AGRICULTURAL AND
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WORKING DOCUMENT

4

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by

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# Acknowledgements

The successful implementation of field projects, more so for conservation agriculture, requires the close collaboration of all stakeholders as they cannot be done in isolation. The projects described in this publication would not have been possible without the dedicated support of the Ministries of Agriculture in Mongolia and in Kazakhstan, which collaborated directly with the projects through their national project coordinators B. Tungalag and Baataryn Undrakh-od for Mongolia and Dr. Elemesov Kupmagambek for Kazkahstan. Special thanks are owed also to the project implementation teams in Mongolia J. Byambadorj as team leader, T. Turmandakh, Ch. Byambadorj, N. Ganbaatar and S. Otgonsuren. In Kazakhstan thanks go to the team under Murat Karabayev as team leader, Altybai Anarkulovitch Bektemirov, Michail Ivanovich Matyushkov, Asan Kenzhebekov, Vasko Ivan Adamovich and Andrey Vitalevich Rodionov, as well as to Alexei Morgounov and his team from CIMMYT in Kazakhstan.

However, the main actors in both projects were the farmers, whose efforts were critical to the success of the projects. In Mongolia these were D. Dashdendev from Khan Jargalant farm, G. Ganbold from Urgatsiin Undraa farm, T. Narmandakh from Enkh Ganga, T. Baasandorj from Zurt Undur farm and Ningbadjr from Ar Tarkhi farm. In Kazakhstan the project farmers were Darinov Ayezkhan from Daryn farm, Meyram Tungushbayevitch Sagimbayev from Dostyk farm, Viktor Sureiev from Surayeva farm, Vyacheslav Valeryanovitch Cherezdanov from Cherezdanov farm, and Adilhan Umerbayev as president of the Union of Farmers of Kazakhstan.

Finally, the assistance of Larissa D'Aquilio and Rosemary Allison in the preparation of the document is gratefully acknowledged.

# Foreword

In view of the difficult agro climatic conditions, the seriously degraded soil resources and the need for heavy investment into new machinery inputs for agricultural production in northern Kazakhstan and Mongolia the introduction of conservation agriculture into this region appears to be timely. This report describes the experiences of two FAO technical cooperation projects, one in Mongolia and one in northern Kazakhstan, which aimed to introduce conservation agriculture practices into the region. Conservation agriculture projects by their nature are multidisciplinary and involved several FAO technical units working together in a Conservation Agriculture workgroup. Both projects were technically led by the FAO Crop and Grassland service (AGPC), while the Agricultural and Food Engineering Technologies service (AGST) carried out the main responsibility for the mechanisation components of both projects.

It must be clearly stated that FAO did not invent conservation agriculture and the FAO projects were not the first in the region. The projects joined with ongoing research and development activities. An attempt was made to strengthen the promotion of sustainable farming practices in collaboration with other organizations already actively working in the region in this field. In Mongolia these were the USAID funded ACDI/VOCA project, the EU funded TACIS project and the Canadian funded CIDA project and, in Kazakhstan, CIMMYT. All shared resources and experiences with FAO and worked to complement each other in the promotion of conservation agriculture. This present publication reports on the FAO contribution to this joint effort which in both cases led to the publication of a joint CIMMYT-FAO manual on Conservation Agriculture in Kazakhstan and a joint manual on all the projects involved in Mongolia.

Gavin Wall
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# Acronyms

| | |
|---|---|
| ACDI | L'Agence canadienne de développement international |
| ACDI/VOCI | ACDI/VOCA is a private, nonprofit organization that promotes broad-based economic growth and the development of civil society in emerging democracies and developing countries. Offering a comprehensive range of technical assistance services, ACDI/VOCA addresses the most pressing and intractable development problems. |
| AGPC | (FAO) Crop and Grassland Service |
| AGS | Agricultural Support Systems Division |
| AGST | (FAO) Agricultural Food and Engineering Technologies Service |
| CA | Conservation agriculture |
| CACAN | Central Asian Conservation Agriculture Network |
| CIDA | Canadian International Development Agency |
| CIMMYT | International Maize and Wheat Improvement Center |
| EU | European Union |
| FAO | Food and Agriculture Organization of the United Nations |
| KRIGF | Kazakhstan Research Institute of Grain Farming |
| MNT | Tugrik (Mongolian currency) |
| MoA | Ministry of Agriculture |
| PSART | Plant Science and Agricultural Research Institute |
| TACIS | Launched by the EC in 1991, the Tacis Programme provides grant-financed technical assistance to 12 countries of Eastern Europe and Central Asia (Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan), and mainly aims at enhancing the transition process in these countries. (Mongolia was also covered by the Tacis programme from 1991 to 2003, but is now covered by the ALA programme.) |
| TCP | (FAO) Technical Cooperation Programme |
| UFK | Union of Farmers of Kazakhstan |
| USAID | United States Agency for International Development |

# Summary

This report describes the experiences of two FAO projects while introducing conservation agriculture practices to the wheat farming areas of Mongolia and northern Kazakhstan. Both project regions are characterised by unfavourable climatic conditions, with long and cold winters, low and irregular annual precipitation in the range of 200 to 300 mm and strong winds. Intensive cropping practices, combined with wind and water erosion, have led to serious soil degradation in both countries. After the collapse of the Soviet Union and the change to a free market economy support to the agricultural sector discontinued. Obsolete machinery and lack of investment capital for the newly privatised individual or cooperative farms has led to a serious decline in wheat production in both countries.

The projects described in this report were implemented under the respective Ministries of Agriculture as demonstration projects on private farms. The projects aimed to introduce conservation agriculture practices to achieve the sustainability of farming mainly through improvement of soil structure; reduction of wind and water erosion; saving water and making cropping less vulnerable to unfavourable climatic conditions. In addition, the projects sought to reduce farm power requirements and with this the need to invest in new machinery thus improving the profitability of farming. Demonstration plots of 100 ha each were established in both countries on a number of private farms (five in Mongolia and four in Kazakhstan) to introduce conservation agriculture practices in commercial-scale farming operations. These practices were no-tillage; direct seeding; retention of residues; chemical weed control on fallow and, to the extent possible, crop rotation.

The FAO projects demonstrated that conservation agriculture is a technically viable alternative to current crop production practices in northern Kazakhstan and Mongolia and provides a prospect for future sustainability. The increased yields achieved under conservation agriculture demonstrate that this technology is economically feasible. However, introduction of conservation agriculture is a learning process and more adaptive research needs to be carried out. Plant varieties and other agronomic parameters need to be adapted to zero tillage technologies. An extension service providing advice to farmers in the transition period would also be helpful.

The following results were achieved:

- ***Inputs*** – Conservation agriculture can save on labour and fuel.
- ***Weed control*** is still a challenge for conservation agriculture but not impossible to solve.
- ***Residue management*** is crucial although there is still a need for adequate equipment for its implementation.
- ***Yield data*** show that conservation agriculture provides more reliable yields during periods of drought.
- ***Training*** needs to be continued to ensure the successful widespread introduction of these technologies.
- ***Government support*** needs to be continued and has, in both cases, been provided.

# Chapter 1
# Introduction

## CONSERVATION AGRICULTURE

Conservation Agriculture (CA) is based on the integrated management of soil, water and agricultural resources to achieve the objective of economically, ecologically and socially sustainable agricultural production.

There are three main principles:

- permanent soil cover;
- minimal soil disturbance;
- crop rotation.

Box 1 lists the main characteristics of conservation agriculture.

The experiences described in this report are the first phases in the change over from conventional to conservation agriculture practices.

## AGRICULTURE IN KAZAKHSTAN AND MONGOLIA

### Natural conditions for agriculture

Northern Kazakhstan and the central Mongolian cropping region are well suited for wheat production. Although agricultural production is constrained by the dry continental climate with its short growing period, cold winters and low precipitation. Moreover, high winds, particularly during April and May, reach speeds between 15 and 20 m/s, which dry out the soil and create serious wind erosion before and after seeding in May.

Soils are predominantly silt or sandy silt and are especially vulnerable to erosion. In northern Kazakhstan, moisture accumulates in the soil from autumn rain and winter snow, though the spring rainfall completely evaporates. Thus soil moisture does not refill between the time the snow melts and planting. The lack of soil moisture, especially at seeding and during crop establishment in May and June, is the primary constraint to wheat yields. In addition, yields may often be reduced by violent thunderstorms and hail. Only early maturing spring crops such as spring wheat, potatoes and fodder crops are grown because of the short growing period, mid-May until mid-September. In northern Kazakhstan, however, there is the potential for introducing winter cereals provided snow accumulates in winter for crop protection and soil moisture retention can be increased. The area is well suited for the production of pulses and oilseed. Detailed information on the natural conditions in the project areas is given in Box 2 and Box 3.

BOX 1

**Key features of conservation agriculture**

- no ploughing, discing or seed bed preparation;
- green manure/cover crops are integrated into the cropping system;
- crop, weed and cover crop residues applied as mulch permanently protect the soil;
- direct seeding or planting;
- no burning of crop residues or fallow vegetation;
- no uncontrolled grazing;
- nutrient cycling through the biomass in and above the soil;
- surface application of lime and fertilizers;
- specialised equipment for seeding and mulch management;
- continuous use of crop land;
- crop rotations and cover crops are used to maximise biological controls.

Source: Benites *et al*., 2002

| Farm | Khan Jargalant | Urgatsiin Undraa | Zurt Undur | Ar Tarkhi | Enkh Ganga |
|---|---|---|---|---|---|
| *Soum* | Jargalant | Saikhan | Khushaat | Tarialan | Uroo |
| Elevation [m] | 1 000 | 750 – 850 | 800 – 900 | 1 240 – 1350 | 800 |
| Late frost | 27/05 | 25/05 | 23/05 | 06/06 | |
| Early frost | 30/08 | 05/09 | 05/09 | 25/08 | |
| Length of growing period [days] | 92 – 108 | 95 – 115 | 95 – 115 | 82 – 100 | 95 – 100 |
| Average annual temperature [ºC] | -0.7 | 1.1 | -0.6 | -0.6 | -2.6 |
| Average temperature in January [ºC] | -22.5 | -20.7 | -24.1 | -20.0 | -27.1 |
| Average temperature in July [ºC] | 17.1 | 19.6 | 18.4 | 16.0 | 18.3 |
| Average annual rainfall [mm] | 286 | 207 | 292 | 301 | 286 |
| Rainfall May – August [%] | 77 | 67 | 80 | 84 | 77 |

Source: FAO Report, 2001

In northern Kazakhstan there are comparatively dry conditions and chernozem and chestnut soils are inherently fertility. The resulting wheat has a high protein content (between 15 and 18 percent, a high gluten content and is superior to that produced in the more humid regions of Asia and Europe. Grain quality varies because of differences in climatic conditions and because the wheat is dependent on a nutrient supply to the root zone. Potential yields of some 2.5 tonnes/ha should be achievable under good farm management, favourable weather conditions and adequate input supply.

## Agricultural sector

Since the end of the Soviet era and the start of the transformation process, the agricultural sector has faced serious challenges. State and collective farms of up to 20 000 ha were privatised and have become limited partnerships, agricultural cooperatives and joint-stock companies. In many cases, farm employees have become owners, and have taken over the farm from the state, where they use the same physical infrastructure, management structure and trading relations (Plate 1).

