root-stock |
| Fetid Gum | *Ferula assa* | perennial | root-stock |
| Broad-Winged Ferula | *Ferula foetida* | perennial | root-stock |
| Horse Sorrel | *Rumexconfertus* | perennial | taproot |
| Whild Spinach | *Chenopodium album* | perennial | taproot |
| Common Wormwood | *Artemisia vulgaris* | perennial | taproot |
| Frosted orach | *Atriplex tatarica* | annual | root-stock |
| Thick-fruited pagoda tree | *Sophora pachycarpa C.A.Mey* | perennial | root-stock |
| Sedge | *Scirpusjuncoides* | perennial | winter plant |
| St John's wort | *Haplophylium perforatum* | perennial | |
| Pursley | *Portulaca Oleracea* | annual | taproot |
| Parsnip | *Pastinaca sativa* | biannual/annual | root-stock |
| Poison darnel or cockle | *Lolium temulentum* | annual | spring plant |


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Science for Better Livelihoods in Dry Areas

ISBN 978-92-5-109247-7
9 789251 092477
I5694E/1/05.16