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Replacement of Summer Fallow with Oats and Food Legumes on Black Soils of Northern Kazakhstan

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ABSTRACT

Large-scale grain production in northern Kazakhstan started in the 1950s after development of grasslands on black and dark chestnut soils. Since the 1960s, the generally adopted dryland farming system was based on conservation tillage in summer fallow-spring wheat monoculture programs, aiming at the production of high-quality wheat. Trials conducted on black soils under an average annual precipitation of 324 mm have shown the possibility to diversify cropping systems and eliminate the summer fallows, resulting in more sustainable crop production and better soil conservation. The alternatives include replacement of summer fallow with feed grains (oats) and pulses (pea, chickpea and lentil). The fallow was found to be ineffective in moisture accumulation and weed control, but it provided better nitrate availability. During 2006-2008, wheat grain yield after summer fallow was higher than after oats, pea, chickpea and lentil by 11.3, 18.5, 21.2 and 21.6%, respectively. However, grain production from the total cropland area in traditional rotation of fallow with three year grains was lowest (1.58 t ha^{-1}). The highest grain production was obtained when fallow was replaced by oats (2.11 t ha^{-1}), followed by a crop rotation in which fallow was replaced by pea (1.83 t ha^{-1}). Chickpea and lentil provided lower grain yields than pea. Replacement of summer fallow with food legumes improved the grain quality of spring wheat as compared to wheat sown after grain crops.

Keywords: continuous wheat, lentil, pea, soil moisture, spring wheat

INTRODUCTION

Large-scale spring wheat grain production in northern Kazakhstan started in the 1950s under Nikita Khrushchov's Newland Development Program for increased grain production in the Soviet Union. During a short period 25 million ha of grassland were plowed up to mainly produce spring wheat in Kazakhstan. As a result of this campaign Kazakhstan started growing annually about 25 million ha of grain crops, primarily spring wheat (15-16 million ha) and barley (7-8 million ha). Most spring wheat and barley was grown in northern Kazakhstan in rotations including a one-year fallow period (the so-called "summer fallow") once in 4-6 years and continuous grains during 3-5 years. This was practiced to provide the largest possible production of high quality wheat grain for the entire country.

Since Kazakhstan's independence in 1991, grain production area fell dramatically down to 11.4 million ha in 1998, including 9.0 million ha of wheat. About 14 million ha of cropland were abandoned and left as weedy fallow. This radical reduction of grain production area is explained by several factors. Most important was the economic collapse, because of the broken linkages between the industries in the newly independent countries. Due to insufficient funds and resources, farms failed to grow crops on large areas and started reducing the scale of production by abandoning marginal lands.

During the privatization process of agricultural lands, all laborers in former state farms were given land shares; they had to decide about which type of farming unit they wanted to establish. Two types of farms were established, collective and individual. Most collective and many individual farms became bankrupt during the first 10 years of independence. The land from these farms was returned to the government and leased out to grain-handling companies which were reorganized into integrated grain companies taking up production, processing, storage and grain marketing. The small individual farms in the North of the country have a size of several hundred ha, small-size companies have 20-30,000 ha, and larger companies have 30,000 ha and higher. The large-scale integrated companies however succeeded to return about 4 million ha of earlier abandoned cropland for grain production in recent five years (2005-2009) (Ministry of Agriculture).

The type of production system did not change much, although decision-making became independent. All farms continued to produce spring wheat reaching 13.5 million ha in 2008 which is close to area sown in 1990, while the area under barley was significantly reduced from about 7 million ha in 1990 to 2.2 million ha in 2008 (Agriculture, forestry and fishery of Kazakhstan 1990, 2008), which is explained by more favorable wheat grain prices and the collapse of the livestock industry. The type of farming practices also did not change significantly, consisting essentially of summer fallow-grains rotations. While in the Soviet period all farms had a standardized scheme of leaving some 20% of their cropland under summer fallow, presently the producers have variable strategies in which the share of fallow varies between zero up to one third of the cropland. In general the large companies have reduced fallow area whereas small farms with limited resources tend to have larger areas under fallow.