BOX 2

### Natural conditions in northern Kazakhstan

- Fertile chernozem and chestnut soils with good water retention, high soil organic matter (between 3 and 9 percent) and nutrient and phosphorus content.
- Precipitation varies from 190 to 320 mm (130 to 200 mm rainfall in summer; 60 to 120 mm snow in winter).
- Vegetative growing period from mid-May until mid-September with a maximum of only 120 frost-free days.
- The average temperature is 20C in summer; -20 ºC in winter.

Source: FAO 2002

BOX 3

### Natural conditions on Mongolian project farms

The project farms are situated in the central cropping region in northern Mongolia. Ar Tarkhi farm is located in Hovsgol aimag, the other project farms are close to Darkhan in the Selenge and Tov aimags. The table below gives information on the conditions for agriculture in the *soums* (sub-provinces, districts or counties) where the farms are located.


**Plate 1**
*Machinery yard on Kazakh farm with 300 hp tractors K701 and sprayer*


**Plate 2**
*Traditional seed drills on a Kazakh farm*

Farm size generally reduced during the privatisation process; though much arable land still belongs to large-scale agricultural enterprises of up to several thousand hectares.

After the change from the centrally planned economy to a market economy, the Governments of Mongolia and the Republic of Kazakhstan largely withdrew their support, in the form of subsidies, to agriculture. As a result, many farms reported losses and were unable to repay seasonal production credits. This is partly related to the prices for cereal commodities, which had been fixed by the governments under the state order system. In Kazakhstan this is about 30 percent of total production; well below world market prices. The infrastructure for marketing agricultural products remains undeveloped, resulting in low prices for the producer. On the other hand, input prices were liberalised and increased substantially.

To some extent, the supply infrastructure for inputs collapsed and the situation in Mongolia became particularly difficult. The agricultural machinery and input supply sector were previously dominated by the privatised former state supplier which, in 2000, still operated much like a government institution and had a sub-optimal network of regional dealers. Today, most farms still use machinery that was produced before the start of the transformation process (Plate 2).

Farmers continue to find it difficult to obtain credit to purchase new machinery and this lack of funds can lead to insufficient maintenance. As prices for agricultural inputs such as seeds, fuel or fertilizer increased sharply, farmers attempted to reduce their input into farming operations. Thus, agricultural production has reverted to a low input/low output system where farmers' focus on surviving the prevailing economic crisis. To this end, cultivation of less suitable land has been abandoned and, in Mongolia, the area under wheat has fallen from 650 000 ha in 1990 to 300 000 ha in 1998. The switch to less-intensive wheat production during the 1990s allowed farmers to cut production costs per hectare by half. This low input/low output production system is based on fallow with up to five passes with broad-sweep. Box 4 gives an example of changed production technology in cereal production.

| Year | Intensive (centrally planned economy) | Extensive (transformation process) |
|---|---|---|
| 1 | Wheat | Wheat |
| 2 | Fallow | Fallow |
| 3 | Wheat | Fallow |
| 4 | Fallow | Wheat Fallow |
| 5 | Wheat | Fallow |
| 6 | Barley | Fallow |
| 7 | Wheat | Wheat |

BOX 4

**Reduced inputs for spring wheat production**

- one ploughing;
- one harrowing (sometimes omitted);
- seeding without fertilizer and with reduced seed rate (120 kg/ha);
- no herbicide application;
- – minimal machinery maintenance;
- – no seed treatment;
- – retention of seeds for next crop;
- – changed crop rotation (monocropping).

The seed production system does not function well and, because of lack of funds, farmers plant the seed they have saved from the previous harvest. Although cereal monocropping leads to serious disease and pest problems, chemical control of weeds, pests and diseases is seldom implemented. Perennial weeds, such as couch and sow thistle are often poorly controlled and have become resistant to the widely used 2.4-D herbicide. Strong weed infestation can lead to a yield reduction of up to 40 percent and harvest and post-harvest losses have dramatically increased: 1) Many farms have discontinued or reduced fertilizer use to marginal amounts. 2) This has caused soil degradation and led to a significant decrease in production.

While Kazakhstan is still able to export grain and other agricultural products, the number of malnourished people in Mongolia rose sharply. Therefore, in 1999, the international community pledged approximately 60 000 tonnes of food aid to Mongolia to alleviate problems related to food production. Box 5 lists situations that impacted upon agriculture during the transformation process in the Republic of Kazakhstan.

There is, therefore, considerable potential in Mongolia and Kazakhstan for improvement in the wheat production and marketing sectors; in productivity and adoption of new technologies. Most farmers may resume investment and adopt low-cost changes involving low-input methods of production. Though, these changes will largely depend on appropriate policies; wheat prices; strengthened agricultural research and improved crop and land management.

## Environmental impact of current production practices

Under the centrally planned economy high energy and input-intensive agricultural technologies were used for agricultural production, which led to soil degradation and erosion. The current cropping system, with fallow, was introduced to increase soil moisture storage and to control weeds. However, it is environmentally unsustainable as it is based on intensive tillage, which eventually leads to reduced soil fertility; degraded soil structure and erosion (Plates 3, 4 and Box 6).

BOX 5

### Kazakhstan: Changes in agricultural production during the transformation process, 1990s

- Agricultural production decreased by 55 percent;
- agriculture accounted for 10 percent of total Kazakh export revenue in the mid-1990s ; and
- for 25 percent of the national economy in 1991 and 12 percent in 1997;
- in 1997, the 45 percent of the population living in rural areas produced only 11.5 percent of the country's GDP;
- estimate hidden unemployment in rural areas between 40 and 50 percent;
- purchase of tractors fell from 7 000 to 1 000 per year;
- cultivation of marginal lands reduced;
- total area for cereals decreased from 23 million ha in 1990 to 11 million ha in 1998, more than 50 percent;
- cereal production of barley (-75 percent) and maize (-50 percent) fell because of the contraction in livestock production and the feed industry, resulting in reduced profitability of these crops;
- wheat production decreased dramatically in the 1990s by some 50 percent from 24 million tonnes to 11.8 million tonnes;
- spring wheat yield decreased from an average of > 1 tonne/ha in the 1980s to < 1 tonne/ha in the 1990s;
- the Republic of Kazakhstan exported 12 million tonnes of grain mostly to the Russian Federation in 1991, which fell to 5.5 million tonnes in 1997;
- main agricultural export products: grain (50 percent), meat and wool.

Source: FAO 2002

FAO/T.FRIEDRICH

**Plate 3**
*Dust formation caused by conventional tillage*

FAO/T.FRIEDRICH

**Plate 4**
*Erosion on a recently tilled field*

At one time, soil tillage was considered an effective factor in mobilising soil nutrients. However, intensive and deep tillage of chernozem soils under extensive land-use systems increases aeration. This means that part of the released nitrogen is irretrievably lost because nitrate is washed down to deeper soil layers or gaseous nitrogen evaporates. Tillage, therefore, results in dramatic losses of organic matter in the top soil. Since cultivation began in the 1950s, Mongolian soils, mostly silt or sandy silt, have lost 50 percent of their original organic matter and are highly susceptible to wind erosion. The annual average loss from the upper-most fertile soil layer is 18 tonnes/ha. To some extent, the withdrawal of this fertile soil layer may explain the decline in productivity.

### Past initiatives to improve the sustainability of the production system

The considerable degradation of soils is the result of extensive areas of virgin land being ploughed and cropped over long periods. Techniques have been tested and partially introduced to combat this land degradation, including the use of a paraplough and sweep cultivator, stubble retention, planting of windbreak crops and strip cropping. One technology that has been widely adopted by farmers is the V-shaped shallow sweep cultivator, which replaces the use of the mouldboard plough.

Tillage operations are reduced for cropping; although they are increased during the fallow period to control the overwhelming weed problem. This is because mechanical weed control is the only control method used by farmers since the increase in herbicide prices.

FAO/T.FRIEDRICH

**Plate 5**
*Snow ploughs*

FAO/T.FRIEDRICH

**Plate 6**
*Strip cropping*

Moreover, as snow is a major source of water in the region, its management is one of the most important practices in the production system. The recommended methods are snow ploughing (Plate 5) or planting of low plant barriers (kulissy) on summer fallow. Another way to trap snow is to leave alternating strips of high and low stubble after harvest (Plate 6).

Seeding is carried out in strips of 50 m placed transverse to the main wind direction and 50 m bands of residues from the previous harvest are left in between. This practice helps hold down the ground during strong spring storms. Herbicides are used to control weeds in the seeded area in order to keep vegetation residues on the ground and to reduce soil erosion. Notwithstanding the use of the above-mentioned technologies they have been insufficient in creating a sustainable production system.

BOX 6

**Impact of current production practices**

- reduced quantity and quality of organic matter;
- increased nitrogen leaching;
- reduced aggregate stability;
- soil compaction;
- enhanced wind and water erosion;
- soil moisture loss due to frequent fallow cultivation and insufficient snow retention.

# Chapter 2
# FAO projects introducing conservation agriculture in Kazakhstan and Mongolia

Previous attempts to sustainably increase production and reduce the environmental impact of agricultural operations have not been successful. There was the need to develop a sustainable and resource-saving conservation agriculture system together with its own appropriate technologies. To this end, the FAO proposed a suitable conservation agriculture system for Central Asia.

The main components of this system were the introduction of chemical fallow with the use of non-selective herbicides, the substitution of black fallow by a more diversified crop rotation and a decreased number of field operations, which greatly reduced operational costs. These techniques allowed farmers a timelier planting, which has been shown to improve cereal yields.

It is also important to improve planting and harvest operations through direct drilling and the introduction of straw choppers or spreaders. Residue management plays an important role in improved land management, both in improved fallow or no-fallow cropping systems. In areas having little demand for straw as a source of livestock feed, such as in northern Kazakhstan, straw in no-till systems is important in conserving soil moisture and fertility. Reduced tillage and soil covered with residues minimise evaporation; the moisture thus retained in the soil can lead to higher yields.

Diversified crop rotation of alternative crops, such as durum wheat; barley; oats; millet; winter rye; winter wheat; buckwheat; pulses (peas, chick peas, lentils) or oilseed (rape, mustard, safflower) could become good income earners considering the market potential for these crops. Diversified crop rotation is, therefore, an efficient way to tackle the problem of weed, pest and disease infestation and herbicide resistance.

Given the obvious advantages of conservation agriculture, the FAO implemented projects in Mongolia from 2000 to 2002 and in the Republic of Kazakhstan from 2002 to 2004 to introduce this technology into these countries. The goal was to develop, test and introduce those technologies that would be suitable for the region. The project took the farmers' financial situation into account, and the decision was taken to use existing machinery (seeders, sprayers) and to upgrade existing machinery with affordable conservation agriculture technology kits. It was also decided to emphasise improvement in seed quality.

The project undertaken in the Republic of Kazakhstan was based on experiences gained in Mongolia and aimed to further develop and test conservation agriculture in Central Asia. Both projects highlighted the training of farmers on demonstration plots in the appropriate use of conservation agriculture technology and the spreading of knowledge of this system among farmers, researchers and government representatives. Collaboration was encouraged between farmers and researchers in Mongolia, Kazakhstan and western Siberia.

Besides the component on introducing conservation agriculture both projects contained a component on seed improvement. The project farmers received training on managing selected fields on their farmland for the production of seeds. They were provided with certified seeds, special care was taken for accurate weed and disease control and later on special cleaning and grading of the seeds. In this way, farmers were enabled to improve their own seed stock through training, some became recognized seed producers. This present report will focus on the conservation agriculture components of the projects.