Previous studies justified summer fallows to accumulate moisture for high grain yields in dry years, and to control weeds (Barayev 1960). This concept was borrowed from Canadian alternate fallow-wheat practices widespread in Saskatchewan in the 1950-60s, because soil and climatic conditions in Saskatchewan are very much like North Kazakhstan. The fallow-grains rotations in dryland agriculture of North Kazakhstan and West Siberia were never questioned until 1988. The research conducted in these regions was only directed to find out as how frequent summer

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fallow practice should be. In one publication grain yield was found to steadily reduce every year as longer continuous cropping was practiced (Shiyatiy 1985).

The first publication on inefficiency of summer fallow on black soils was based on results of trials conducted in the Shortandy site comparing various fallow-wheat rotations with continuous wheat (Suleimenov 1988). It was shown that under adequate cultural practices wheat grain yield can be maintained at the same level irrespective of duration of continuous wheat cropping.

This conclusion was unanimously rejected by scientists from different parts of the Soviet Union in a discussion organized by a Moscow journal Zemledeliye (Soil and Crop Management) in 1988-1989 (Buyankin and Burakhta 1988; Kashtanov 1988; Korchagin 1989; Shiyatiy 1989; Zhigailov *et al*. 1989). The major argument was that summer fallow is the base of dryland agriculture and research should be directed not on elimination but on improvement of fallow management practices for better moisture accumulation, soil conservation and weed control.

More recent research has shown, however, that weeds can be efficiently controlled by chemicals, while water storage can be managed not only by summer fallow but also by snow management practices on stubble land. In a trial started from 1983, replacement of summer fallow with oats gave positive results, significantly increasing grain production from the total cropland area. This was because grain yield of wheat sown after oats was lower only by 15% than the wheat yield after summer fallow, while the grain yield of oats was much higher than that of wheat (Suleimenov and Akshalov 2007).

The goal of this study was to identify the possibility of replacing summer fallow by food legumes for increased soil fertility and grain production.

MATERIALS AND METHODS

A study was conducted in a long-term trial on crop rotations established back in 1961 at the Shortandy site on black soil with organic matter content of 3.75%, total N of 0.30%, total P of 0.12%. Since then, most crop rotations tested included various combinations of small grains and summer fallow. The goal of research at that time was to find the best ratio between summer fallow and grains.

In 1998, one of the most popular rotations, "fallow-wheat-wheat-barley", was taken as control and new treatments were established by replacing summer fallow with oats, pea and chickpea. In 2000 lentil was also included as one of the first year crops in the rotations. Thus, by 2006 all five crop rotations had had a full turn over and studies were conducted having each year data in all four fields of the five crop rotations. The crop rotations established were as follows: "fallow-wheat-wheat-barley", "oats-wheat-wheat-barley", "pea-wheat-wheat-barley", "chickpea-wheat-wheat-barley", and "lentil-wheat-wheat-barley". All treatments were established in 3 replicates with plot size 480 m^2 (4 m wide and 120 m long).

The summer fallow period lasts about 21 months, leaving a 3-month growth period for crops. During the summer fallow period 4 times tillage operations 10-12 cm deep were completed with blade type cultivators to control weeds while stubble land was tilled in the fall 12-14 cm deep to prevent run-off of snowmelt water in spring. During winter snow holding was made on the stubble land by snow ridging with special snow plows. In spring weeds were sprayed by Glyphosate herbicide (Monsanto) at a rate of 3 l ha^{-1} about one week before sowing with an experimental no-till planter. Spring wheat, pea, chickpea, and lentil were planted during 20-25 May and oats were planted at the end of May. Fertilizers were applied with seeds: 15 kg of P_2O_5 ha^{-1} for all crops and 35 kg of N ha^{-1} on stubble land. Herbicides were applied at the tillering stage: on wheat to control broadleaves and wild oats mixture of Topic (Syngenta) 0.4 l ha^{-1} and Granstar (Dupont) at 7 l ha^{-1}, while barley was sprayed by Luwaram (2,4-D; Ufa, Russia) at 1.6 l ha^{-1} to control broadleaves. Oats and food legumes were not sprayed, because oats is planted one week later than wheat and weeds are better controlled before sowing, while for food legumes reliable herbicides were not available in the market.