BOX 7

### Crop management practices on Mongolian project farms

***CONSERVATION AGRICULTURE FIELDS***

***Planting date:***
- May 5 on Ar Tarkhi farm in the mountain region, May 15 on all other farms;
- 165 to 180 kg/ha seeds at a depth of around 6 cm;
- 20 kg/ha fertilizer.

***Weed control:***

Application of 2.4-D herbicide at tillering stage:
- on fallow, first spray of Roundup between July 3 and 17 (2.5 litres/ha) when average height of weeds during intensive growth stage was between 10 and 15 cm. Second Roundup application (1.5 litres/ha) around August 15 depending on re-growth and density of weeds after the first application.

***CONTROL FIELDS***
- first fallow cultivation: mouldboard plough (PN-4-35, 20 to 22 cm deep, June 20) or wide sweep cultivator (KPS-5, 10 to 12 cm deep, June 10);
- July 20: cultivation with sweep cultivator (KPS-4, between 10 and 12 cm deep);
- August 15: pass with disc harrow (LDG-10);
- Seed depth around 8 cm.

In the second year, the seedbed was prepared with light cultivation and an SZP-3.6 disc drill was used for seeding. On fields where the wide sweep cultivator had been used for the first fallow cultivation, the seedbed was prepared by light tillage and harrowing (diamond harrow type) in the second year. This was required to level and firm the soil for the next operation, which was seeding with hoe drills (SZS-2.1).

## Field work

### *Mongolia*

In Mongolia, demonstrations of the modified hoe drill coulters were carried out on 100 ha plots on each of five privatised farms. During the first year of the project, demonstrations were conducted on fallow land destined for planting in the following year. Soil moisture and weed control were monitored on both demonstration and nearby control fields. Prior to seeding in the 2001-season, those plots that had been mechanically tilled in their fallow year were lightly cultivated; plots treated with chemicals for weed control were directly seeded.

Planting operations on the project farms were carried out on different dates depending on site-specific conditions. The project team provided technical assistance in seed treatment with fungicides, pre-season seed handling such as grading and cleaning; installation and calibration of drill fittings for optimal seeding depth and rate. A summary of planting operations on the five farms is given in Box 7.

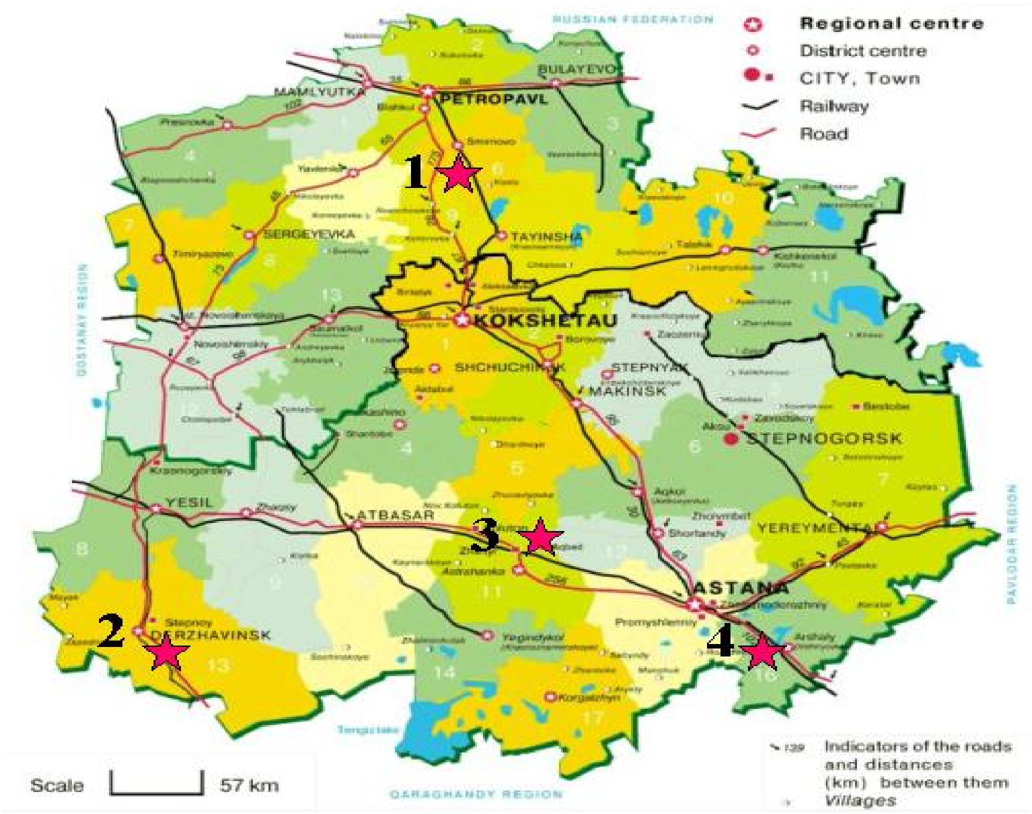


**Plate 7**
*Northern Kazakhstan: Location of project farms (FAO et al., 2004).*
*1. Cherezdanov; 2. Daryn; 3. Dostyk; 4. Surayev*

***Kazakhstan***

In Kazakhstan, demonstrations were conducted on four demonstration farms on 100 ha plots. The map in Plate 7 shows the locations of the project farms where the plots were divided into 50 ha for spring crops and 50 ha for fallow.

The fields were not cultivated to allow for direct seeding in spring and chemical fallow. Demonstration fields for spring crops were further subdivided into three units to test the different seeder modifications: The Brazilian disc seed drill and the disc and chisel drill, developed by the Kazakh Research Institute of Grain Farming (KRIGF). Further details are given in Table 1 and Box 8. During project implementation soil conditions, weed growth, diseases, plant vegetation and grain quality were monitored.

Plate 8 shows a field of directly seeded spring wheat.

FAO/T.FRIEDRICH

**Plate 8**
*Directly seeded spring wheat*

TABLE 1
**Demonstrations on Kazakh project farms**

| | Plot 1 | Plot 2 |
|---|---|---|
| 2003 | Direct seeding of wheat;<br>treatment with glyphosate (between 2.5 and 3.0 litres/ha) before seeding;<br>application of 50 kg/ha ammophos;<br>retention of stubble at its maximum height, chopping of the straw and distribution over the field. | Subdivision into three equal parts of 16.7 ha for the following treatments:<br>Traditional mechanical fallow<br>Chemical fallow with glyphosate<br>Chemical fallow and direct seeding of winter rye in August |
| 2004<br>Both plots<br>subdivided into<br>three equal parts | Direct seeding of wheat using seeders with disc openers.<br>Direct seeding using seeders with chisel.<br>Traditional seeding with seeders normally used on the farm. | Wheat was seeded and harvested using conventional farm technologies on subplot previously treated with mechanical fallow.<br>Wheat crop directly seeded using disc and chisel seeders on subplot previously treated with chemical fallow.<br>Harvesting and calculation of the yield was conducted on subplot where winter rye has been grown. |

Source: FAO Report, 2004

BOX 8
**Crop management practices for spring wheat on Kazakh project farm**

***LOCAL SPRING WHEAT VARIETIES: OMSKAYA 19, SHORTANDINSKAYA 95, SELINAYA 3C, AKMOLA 40;***

- Planting: mid- to end-May;
- Spacing: 22.6 cm;
- planting depth: 5 cm;
- seed rate: 120 kg/ha;
- fertilizer: ammophos (12-46-0), 50 kg/ha;
- chemical weed control: pre-emergence application of glyphosate (1. litres/ha);
- harvest: September/October, chopped straw and high stubble.

***DIRECT PLANTING OF WINTER RYE IN CHEMICAL FALLOW***

- Direct seeding: mid- to end-August;
- seed provided by CIMMYT;
- fertilizer: ammophos (50 kg/ha);
- chemical weed control: pre-emergence application of glyphosate (1.5 litres/ha) late June to early July (2.5 litres/ha);
- harvest: late June 2004, high stubble;
- follow-up: fallow until next spring.

***CHEMICAL FALLOW***

***Land management:***

- No tillage between last crop harvest and following crop 18 months later;
- chemical weed management: two applications of glyphosate during summer fallow period, one in June/July and one in August/September.

***CONVENTIONAL SUBSURFACE TILLED FALLOW***

***Land management:***

- Fall tillage after harvest in September at 25 cm soil depth;
- four subsurface cultivations with sweep at 12 to 16 cm soil depth;
- fertilizer 100 kg/ha ammophos before shallow tillage.

## INTRODUCTION OF CONSERVATION AGRICULTURE TECHNOLOGIES

The implementation of zero tillage technologies requires special equipment such as seeders for direct seeding. Due to economic constraints existing machinery was updated with local modifications that could be adjusted in the mechanical workshops on the farms.

### Seeders

The Mongolian project began with the modification of an SZS-2.1 seed drill as follows:

- shortened wings (wing width about 6 cm) of the duck-foot drill shares to reduce soil disturbance (Plates 9 and 10);
- additional seed spreader for better distribution of seed and fertilizer in the row;
- modified packer with opener changes.


FAO/T.FRIEDRICH

**Plate 9**
*Original SZS-2.1 hoe-drill coulters*


FAO/T.FRIEDRICH

**Plate 10**
*Modified hoe-drill coulters for direct seeding*

BOX 9

**Wheat seeders used in Central Asia**

The most commonly used wheat seeders in Central Asia are of standard design; one model is SZS-2.1. These are rustic, conventional, tractor pulled, with an independent hydraulic lifting device. The single units are small and cover nine rows of wheat for a total width of 2 m per unit. Usually three to five units are combined to cover a working width of 6 to 10 m. The seeders have a row distance of 22 cm and a hoe width of 27 cm and completely move the soil. Fertilizer is applied together with the seed. The metering mechanism is driven by metal rollers which, at the same time, act as compacting wheels in the rear.

BOX 10

**Conservation agriculture technologies – direct seeding**

Direct seeding machines are capable of placing seeds at the required depth (3 to 6 cm) into the untilled soil in the presence of evenly scattered straw on the surface and high stubble. Disc or chisels can be used as furrow openers.

***Disc openers:***

- equipped with one, two or three discs per furrow-opener body;
- discs can be smooth, toothed or undulated;

*Advantage*: no blockade by vegetative residues and soil.
*Disadvantage*: weight of seeders (up to 200 kg per cutting disc) required to penetrate hard soil; problems with cutting of thick or moist straw layers.

***Chisel openers:***

*Advantage*: good penetration into soil of any density without application of additional weight; placement of seeds at the necessary depth under any soil condition.
*Disadvantages*: stronger loosening of soil causes increased moisture evaporation; blockage by long straw more likely than with discs; higher energy demand.

FAO/ V. CHEREZDANOV

FAO/T.FRIEDRICH

**Plate 11**
*Direct seeding using SZS-2.1 seeders with Brazilian disc openers*

Because of the rich Brazilian experience in affordable conservation agriculture technology, an attempt was made to update existing machinery using kits produced in Brazil. The seeders' conventional hoe-type furrow openers were substituted by double disc furrow opener units, with or without cutting discs and the seeder frame was modified accordingly (Plate 11).

Double discs with preceding cutting discs allow the seeder to be operated in fields with substantial soil cover or in the native vegetation of abandoned fields. The project in Mongolia demonstrated locally modified hoes using a wing width of about 6 cm. Shortly before the end of the project a seeder element was modified and equipped with a disk-type furrow opener update kits from Brazil.

Based on the good experiences with the Brazilian update kits in the Mongolian project, these were tested on farms during project implementation in the Republic of Kazakhstan. The Agromash Company in Astana, in collaboration with KRIGF, also produced modified seeders with simple chisel furrow openers (Plates 12, 14 and 15). These were tested during project implementation together with the Brazilian furrow openers.

## Results in Mongolia

The modified hoe drill seeder performed better than the original on the Mongolian test areas (see Box 11). The residues left on the surface after planting were less than the required 85 percent of soil cover, but more than 50 percent and could still be considered adequate. The furrow openers were fixed onto the seeder frame and were unable to adapt well to the surface contours. This meant that the requested tolerance of 1 cm for the planting depth was difficult to achieve and the planting depth of around 3 cm was relatively shallow. However, the seeder had good seed placement and left a rough surface compressing only the seed rows.

FAO/T. M. MATYUSHKOV

**Plate 12**
*Direct seeding using SZTS-6 with Kazakh chisel openers*

FAO/T.FRIEDRICH

**Plate 13**
*Direct seeding into stubble fully covered by chopped straw using seeder with chisel openers*

The hoe drill SZS-2.1 seeder, modified with Brazilian discs, performed best and did not move the soil or incorporate residues. The requested seeding depth of 6 cm was achieved and fertilizer was deposited at the desired depth. Compaction of the seed rows was not high, which improved germination.

### Results in Kazakhstan

When testing direct seeders on the Kazakh project farms, the Brazilian disc openers and cutting discs performed best. The Brazilian disc openers did not become blocked with soil and residues during direct seeding into stubble and planted well. Though mounting the furrow opener units was difficult because of their weight (93 kg).

The SZS-2.1, with the less expensive chisel openers and cutting discs manufactured by KRIGF at the Agromash plant, were almost as good and yields did not differ significantly between the two models. Farmers were satisfied with the drill's performance. Neighbouring farmers expressed keen interest in the modified drill and Agromash received orders for more kits.

The KRIGF chisel coulters cut stubble ground well. They maintained the seed placement depth and were not blocked by straw; making the use of cutting discs unnecessary. The chisel openers were mounted on the SZS-6 seeders in place of the standard hoe-type furrow openers. This modification reduced the price of the direct seeder by up to 40 percent compared with the conventional seeder.

Accuracy of seed depth varied between the different furrow openers. Those with independent depth control for each furrow performed better than openers that were fixed to the seeder unit frame. The Brazilian disc openers achieved an average seeding depth of 3.8 cm and had independent depth control. Ninety percent of all seeds were placed in the layer at 3.5 ± 1 cm. Using traditional technologies, an average seed depth of 5.6 cm was achieved by the SZS-6 seeders in the control variants. Only 67 percent of seeds were placed in the layer 5 ± 1 cm.

Direct seeding, using disc openers with independent depth control for each row, provided for good seed placement into hard soil and resulted in uniform emergence. Spring wheat emerged 3 to 4 days earlier as compared with traditional technologies. Directly seeded spring wheat matured 2 to 3 days before traditionally seeded crops, which is important in Central Asia where the growing period is relatively short.

BOX 11

**Mongolia: advantages of modified hoe drill seeder**

- Reduction of soil disturbance by 30 to 40 percent;
- wider seed row, allowing seeds to obtain more soil nutrients;
- less power or draught requirements;
- wider press wheel that exactly follows the drill share;
- deposits seed and fertilizer in wider layers of the soil and thus allows better use of fertilizer;
- option to place seeds shallower;
- excellent moisture conditions under stubble.

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**Plate 14**

*Direct seeder SZS-2.1 without cutting discs*

***Sprayers***

Because of the high cost of pesticides and the environmental impact of pesticide use, correct dosage and distribution is vital. Existing sprayers were unsuitable for the precise application of herbicides. The main problem was uneven distribution of liquid from the nozzles.

In both projects, project farmers' existing OP-1800 and OP-2000 boom sprayers were upgraded with commercially available sprayer update kits (see Box 12 and Plate 16). A few sprayers were improved by equipping them with a marker at the ends of the boom and by adding adjustable wheels to reduce bouncing. This contributed to a more accurate matching of the spray-paths.

The modification has proved to be a quick and relatively inexpensive means of upgrading sprayers to an acceptable level. The modification of OP-2000 sprayers resulted in savings of 10 to 12 percent of the application volume. Weed control efficiency increased by 20 to 22 percent.

FAO/T. M. MATYUSHKOV

**Plate 15**
*Direct seeder SZS-2.1 with cutting discs developed by the Shorthandy Institute*

FAO/T.FRIEDRICH

**Plate 16**
*Updated sprayer OP-2000*

BOX 12

### Features of updated sprayers

- The update kits include pump, tubes, nozzles and sprayer controls. A measuring cylinder and manuals to calibrate the sprayer were also provided.
- The kits were fitted to OM-2000 and OM-1800 sprayers only. The tank, frame and boom structure were retained from the original sprayer.
- All liquid carrying parts can be easily removed and stored in a safe place during off-season, preventing sun and frost damage.
- The application rate of the liquid herbicide or fertilizer can be easily and accurately adjusted using the controls or changing nozzles.
- Three to four filters enable the reliable operation of nozzles preventing obstruction caused by impurities in the spray liquid.
- Independent spray liquid lines to different boom sections equalise the pressure and hence distribution across the boom.
- The positioning of nozzles and the proper alignment of the boom require special care.

***TECHNICAL DATA AND SETTINGS:***

- herbicide application width: 15 to 17 m;
- working speed: 6 to 12 km/h;
- pressure: 2.5 to 3 bar;
- nozzle spray-angle: 110º;
- application volume: 120 to 240 litres/ha;
- working capacity: 9 to 12 ha/hour.

FAO/T.FRIEDRICH

**Plate 17**
*Straw spreader*

FAO/T.FRIEDRICH

**Plate 18**
*Mongolia: Distribution pattern of unchopped straw left by the project straw spreader*

***Straw spreaders***

As residue management is a vital component of conservation agriculture, a straw spreader fitting was developed for existing combine harvesters during the Mongolian project (Plate 17). The spreader was less expensive and consumed less power than a straw chopper.

When the spreader was used for pick up threshing of a double swath of straw the spreading width and handling capacity proved to be insufficient (Box 13 and Plate 18). During tests on Zurt Undur farm, the spreader barely achieved a spreading width of 5 m and pick-up threshing from a double swath left strips 6 m wide without straw cover in between. The straw was thicker in the centre than at the border of the 5 m strip. Frequent heaps of straw were left when the spreader blocked. At Khan Jargalant, the farmer modified the spreader with a stronger drive-belt and only used it for single swath threshing. Under these conditions it worked and spread well, although more straw was still left at the centre than at the sides of the combine passes.

Possible options to improve the straw spreader would be to increase the speed and transmission power (for example use of a double belt) or increasing the size of the paddles on the spreader discs to increase the blowing effect.

Constraints to the use of plant residues as mulch are uncontrolled grazing in some areas of Mongolia and the common burning of crop residues in Kazakhstan.

## CROP ROTATION AND COVER CROPS

Chick peas in summer and winter rye as a post fallow crop were tested for the purpose of crop diversification (Plate 19). Chick pea, as an export crop, has good market potential in Uzbekistan and rye is the preferred bread cereal in the region; the Mongolian project farms planted malting barley as a rotation crop.

Cover crops were not introduced because farmers were reluctant to plant crops that did not bring them direct financial benefit. Furthermore, earlier small-scale tests, carried out by the International Maize and Wheat Improvement Center (CIMMYT), had shown that spring wheat yields were reduced when planted following a cover crop. This is caused by increased utilisation of soil nutrients and moisture by the cover crop. The potential merits of cover crops were, however, recognized and further investigation will be required.

BOX 13

**Wheat harvest**

Wheat in Mongolia is often harvested in two steps. During a first pass, it is cut and left in windrows to dry. In a second pass, the combine picks up the windrow and threshes the wheat. To increase the work rate the windrows are often arranged as double swathes; two windrows are aligned in such a way that they can be picked up in one pass by the thresher. As each windrow corresponds to a strip of about 5 m wide, the double swath would require straw to be spread across 10 m.


**Plate 19**
*Field emergence of directly planted winter rye in weed fallow*


**Plate 20**
*Mechanical fallow with heavy quack grass infestation versus chemical fallow in Jargaland*

## WEED AND DISEASE CONTROL

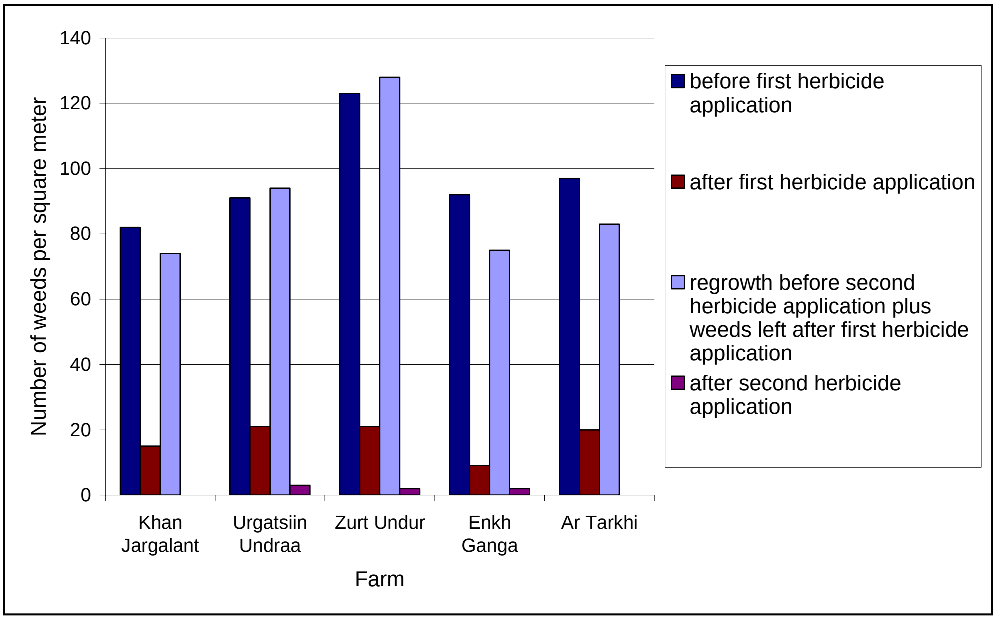
Weed infestation under the current wheat monocropping system is a major problem in the region. Mechanical weed control during the fallow period is unsatisfactory. Under conservation agriculture, mechanical weed control is replaced by other weed management strategies such as efficient use of herbicides and crop rotation. Experience shows that weed infestation decreases under the long-term use of conservation agriculture systems. This was confirmed by project farmers who reported a decrease in weed pressure after only two years. If optimal crop rotation of wheat and other crops is observed the need for herbicides declines sharply.

### Mongolia

The use of 2.4-D herbicide at the crop tillering stage produced positive results on Mongolian farms. On fallow, rates of 2.5 litres/ha of Roundup applied in mid-June and followed by a second application, at a rate of 1.5 litres/ha at the end of August provided weed-free fallow (Plate 20).

The effectiveness of Roundup in the 2001 season was close to 100 percent after the second application. The results of the analysis of the effect of pesticide application are summarised in Figure 1. The main weed species are listed in Table 2.