Annual precipitation in the three years was as follows: 2006 – 207 mm, 2007 – 307 mm, 2008 – 239 mm, against an average of 319 mm for 1936-2008. Average annual atmospheric temperature was above the long-term average of 1.8°C in all three years (2.8, 3.6 and 3.0°C, respectively). In northern Kazakhstan, the distribution of rainfall during the vegetation period is the most significant, and more essential than total annual precipitation. In 2005-06, precipitation during the fall and winter was well below average followed by sufficient rainfall in spring and beginning of summer while the rest of the season, including July and August, was very dry. In 2006-07, fall and winter were characterized by good precipitation, while the summer was dry with good rainfall only in July. In 2007-08, the pattern of rainfall distribution was similar to the previous year, but more contrasted, with more pronounced drought in June and more rainfall in July.

RESULTS

Effect of crop rotations on soil moisture

Soil moisture prior to sowing is one of most important factors of grain production. Highest moisture storage was observed in spring after the year of summer fallow only in one of three years, but the difference between summer fallow and stubble crops depended on the weather pattern a great deal in three years (**Table 1**).

The highest advantage of summer fallow was noticed in spring 2006 after the previous fall and winter with low precipitation. The water storage after summer fallow was 22-37 mm higher than under grain stubble and 60 mm more than after food legumes. Contrasting with this was the following year which was characterized by sufficient precipitation during the fall-winter period, and where water storage was essentially higher after food legumes, while there was no difference between summer fallow and grain stubble plots. The same pattern was repeated in 2007-08 with a less dramatic difference in favor of food legumes. This shows that summer fallow was advantageous in a year with low precipitation in the preceding fall and winter period, but was of no advantage in years with favorable rainfall in the preceding fall and where snow fall in winter allowed for snow holding practices to be applied on stubble land. The advantage of food legumes in water storage in some years is explained by less water use by these crops because of a shallow root system. It is also important to emphasize that evaporation in spring was more remarkable on summer fallow fields, which were not covered with mulch, after traditional tillage application in the summer fallow period to control weeds.

The availability of nitrate in the 0-20 cm soil layer prior to sowing was highest after summer fallow and amounted on average to 8.5 mg/100 g of soil against 3-4 mg/100 g in all stubble land with no large differences between treatments. In all crops sown on stubble, 35-40 kg ha^{-1} of N was applied.

Table 1 Soil moisture (mm) in 0-100 cm layer before sowing spring wheat as affected by preceding crops.

Fallow or	Year			Average
preceding crop	2006	2007	2008	
Summer fallow	140	100	113	118
Spring wheat	103	96	117	105
Oats	118	94	102	105
Dry pea	80	141	135	119
Chickpea	73	140	125	113
Lentil	80	141	126	116

Effect of crop rotations on weed infestation

Weed infestation is one of the most critical factors to justify summer fallow in on-farm conditions. Normally, four tillage operations are needed to control appearing weeds by cutting them regularly every 3 weeks. In wet years, more tillage is

Table 2 Weed infestation during wheat tillering stage (pieces m^{-2}) as affected by 4 yr crop rotation on average in 2006-2008.

Year of rotation	Summer fallow or 1st crop				
	Fallow	Oats	Pea	Chickpea	Lentil
First	-	42	38	48	23
Second	32	20	20	14	25
Third	22	27	22	15	23
Fourth	23	32	48	41	38

Table 3 Weed dry matter (g m^{-2}) at wheat tillering stage as affected by 4yr crop rotation on average in 2006-2008.