FIGURE 1
**Mongolian project farms. Impact of herbicide application in the 2001 season**




Source: FAO Report, 2001

TABLE 2

**Mongolian project farms: Weed conditions, 2001**

| Farm | Number of weed species | Main weeds |
|---|---|---|
| Ar Tarkhi | 20 | Quackgrass, Canada thistle, sow thistle, toadflax, lamb's quarter, wild oat, buckwheat |
| Urgatsiin Undraa | 24 | Canada thistle, sow thistle, toadflax, lamb's quarter, wormwood |
| Zurt Undur | 36 | Quack grass, Canada thistle, sow thistle, wild millet, buckwheat, field bindweed, flixweed, lamb's quarter, wormwood, |
| Khan Jargalant | 24 | Quack grass, Canada thistle, sow thistle wild millet, flixweed, lamb's quarter, wormwood, barnyard grass |
| Enkh Ganga | 19 | Quack grass, sow thistle, wild millet, hawksbeard, flixweed, lamb's quarter, buckwheat, wild oat |

Source: FAO Report, 2001

The following are the results of an assessment of the resistance of particular weed species to herbicide:

- highly resistant – 4 species or 8.5 percent;
- moderately resistant – 11 species or 23.4 percent;
- low resistance – 20 species or 42.6 percent;
- no resistance to Roundup 12 species or 25.5 percent.

## Kazakhstan

The most widespread weeds on project farms in Kazakhstan were ordinary wild oat, sow thistle, smartweed and bindweed. Application of 2.5 litres/ha glyphosate 2 to 4 days after seeding was very effective in controlling the weeds. An application rate of 1.5 litres/ha, as tried on Daryn farm was not very effective and an increase of wild oat was observed under direct seeding as compared with traditional treatments. The low efficiency of the herbicide on Daryn farm was also caused by rainfall after seeding and high rainfall during the vegetation period, which led to strong weed growth. Under the climatic conditions of northern Kazakhstan an additional application of selective herbicides may occasionally be required to combat secondary weed regrowth.

The results of weed analysis in 2003 are summarised in Table 3.

TABLE 3

**Weed infestation of spring wheat at tillering stage under different technologies, 2003**

| Technology<br>Farm | Weeds per square metre | | | | Total |
|---|---|---|---|---|---|
| | Wild oat | Knotweed | Bindweed | Other | |
| ***Cherezdanov*** | | | | | |
| Wheat-after-wheat, traditional seeding | 13 | 57 | 2 | – | 72 |
| Wheat-after-wheat, direct seeding | 71 | 89 | 2 | 2 | 164 |
| ***Dostyk*** | | | | | |
| Wheat-after-wheat, traditional seeding | 15 | – | 4 | 8 | 27 |
| Wheat-after-wheat, direct seeding | 5 | – | 6 | 3 | 14 |
| ***Surayev*** | | | | | |
| Wheat-after-wheat, traditional seeding | 80 | 26** | - | 18 | 124 |
| Wheat-after-wheat, direct seeding | 9 | 8 | 6 | 5 | 28 |
| ***Daryn*** | | | | | |
| Wheat-after-wheat, traditional seeding | 9 | – | 10 | 11 | 30 |
| Wheat-after-wheat, direct seeding | 28 | – | 12 | 8 | 48 |

** Sow thistle

Source: FAO *et al.*, 2004

Under chemical fallow, the main weeds were wild oat and the previous year's outgrown seed (up to 313/m$^2$). The use of 3 litres/ha glyphosate-360 during fallow at the weed-budding stage totally killed the weeds. After treatment with glyphosate, the weeds are left standing in the field to improve snow retention. Under traditional seeding, weeds were controlled during soil cultivation before and at planting. High weed infestation was observed on the Cherezdanov and Surayev farms, 72 and 124/m$^2$, respectively.

In 2004, weed evaluation at the spring wheat tillering stage showed that weeds were perennial root weeds (bindweed, knotweed, etc.), annual weeds (wild oat, barnyard grass) and broad leaf weeds (amaranth, *Chenopodium album*). The data in Table 4 show that weed infestation was less severe in 2004 than in 2003.

TABLE 4
**Weed infestation of spring wheat at tillering stage under different fallow management and seeding technologies, 2004**

| Technologies used on farm | Weeds per square meter | | | Total |
|---|---|---|---|---|
| | Perennial | Wild oat | Other | |
| ***Cherezdanov*** | | | | |
| Mechanical fallow, traditional wheat seeding | 2 | | 3 | 5 |
| Chemical fallow, direct wheat seeding | 4 | 4 | 1 | 9 |
| Wheat-after-wheat, traditional seeding | 25 | 13 | 9 | 47 |
| Wheat-after-wheat, direct seeding | 2 | 4 | 3 | 9 |
| ***Dostyk*** | | | | |
| Mechanical fallow, traditional wheat seeding | 0 | 1 | 2 | 3 |
| Chemical fallow, direct wheat seeding | 2 | 4 | 3 | 9 |
| Wheat-after-wheat, traditional seeding | 21 | 18 | 6 | 45 |
| Wheat-after-wheat, direct seeding | 3 | 7 | 1 | 11 |
| ***Surayev*** | | | | |
| Mechanical fallow, traditional wheat seeding | 3 | 4 | 4 | 11 |
| Chemical fallow, direct wheat seeding | 3 | 6 | 6 | 15 |
| Wheat-after-wheat, traditional seeding | 18 | 33 | 2 | 53 |
| Wheat-after-wheat, direct seeding | 3 | 5 | 3 | 11 |
| ***Daryn*** | | | | |
| Mechanical fallow, traditional wheat seeding | 2 | 3 | 2 | 7 |
| Chemical fallow, direct wheat seeding | 2 | 5 | 4 | 11 |
| Wheat-after-wheat, traditional seeding | 35 | 3 | 3 | 41 |
| Wheat-after-wheat, direct seeding | 4 | 6 | 1 | 11 |

Source: FAO et al., 2004

The prevailing diseases on Cherezdanov and Surayev farms were *septoriosis* and *helmithosporiosis* (Table 5). Septoria infestation was between 80 and 100 percent at the time of evaluation. The data suggest that septoria was widespread on both farms, but was more severe in the chernozem soil zone; brown rust was less developed. Severity and distribution of diseases was the same under zero and traditional tillage systems for the two-year research period on both farms.

## YIELDS AND GRAIN QUALITY

### Mongolia

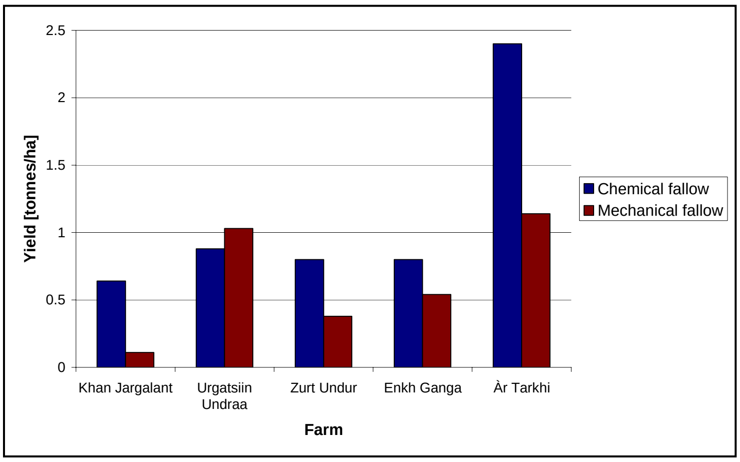
The yields on the Mongolian project farms are shown in Figure 2. In 2000 and 2001 the climate was unfavourable for crop production, except for Ar Tarkhi, which benefited from abundant rainfall throughout the season, resulting in the highest yield of all project farms, up to 1.26 tonnes/ha. In most other cases yields were low because there was little rain and drought continued throughout the season. In 2001, yield increases after chemical fallow were reported on four farms. On the fifth farm, Urgatsiin Undraa, yield decreases were the result of late herbicide application in the 2000-season making full weed control impossible. Finally, the conservation agriculture demonstration plot at Urgatsiin Undraa was located on top of a hill making it more susceptible to drought.

TABLE 5
**Phytopathological evaluation of spring wheat at booting – heading stage under different technologies**

| Technologies | *Septoriosis* [%] | | *Helminthosporiosis* [%] | | Other diseases |
|---|---|---|---|---|---|
| ***Farm*** | **Distribution** | **Infection rate** | **Distribution** | **Infection rate** | |
| ***Cherezdanov*** | | | | | |
| Traditional | 100 | 50 | 30 | 5 | - |
| Direct seeding using Brazil disc openers | 80 | 40 | 30 | 5 | - |
| ***Surayev*** | | | | | |
| Traditional | 100 | 7–10 | 100 | 10–15 | |
| Direct seeding using Brazil disc openers | 80 | 10–15 | 100 | 10–12 | - |

Source: FAO et al., 2004

FIGURE 2
**Mongolian project farms: yields from conservation and traditional agricultural technologies, 2001**




Source: FAO Report, 2001

## Kazakhstan

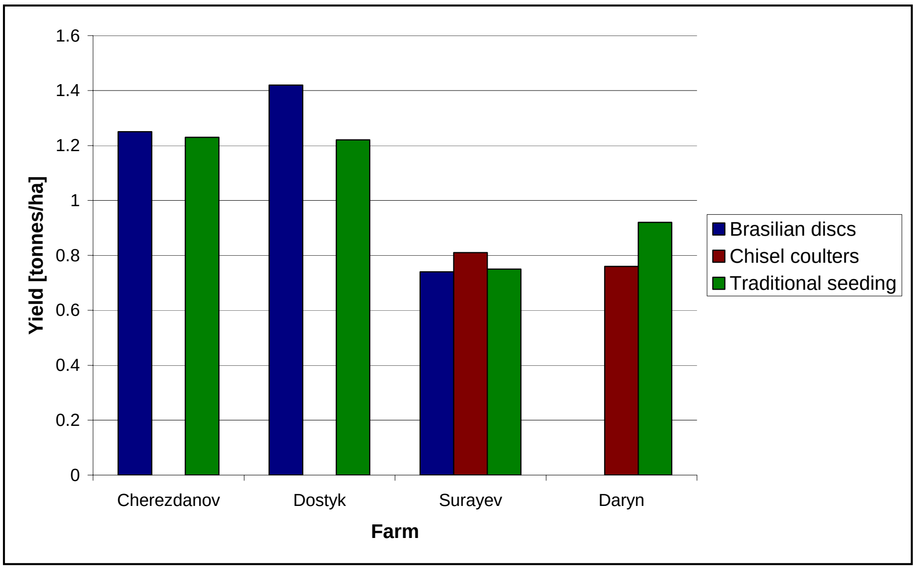
In 2003, the directly seeded spring wheat yield on the Kazakh project farms exceeded that for traditionally planted wheat by 20 to 200 kg/ha (see Figure 3). The highest spring wheat yield under direct seeding was produced on Dostyk farm with 1.42 tonnes/ha. The yield for directly seeded wheat was lower than that for traditionally planted wheat only on Daryn farm. There were a number of reasons for this result: the farm was included in the project quite late and planting was delayed by a week. Second, the seed rate was only 120 kg/ha and there was insufficient weed control (see section on *Weed and disease control*). The low yield on Surayev farm was caused by the soil type, drought and high weed infestation during the spring wheat growing period.