Yr of rotation	Summer fallow or 1st crop				
	Fallow	Oats	Pea	Chickpea	Lentil
First	-	39.4	43.4	79.6	64.6
Second	35.8	29.7	28.6	39.1	41.4
Third	26.0	31.9	22.2	45.4	46.3
Fourth	47.8	37.2	40.2	35.1	48.2

needed to timely cut the emerging weeds. In the traditional summer fallow management, recommendations state that the last tillage during summer fallow in the fall has to be deep tillage at 25-27 cm (Barayev 1984). Our observations during 3 years did not show any advantage of summer fallow to control weeds efficiently (**Table 2**).

During the first year after summer fallow, the weed density in spring wheat was even higher than that sown after oats, pea and chickpea. Weed density in spring wheat in the third year of the rotations was at the same level, while in the last, fourth year of the rotations barley was a little clearer from weeds in rotation with summer fallow.

The picture was different in terms of weed dry matter (**Table 3**). Again, during the first year the dry matter weight of weeds was higher after summer fallow than after oats and food legumes. During the second and third years of the rotations, weed dry matter was about the same in all treatments, with a slight advantage in the rotation of small grains with chickpea.

Grain yield of crops replacing summer fallow

Instead of the summer fallow which provided no crop, an attempt to grow oats and food legumes proved to be successful in all three years (**Table 4**).

Oats, in general, were higher yielding than pulses, but in 2006 – a year characterized with low water storage before sowing and sufficient rainfall in June – oats suffered from drought in July more than dry pea. Dry pea differed from all other crops with grain yield uniformity under various weather scenarios.

All crops produced more grain in 2007, which had above average rainfall in July. Chickpea provided about the same grain yields as pea in both 2007 and 2008, which had drought in June and good rainfall in July, and it had a lower yield in 2006 (drought in July). Lentil provided the same yield as chickpea in 2006 but suffered more than chickpea from drought in June, especially so with the prolonged June drought in 2008.

Table 4 Grain yield (t ha^{-1}) of different crops sown as replacement of summer fallow.

Crop	Year			Average
	2006	2007	2008	
Oats	1.53	2.90	2.00	2.14
Pea	1.74	1.80	1.17	1.57
Chickpea	1.03	1.79	1.05	1.29
Lentil	0.94	1.22	0.67	0.94

Spring wheat grain yield as affected by preceding crop

The wheat grain yield on average was higher when sown after summer fallow but the efficiency of summer fallow varied much, depending on the weather scenario (**Table 5**).

The largest advantage of sowing spring wheat after summer fallow was observed in 2006 when grain yield was doubled compared to sowing after wheat and pulses. Due to better water storage oats as a preceding crop provided higher grain yield of spring wheat than continuous wheat. The wheat grain yield after the pulses was the same as on continuous wheat, although moisture storage was better on plots after wheat.

In 2007, a year characterized with good water storage after pulses as compared to summer fallow, there was a clear disadvantage of the summer fallow as compared to any crop-replacing fallow. The wheat yield after small grains and pulses, however, had no notable differences except for wheat sown after lentil, which was equal to wheat after summer fallow.

In 2008, characterized by a pattern of rainfall distribution similar to 2007 but with a more severe drought, summer fallow again showed advantage, but the difference was not as high as in 2006 and amounted only to a 14% yield increase compared to continuous wheat. Oats again proved to be the better preceding crop for wheat than any other crop. Pulses as preceding crops provided about the same wheat yield as did continuous wheat, with chickpea being the least productive crop.

Table 5 Spring wheat grain yield (t ha^{-1}) as affected by summer fallow or preceding crop.

Fallow or crop	Year			Average
	2006	2007	2008	
Summer fallow	2.39	2.17	2.10	2.22
Oats	1.53	2.45	1.94	1.97
Pea	1.32	2.32	1.79	1.81
Chickpea	1.30	2.39	1.56	1.75
Lentil	1.29	2.17	1.75	1.74
Wheat	1.25	2.47	1.80	1.84
LSD_{05}	0.26	0.12	0.16	

Effect of crop rotations on grain production from total area

There is a definite advantage of summer fallow in producing uniform grain yield in three subsequent years under different weather. The main goal of the productive use of cropland, however, is to increase crop production from the total cropland area. Crop yield from the total area was, indeed, lowest in the rotation with summer fallow (**Table 6**).