In 2004, the vegetation period was characterised by drought that affected cereal crop yields. The average yield of traditionally seeded spring wheat after chemical fallow was 1.35 tonnes/ha, which is 0.14 tonnes/ha lower than that of directly seeded spring wheat following chemical fallow (Figure 4). Wheat-after-wheat demonstrations resulted in higher average yields for direct seeding of 1.24 tonnes/ha compared with 1.12 tonnes/ha on traditionally cultivated plots (Figure 5).

The results show that under conservation agriculture the wheat yield increased, as compared with traditional technologies. The advantage of direct seeding over the traditional method was particularly obvious on Dostyk farm in 2003 (see Figure 3). The increased yield may be explained by uniform direct planting at 3 to 4 cm depth with SZS-2.1 seeders mounted with Brazilian disc openers. Contrary to traditional technologies, emergence of spring wheat was uniform under direct seeding, which was facilitated by good contact between seed and soil.

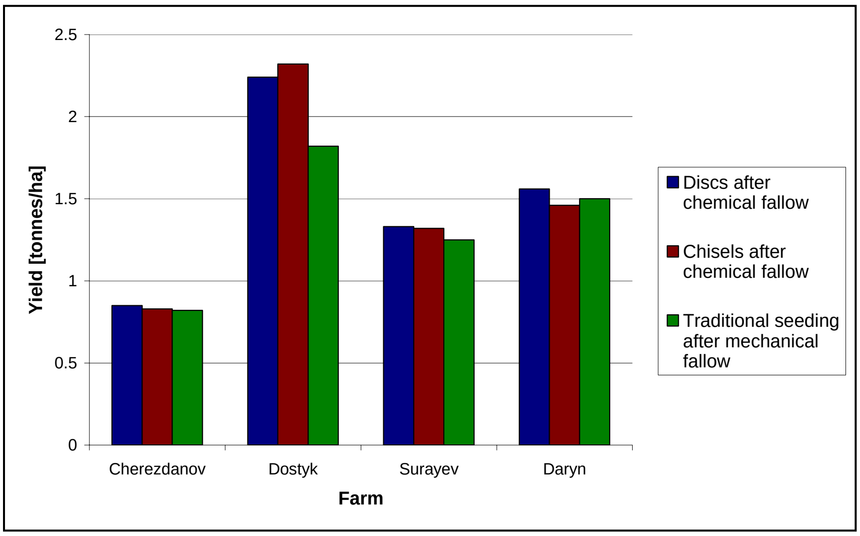
Parallel research carried out by the Kazakh Research Institute of grain farming in Shorthandy demonstrated that a relative yield improvement of spring wheat was facilitated by close placement of mineral phosphor fertilizers to the plant's roots, optimal soil density and mulching with straw. Under traditional seeding technology, the emergence of spring wheat was uneven and largely influenced by rough micro-relief resulting in a non-uniform seed depth.

FIGURE 3
**Kazakh project farms: wheat yield under different seeding methods, 2003**



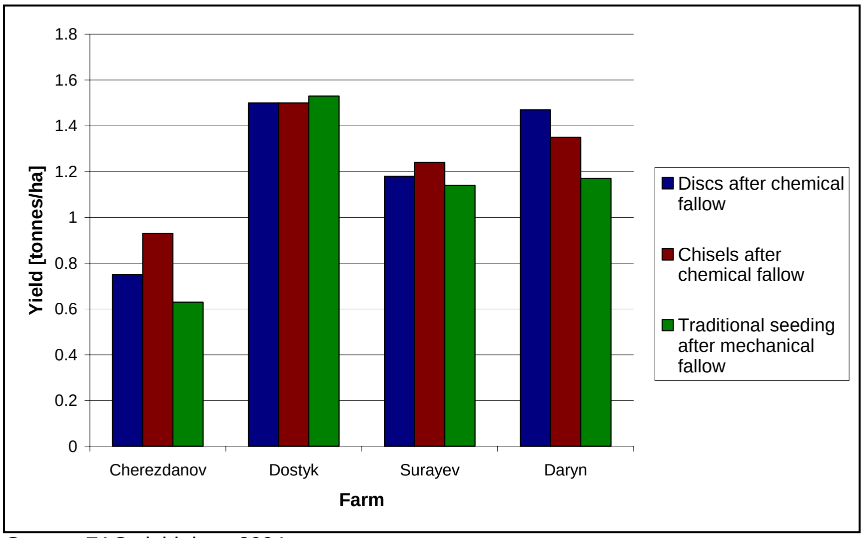

Source: FAO yield data, 2004

FIGURE 4
**Kazakh project farms: yield from traditionally and directly seeded spring wheat after mechanical and chemical fallow, 2004**




Source: FAO yield data, 2004

FIGURE 5
**Kazakh project farms: yield (tonnes/ha) from traditionally and directly seeded spring wheat-after-wheat, 2004**




Source: FAO yield data, 2004

The winter yield on Daryn and Cherezdanov farms amounted to 1.2 and 1.5 tonnes/ha, respectively. The low yield for winter rye on Dostyk of 0.79 tonnes/ha was influenced by the wrong setting of the disc furrow openers. This resulted in a very shallow planting as the discs did not penetrate into the relatively hard soil. Harvesting was also delayed. It was noted that the use of chisel openers for direct seeding is better for hard soils. The yield of 2 tonnes/ha on Surayev includes spring barley, which was additionally seeded in May when a poor crop stand of rye was obvious. Winter rye was unaffected by frost on the most northern farm, Cherezdanov, because of good snow cover. Improved residue management can also prevent frost damage in southern regions. Winter rye, following chemical fallow, did not freeze when directly seeded because 30 to 40 cm high weeds led to snow accumulating to the same height at a density of 0.3 g/cm$^3$.

Per thousand seed weight, gluten content and other parameters were analysed for all demonstration plots in the Kazakh project. It may be stated that different production systems, such as conservation agriculture, did not significantly influence grain quality, while weather conditions had a strong impact. For example, on Cherezdanov, gluten content was 26 percent in 2003 whereas it rose to 33 percent in the dryer year 2004, when yields were lower. There was substantial variation between project farms, e.g. gluten content varied between 25 and 35 percent in 2004 (FAO Report, 2003; FAO Final-Report-TCP-North-Kazachstan-2002–04).

## SOIL CONDITION

### Nutrient status

In general, there was low nitrogen content in the soils on the project farms as a result of a decline in organic matter in the soil and insufficient crop fertilization. Mobile phosphorous content was moderate in ordinary chernozems and dark-chestnut soils and low in chestnut soils (Table 6). Potassium content was high in all soils.

In comparison with a wheat-after-wheat system, nitrogen content was higher after fallow because no nitrogen had been taken up by plants during the previous season. Under direct seeding treatment, nitrogen content was lower when compared with traditional seeding because of nitrogen fixation in the wheat straw. Mobile phosphorus content was higher, which may be the result of increased phosphorus mobilisation by organic acids because of a build up of organic matter in the soil. The correlation between phosphorus and nitrate under direct seeding increased from 3.8 to 5.8 indicating that nitrogen is the limiting factor. Adequate nitrogen fertilization is important during the first years of transformation from traditional to conservation agriculture systems. No clear trend could be observed concerning the distribution of nutrients to the root zone. Nutrient accumulation in the upper soil layer and nutrient deficiencies in lower soil layers could not be confirmed.

TABLE 6

**Kazakh project farms: soil nutrients in chernozems and chestnut soils under different management methods for spring wheat**

| Farm management method | Average NO3 content in the 0 – 40 cm soil layer [mg/kg] | Average P2O5 content in the 0 – 40 cm soil layer [mg/kg] |
|---|---|---|
| ***Ordinary chernozems (Cherezdanov)*** | | |
| Mechanical fallow, traditional seeding | 7.3 | 21.7 |
| Chemical fallow, direct seeding | 5.2 | 25.9 |
| Wheat-after-wheat, traditional seeding | 4.3 | 21.7 |
| Wheat-after-wheat, direct seeding | 3.5 | 22.2 |
| ***Dark-chestnut soils (Dostyk)*** | | |
| Mechanical fallow, traditional seeding | 6 | 48.3 |
| Chemical fallow, direct seeding | 5 | 56.5 |
| Wheat-after-wheat, traditional seeding | 2.2 | 46.8 |
| Wheat-after-wheat, direct seeding | 2 | 48.5 |
| ***Dark-chestnut soils (Surayev)*** | | |
| Mechanical fallow, traditional seeding | 5.1 | 18.1 |
| Chemical fallow, direct seeding | 3.4 | 24.4 |
| Wheat-after-wheat, traditional seeding | 3.4 | 21.5 |
| Wheat-after-wheat, direct seeding | 2.9 | 26.4 |
| ***Chestnut soils (Daryn)*** | | |
| Mechanical fallow, traditional seeding | 3.4 | 18.4 |
| Chemical fallow, direct seeding | 2.7 | 15 |
| Wheat-after-wheat, traditional seeding | 1.8 | 11.6 |
| Wheat-after-wheat, direct seeding | 1.6 | 12.9 |

Source: FAO *et al.*, 2004

## Soil biological activity

In order to compare soil biological activity in conservation agriculture and traditional plots, the number of soil fungi, cellulose composing cells and bacteria utilising mineral and organic nitrogen were determined. It was found that the ratio between bacteria utilising mineral and organic nitrogen is higher under zero tillage. Combined with a higher biological activity under direct seeding these bacteria utilise mineral nitrogen to decompose organic matter with a high carbon content. In the first instance, this reduces the availability of mineral nitrogen to the crop.

TABLE 7

**Biological soil activity under different cultivation techniques for spring wheat, 0 to 20 cm soil layer, 2004**

| Technology | Soil humidity, % | Micro-organisms per gram of soil | | | | |
|---|---|---|---|---|---|---|
| | | Bacteria | | | | |
| | | Bacteria utilizing organic N [million cells] | Bacteria utilizing mineral N [million cells] | Ratio of bacteria using mineral and organic N | Soil fungi [1 000 cells] | Cellulose-decomposing [1 000 cells] |
| ***Ordinary chernozem (Cherezdanov)*** | | | | | | |
| Mechanical fallow, traditional seeding | 12.8 | 2.8 | 14.5 | 5.2 | 9.3 | 38.8 |
| Chemical fallow, direct seeding | 11.7 | 2.8 | 7 | 2.5 | 12.3 | 29 |
| Wheat-after-wheat, traditional seeding | 13.4 | 0.8 | 3.9 | 4.9 | 6.9 | 35.6 |
| Wheat-after-wheat, direct seeding | 11 | 1.2 | 6.6 | 5.5 | 12 | 26.1 |
| ***Dark-chestnut soil (Dostyk)*** | | | | | | |
| Mechanical fallow, traditional seeding | 9.2 | 3.4 | 14.7 | 4.3 | 1.3 | 46.3 |
| Chemical fallow, direct seeding | 12 | 2.9 | 14.2 | 4.9 | 1.7 | 31.4 |
| Wheat-after-wheat, traditional seeding | 10.9 | 3 | 10.5 | 3.5 | 1.4 | 25 |
| Wheat-after-wheat, direct seeding | 13 | 3.2 | 15.9 | 5 | 0.5 | 52.5 |
| ***Dark-chestnut carbonate soil (Surayev)*** | | | | | | |
| Mechanical fallow, traditional seeding | 6.5 | 2.2 | 7.3 | 3.3 | 1.7 | 29.2 |
| Chemical fallow, direct seeding | 11.1 | 1.3 | 8.7 | 6.7 | 1.7 | 26.1 |
| Wheat-after-wheat, traditional seeding | 6.2 | 2.4 | 16.2 | 6.8 | 4.6 | 37.1 |
| Wheat-after-wheat, direct seeding | 10.4 | 2.1 | 10.7 | 5.1 | 4.3 | 23.2 |
| ***Chestnut soil (Daryn)*** | | | | | | |
| Mechanical fallow, traditional seeding | 7.6 | 1 | 5.7 | 5.7 | 0.9 | 28.1 |
| Chemical fallow, direct seeding | 7.9 | 0.7 | 5.4 | 7.7 | 1.1 | 33.5 |
| Wheat-after-wheat, traditional seeding | – | – | – | – | – | – |
| Wheat-after-wheat, direct seeding | 7 | 1.1 | 3.2 | 2.9 | 1.3 | 42.8 |

Data source: FAO Final Report, TCP-North-Kazachstan-2002–04

The nitrogen is not lost. It becomes available in the long term because of the higher level of micro-organisms and will be released. This means that the nitrogen deficiency will be no worse under conservation agriculture than under traditional agriculture after a transformation process.

The large variations between farms are because agroclimatic conditions interfere with the effect of technologies, mineral fertilizers and plant residues on soil micro-organisms (see Table 7).

## Soil moisture dynamics

In 2000, soil samples were taken from both chemical and mechanical fallow at two different times to analyse soil moisture content on the Mongolian project farms. It was found that the soil moisture content of fields under chemical fallow was higher than for fields with mechanical fallow (see Table 8).

TABLE 8
**Mongolian project farms: Results of soil moisture analysis, 2001**

| Farms | Soil layer [cm] | Prior to seeding | | After harvest | |
|---|---|---|---|---|---|
| | | Chemical fallow mm | Mechanical fallow mm | Chemical fallow mm | Mechanical fallow mm |
| Khan Jargalant | 0–10 | 11 | 12 | 15 | 14 |
| | 10–20 | 13 | 13 | 15 | 12 |
| | 0–60 | 47 | 46 | 59 | 42 |
| Urgatsiin Undraa | 0–10 | 21 | 23 | 10 | 11 |
| | 10–20 | 23 | 21 | 12 | 10 |
| | 0–60 | 92 | 88 | 44 | 47 |
| Zurt Undur | 0–10 | 6 | 5 | 11 | 11 |
| | 10–20 | 9 | 8 | 12 | 12 |
| | 0–60 | 37 | 37 | 47 | 47 |
| Enkhganga | 0–10 | 26 | 21 | 17 | 12 |
| | 10–20 | 26 | 19 | 19 | 13 |
| | 0–60 | 100 | 68 | 63 | 40 |
| Àr Tarkhi | 0–10 | 19 | 26 | 18 | 17 |
| | 10–20 | 25 | 34 | 19 | 18 |
| | 0–60 | 90 | 98 | 69 | 71 |

Source: Plant Science and Agricultural Research Institute (PSARTI) in FAO Report, 2001

Similar results were found on project farms in Kazakhstan. Where, in 2004, at planting time for spring wheat, soil moisture supplies were better after chemical fallow and stubble than after mechanical fallow. The available moisture in a soil layer of one metre after chemical fallow was between 104 and 143 mm as compared with 97 to 131 mm after mechanical fallow (Table 9). The difference in moisture between conservation agriculture and mechanically tilled treatments averaged 8 mm. The moisture content of the top layer before planting was significantly better after chemical fallow and stubble (see also Plate 21).

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**Plate 21**
*Soil under heavy mulch on a Kazakh field – completely moist in May 2003*

Plants under direct seeding had higher 'starting' moisture in the soil and better conditions at early stages, which provided for a good yield. The field work confirmed that although fall tillage is supposed to allow for better absorption of water from melted snow, this advantage is compensated for by protection from loss of moisture by evaporation. The data are merely indicative because the number of repetitions did not allow for a statistical analysis to be made.

## Soil density

The bulk density in the upper layer of the soil between 0 and 10 cm was a little higher under conservation agriculture, with 1.07 to 1.15 g/cm$^3$ compared with 1.01 to 1.07 under traditional technologies (Table 10). A slightly higher bulk density under conservation agriculture was also measured in the 10 to 20 cm and the 20 to 30 cm soil layers. Average bulk density for the 0 to 30 cm layer never exceeded 1.25 g/cm$^3$, which is considered optimal for dark-chestnut and chestnut soils in Kazakhstan. Direct seeding on medium and heavy loamy chernozem and chestnut soils of northern Kazakhstan does not lead to soil compaction. Natural decompaction of the soils, through soil biology, facilitates zero tillage applications for cereal production. Conservation agriculture increases the amount of macro-pores and does not cause a ploughing pan, thus improving water infiltration. This advantage is not taken into account by the parameter bulk density.

TABLE 9

**Kazakh project farms: dynamics of productive moisture under different fallow management and seeding methods for spring wheat, layer 0 to 100 cm, 2004**

| Technology used on farm | Moisture supply [mm] | | Moisture consumed [mm] | Rainfall within growth period [mm] | Total moisture consumption within growth period [mm] |
|---|---|---|---|---|---|
| | Before planting | After harvest | | | |
| ***Ordinary chernozem (Cherezdanov)*** | | | | | |
| Mechanical fallow, traditional seeding | 97 | 38 | 60 | 88 | 128 |
| Chemical fallow, direct seeding | 104 | 42 | 63 | | 131 |
| Wheat-after-wheat, traditional seeding | 77 | 39 | 38 | | 126 |
| Wheat-after-wheat, direct seeding | 92 | 30 | 61 | | 150 |
| ***Dark-chestnut soil (Dostyk)*** | | | | | |
| Mechanical fallow, traditional seeding | 100 | 15 | 85 | 137 | 222 |
| Chemical fallow, direct seeding | 120 | 9 | 110 | | 246 |
| Wheat-after-wheat, traditional seeding | 90 | 7 | 83 | | 220 |
| Wheat-after-wheat, direct seeding | 98 | 10 | 88 | | 225 |
| ***Dark-chestnut carbonate soil (Surayev)*** | | | | | |
| Mechanical fallow, traditional seeding | 131 | 27 | 104 | 114 | 218 |
| Chemical fallow, direct seeding | 143 | 25 | 118 | | 232 |
| Wheat-after-wheat, traditional seeding | 135 | 28 | 106 | | 260 |
| Wheat-after-wheat, direct seeding | 137 | 25 | 120 | | 226 |
| ***Chestnut soil (Daryn)*** | | | | | |
| Mechanical fallow, traditional seeding | 130 | 23 | 107 | 90 | 197 |
| Chemical fallow, direct seeding | 141 | 28 | 113 | | 204 |
| Wheat-after-wheat, traditional seeding | 122 | 35 | 87 | | 177 |
| Wheat-after-wheat, direct seeding | 129 | 24 | 105 | | 195 |

Source: FAO Report, 2001

TABLE 10
**Kazakh project farms: soil density, spring wheat under different fallow management and seeding technologies, g/cm$^3$, 2004**

| Technologies used on farm | Soil layer [cm] | | |
|---|---|---|---|
| | 0-10 | 10-20 | 20-30 |
| **Ordinary chernozem (Cherezdanov)** | | | |
| Mechanical fallow, traditional seeding | 1.05 | 1.09 | 1.11 |
| Chemical fallow, direct seeding | 1.10 | 1.27 | 1.30 |
| Wheat-after-wheat, traditional seeding | 1.07 | 1.15 | 1.27 |
| Wheat-after-wheat, direct seeding | 1.11 | 1.30 | 1.30 |
| **Dark-chestnut soil (Dostyk)** | | | |
| Mechanical fallow, traditional seeding | 1.02 | 1.18 | 1.22 |
| Chemical fallow, direct seeding | 1.08 | 1.25 | 1.30 |
| Wheat-after-wheat, traditional seeding | 1.05 | 1.19 | 1.25 |
| Wheat-after-wheat, direct seeding | 1.10 | 1.21 | 1.28 |
| **Dark-chestnut carbonate soil (Surayev)** | | | |
| Mechanical fallow, traditional seeding | 1.06 | 1.20 | 1.21 |
| Chemical fallow, direct seeding | 1.10 | 1.31 | 1.28 |
| Wheat-after-wheat, traditional seeding | 1.07 | 1.18 | 1.23 |
| Wheat-after-wheat, direct seeding | 1.15 | 1.27 | 1.34 |
| **Chestnut soil (Daryn)** | | | |
| Mechanical fallow, traditional seeding | 1.01 | 1.06 | 1.09 |
| Chemical fallow, direct seeding | 1.07 | 1.32 | 1.34 |
| Wheat-after-wheat, traditional seeding | 1.06 | 1.16 | 1.26 |
| Wheat-after-wheat, direct seeding | 1.08 | 1.29 | 1.32 |

Source: FAO Report, 2004

## ECONOMIC ANALYSIS

New technology must be economically viable for it to be adopted by farmers. Therefore, a comparative economic analysis of traditional and conservation agriculture technologies was undertaken on the project farms.

### Mongolia

The preliminary economic assessment of the Mongolian project farms was conducted in 2001 found that the viability of minimum tillage largely depends on the price of glyphosate, which was the main cost item for chemical fallow. The cost of chemical fallow was estimated to be MNT 18 118/ha (Mongolian Tugrik per hectare). This is approximately MNT 12 000 /ha less than the cost of mechanical fallow using a mouldboard plough and about MNT 7 000/ha less than that using a wide-blade plough. A detailed cost assessment is given in Table 11.

Even though chemical fallow initially increases the expenditure for herbicides, it is the more profitable system because it reduces the cost of fuel, wages, depreciation and spare parts.

### Kazakhstan

The economic comparison between conservation agriculture and the traditional wheat cropping system for Kazakhstan was made by comparing the costs of labour and input based on a cropping plan.

As shown in Table 12, chemical fallow preparation reduced labour costs by 90 percent in comparison with mechanical treatment. Expenses for oil based inputs, such as lubricant and fuel were reduced by 96 percent. Under conservation agriculture the cost of labour for wheat production after fallow decreased by 50 percent and for oil products by 71 percent. When wheat was grown after wheat, labour costs were reduced by about 30 percent compared with the traditional system and lubricant costs by 55 percent.

A production assessment by cost item was conducted for an entire cropping season from autumn preparation until harvest (Table 13).

TABLE 11
**Estimated cost of chemical versus conventional fallow [*MNT/ha]**

| Costs | Chemical fallow | Mechanical fallow | | Difference | |
|---|---|---|---|---|---|
| | | Moldboard plough | Wide blade plough | Moldboard plough | Wide blade plough |
| **A. Variable** | | | | | |
| Fuel | 1 480 | 16 040 | 12 560 | -14 560 | -11 080 |
| Lubricants | 125 | 1 600 | 1 200 | -1 475 | -1 075 |
| Wages | 300 | 2 100 | 1 400 | -1 800 | -1 100 |
| Herbicide | 14 000 | – | – | +14 000 | +14 000 |
| Water transport | 430 | – | – | +430 | +430 |
| Food allowance | 160 | 900 | 700 | -740 | -540 |
| *A. Total variable cost* | *16 495* | *20 640* | *15 860* | *-4 145* | *+635* |
| **B. Fixed** | | | | | |
| Depreciation | 850 | 5 600 | 5 400 | -4 750 | -4 550 |
| Spare parts | 360 | 3 030 | 3 100 | -2 670 | -2 740 |
| Land fee | 560/390 | 560 | 390 | 0 | 0 |
| Labour protection | 23 | 50 | 50 | -27 | -27 |
| Loan Interests | - | 500 | 350 | -500 | -350 |
| *B. Total fixed cost* | *1 793/1 623* | *9 740* | *9 290* | *-7 947* | *-7 667* |
| **A+B TOTAL COSTS** | **18 288/18 118** | **30 380** | **25 150** | **-12 092** | **-7 032** |

*Exchange rate in 2001 MNT1 100/US$1.00
Source: FAO Report, 2001

TABLE 12
**Kazakh project farms: average cost per hectare of labour and lubricants for traditional and conservation agriculture**

| Technology | Persons/h | Oil products [kg] |
|---|---|---|
| Mechanical fallow | 1.1 | 42 |
| Chemical fallow | 0.1 | 2 |
| Wheat after mechanical fallow, traditional seeding | 2.4 | 66 |
| Wheat after chemical fallow, direct seeding | 1.2 | 19 |
| Wheat-after-wheat, traditional technology | 1.6 | 35 |
| Wheat-after-wheat, direct seeding | 1.1 | 16 |

Source: FAO et al., 2004b

TABLE 13
**Average for all Kazakh farm expenses for spring wheat production, traditional and conservation agriculture, 2004**

| Expenses items | Wheat after fallow | | | | Wheat-after-wheat | | | |
|---|---|---|---|---|---|---|---|---|
| | Traditional | | Conservation agriculture | | Traditional | | Conservation agriculture | |
| | US$/ha | % | US$/ha | % | US$/ha | % | US$/ha | % |
| Seeds | 17.15 | 25 | 17.15 | 26 | 17.15 | 26 | 17.15 | 26 |
| Fertilizer | 7.30 | 10 | 7.30 | 11 | 7.30 | 11 | 7.30 | 11 |
| Herbicides | – | | 21.00 | 32 | 12.77 | 20 | 21.00 | 32 |
| Oil products | 19.70 | 28 | 5.75 | 9 | 11.13 | 17 | 5.55 | 8 |
| Depreciation and repair | 19.00 | 27 | 9.60 | 15 | 11.06 | 17 | 9.60 | 15 |
| Salaries | 4.54 | 7 | 2.80 | 4 | 3.54 | 5 | 2.80 | 4 |
| Transport | 1.50 | 2 | 1.50 | 2 | 1.50 | 2 | 1.50 | 2 |
| Tax | 1.00 | 1 | 1.00 | 2 | 1.00 | 2 | 1.00 | 2 |
| Total | 70.19 | 100 | 66.10 | 101 | 65.45 | 100 | 65.90 | 100 |

Source: FAO et al., 2004b

These data were used to assess the economic parameters profit and benefit-cost ratio. All economic parameters for grain production with application of direct seeding technology after chemical fallow were preferable to those for traditional seeding technology after mechanical fallow. General expenses were lower for spring wheat production following fallow, by US$3.62/ha. Financial grain yield was higher by US$15.4/ha, net profit was higher by US$32.47 and the benefit-cost ratio was 0.35 (Table 14).

Expenses were lower by US$2.02 for the production of wheat-following-wheat, net profit and benefit-cost ratio was higher by US$15.22 and 0.3, respectively (Table 15).

TABLE 14
**Kazakh project farms: cost comparison for wheat following fallow, 2004**

| Farm | Technology | Production expenses [US$/ha] | Yield, [tonnes/ha] | Grain cost, [US$/ha] | Net profit, [US$/ha] | Benefit-cost ratio |
|---|---|---|---|---|---|---|
| Daryn | Traditional seeding after mechanical fallow | 67.53 | 1.5 | 165.0 | 98.47 | 2.44 |
| | Direct seeding after chemical fallow | 66.57 | 1.5 | 166.1 | 99.40 | 2.49 |
| Dostyk | Traditional seeding after mechanical fallow | 69.03 | 1.8 | 200.2 | 131.17 | 2.90 |
| | Direct seeding after chemical fallow | 64.47 | 2.1 | 250.8 | 186.33 | 3.89 |
| Surayev | Traditional seeding after mechanical fallow | 69.63 | 1.3 | 137.5 | 67.87 | 1.98 |
| | Direct seeding after chemical fallow | 66.27 | 1.3 | 145.2 | 78.93 | 2.19 |
| Cherez-danov | Traditional seeding after mechanical fallow | 73.99 | 0.8 | 90.2 | 16.21 | 1.22 |
| | Direct seeding after chemical fallow | 68.37 | 0.8 | 92.4 | 24.03 | 1.35 |
| Average | Traditional seeding after mechanical fallow | 70.04 | 1.4 | 148.5 | 64.73 | 2.12 |
| | Direct seeding after chemical fallow | 66.42 | 1.5 | 163.9 | 97.47 | 2.47 |

Source: FAO *et al*., 2004b

TABLE 15
**Kazakh project farms: cost comparison for wheat following wheat, traditional and conservation agriculture, 2004**

| Farms | Technology | Production expenses [US$/ha] | Yield [tonnes/ ha] | Grain cost, [US$/ha] | Net profit [US$/ha] | Benefit-cost ratio |
|---|---|---|---|---|---|---|
| Daryn | Traditional | 64.56 | 1.2 | 128.7 | 64.14 | 2.00 |
| | Direct seeding | 65.56 | 1.4 | 155.1 | 90.03 | 2.36 |
| Dostyk | Traditional | 66.79 | 1.5 | 168.3 | 101.51 | 2.50 |
| | Direct seeding | 63.45 | 1.5 | 165.0 | 101.55 | 2.60 |
| Surayev | Traditional | 70.00 | 1.1 | 125.4 | 55.40 | 1.80 |
| | Direct seeding | 66.25 | 1.2 | 133.1 | 66.85 | 2.00 |
| Cherez-danov | Traditional | 70.30 | 0.6 | 69.3 | 0.0 | 1.00 |
| | Direct seeding | 68.35 | 0.8 | 92.4 | 24.05 | 1.30 |
| **Average** | **Traditional** | **67.92** | **1.1** | **123.2** | **55.28** | **1.80** |
| | **Direct seeding** | **65.90** | **1.2** | **136.4** | **70.50** | **2.10** |

Source: FAO et al., 2004b

TABLE 16
**Cost comparison for winter rye production, direct seeding after chemical fallow 2004**

| Farm | Production expenses US$/ha | Yield [tonnes/ha] | Grain price [US$/ha] | Net profit [US$/ha] | Benefit-cost ratio |
|---|---|---|---|---|---|
| Daryn | 67.94 | 1.2 | 162.0 | 94.06 | 2.38 |
| Dostyk 06 | 67.94 | 0.8 | 106.6 | 38.66 | 1.57 |
| Surayev | 88.57 | 2.0* | 150.0 | 61.43 | 1.69 |
| Cherezdanov | 67.94 | 1.5 | 202.5 | 134.56 | 2.98 |

Grain mixture: rye + barley
Source: FAO Report, 2001

The economic data for winter rye following chemical fallow are given in Table 16. Spring barley was seeded in addition to rye on Surayev. The net profit obtained varied between US$38.66/ha on Dostyk and US$135.56/ha on Cherezdanov.

The economic analysis showed that conservation agriculture is economically viable in Central Asia and that wide-scale introduction of conservation agriculture is possible. This would be further supported by lower herbicide prices and local serial production of widely adopted and relatively inexpensive conservation agriculture equipment. Investment in furrow-opener parts and update kits will result in economic returns from increased yield and reduced field operations. Taking into account ownership costs and increased yields, the initial doubts as to the economic feasibility of conservation agriculture could not be confirmed.

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**Plate 22**
*Farmers at equipment show*

## AWARENESS CREATION, TRAINING AND RESEARCH

An important factor in the widespread introduction of new technologies is the training of farmers and specialists. The introduction of conservation agriculture will succeed where its adoption is farmer-driven; therefore, on-farm demonstration of this technology is especially important. Many project events were conducted such as workshops, training seminars, field days, consultations, lectures. Methodological assistance was also provided to project participants by foreign specialists and scientists (Plate 22).

Greater public awareness of the advantages of the new technologies was achieved through scientific and technical publications and the mass media. The process of project implementation was regularly highlighted in newspapers, journals, radio and on television. In addition, Kazakh farmers and specialists went on a study tour of the United States and Canada to learn from these countries' long experience with conservation agriculture.

Mongolian specialists travelled to Kazakhstan and western Siberia to revitalise the partnership between researchers that had developed over the past decades and to facilitate an exchange of new methods. As a result of these initiatives Mongolia has joined the Central Asian Wheat Consortium. Under the leadership of CIMMYT, a specialised Web site was created by the Kazakh Ministry of Agriculture, FAO and the Union of Farmers of Kazakhstan (UFK) and the Central Asian Conservation Agriculture Network (CACAN) has been founded.

# Chapter 3
# Conclusions and recommendations

The introduction of conservation agriculture is a learning process and more research needs to be carried out; for example, plant varieties are needed that are adapted to zero tillage technologies. Seeding rates need to be optimised and further research is called for to improve weed control options; crop rotations; fertilizer recommendations and technologies. An extension service providing advice to farmers in the transition period would be helpful.

The FAO projects introduced conservation agriculture into Mongolia and the Republic of Kazakhstan and revealed that this technology is a technically viable and economical alternative to current crop production practices and provides a prospective for future sustainability. The increased yields achieved under conservation agriculture demonstrate that this technology is economically viable.

***Inputs*** – Conservation agriculture can save on labour and fuel; although investment will need to be made into machinery and chemical weed control. As local and imported seed drills can be modified this technology can be introduced without heavy investment into new machinery. As local modifications worked as well as the imported Brazilian parts, these could be mass-produced, which would increase savings and availability of parts to farmers. It should be noted that care needs to be exercised in the correct assembly and adjustment of the furrow-opener parts.

***Weed control*** is still a challenge for conservation agriculture. The project showed that herbicide application efficiency can be increased by using up-date kits on existing sprayers. The herbicide glyphosate achieved more than 90 percent efficiency in weed control. Glyphosate production in Kazakhstan is relatively inexpensive ensuring its availability to a more farmers. The field work showed that the introduction of crop rotation is possible and economically viable. As this method facilitates weed control, it will in the long run reduce the amount of herbicides required.

***Residue management*** is crucial although there is still a need for adequate equipment for its implementation. In Mongolia, the project developed a straw spreader, although experimentation should continue in order to identify suitable, affordable technologies for residue management.

***Yield data*** show that conservation agriculture provides more reliable yields during periods of drought. Conservation agriculture facilitates the capture of snow and retention of soil moisture; thus providing better conditions for plant development. In addition, biological activity in the soil and phosphorus availability is enhanced. Grain quality on conservation agriculture plots is comparable with that of traditionally planted cereals.

***Training*** – The projects created much interest in conservation agriculture. However, awareness creation, training and research need to be continued to ensure the successful wide-spread introduction of these technologies.

***Government support*** – Farmers should receive support at the government level in both Mongolia and the Republic of Kazakhstan. This would include credit for renovation and updating of machinery and equipment and support for the purchase of herbicides and fertilizers. It is foreseen that the advantages of this method will increase after an initial transition period, ensuring more profitable farming in Central Asia over the long term. The Governments of the Republic of Kazakhstan and Mongolia have both given priority to conservation agriculture methods.

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