During the first year of the rotations, the highest grain production was obtained from oats followed by pea, chickpea, and lentil, while the summer fallow was without a crop. During the second year of the rotations, the highest grain yield was noted after summer fallow, although the difference was not substantial enough to compensate for the loss of one crop year. The wheat yield in the third year of the rotations was highest in the rotation with oats, followed by the rotations with summer fallow and pea, while it was lowest in the rotations with chickpea and lentil. The barley yield in the fourth year of the rotations was the same in the rotations with fallow, oats and pea, and a little lower in the rotations with chickpea and lentil.

Summing up the total grain production from the area of four fields, one can see a definite advantage of a crop rotation starting with oats. The second highest grain production was obtained in the crop rotation with pea, but it was 13% lower than in the best rotation. The crop rotations with chickpea and lentil produced 20-23%, respectively, less grain than the best rotation. The control rotation of grains with summer fallow produced the lowest grain yield from the total area, which was 25% lower than the best rotation. In the crop rotation with oats replacing summer fallow, the grain yields in the three fields were about the same, while oats provided on average 2.14 t ha^{-1} of feed grains. In the crop rotations with pulses, grain production was very much lower than in the best rotation with oats. This is explained

Table 6 Grain production (t ha^{-1}) as affected by crop rotations from each crop and from total area, average in 2006-2008.

Yr of rotation and crop	Fallow	Oats	Pea	Chickpea	Lentil
	First year				
1st	-	2.14	1.57	1.29	0.94
2nd Wheat	2.22	1.97	1.81	1.75	1.74
3rd Wheat	1.84	2.03	1.73	1.65	1.66
4th Barley	2.28	2.29	2.22	2.07	2.15
From total area	1.58	2.11	1.83	1.69	1.62

Table 7 Protein and gluten content (%) in spring wheat grain as affected by preceding crop or summer fallow.

Fallow or	Protein (%)		Gluten (%)	
preceding crop	2006	2007	2006	2007
Fallow	13.9	12.3	30.4	24.4
Oats	13.0	12.9	26.8	23.2
Pea	14.1	13.7	30.4	27.8
Chickpea	13.4	13.7	30.0	29.2
Lentil	13.9	12.8	30.4	28.0
Wheat	13.5	12.0	28.4	24.0
LSD_{05}	0.4	0.3	1.6	1.5

by much lower grain yields of pulses than oats and lower grain yields of the subsequent grain crops. One of the reasons might be weed infestation in the rotations with pulses. The other reason may be that the seeds of the pulses were not treated with *Rhizobium* bacterial inoculants and there was no advantage of pulses regarding nitrogen availability before sowing of wheat compared to sowing after oats. On average in 2006-2008 availability of nitrates before sowing wheat after grains and food legumes was 3.0-3.4 and 3.5-4.0 mg/100 g of soil, respectively. Also, before 2005 food legumes were neglected in plant breeding programs in Northern Kazakhstan and all cultivars used were imported from Russia: pea from Omsk, chickpea from Saratov and lentil from Penza.

Effect of crop rotations on grain quality

The grain quality of spring wheat was affected by preceding summer fallow or crop in two years (**Table 7**). In 2006, characterized by good rainfall in early summer before heading of spring wheat, protein content was high and not affected by preceding summer fallow or crop, while gluten content was higher in wheat grain sown after pulses. In 2007, characterized by more rainfall during flowering and grain filling of spring wheat, both protein and gluten contents in grain were relatively lower and were notably affected by the preceding crop. Summer fallow did not affect grain quality compared to continuous grain sowing but pulses increased both protein and gluten contents remarkably.

DISCUSSION

The vast grassland area in Northern Kazakhstan was developed in the 1950s to produce high quality spring wheat grain for the Soviet Union. The grain production system in dryland agriculture, established in the region in the 1960s, was based on continuously growing small grains, mainly spring wheat, with a break for summer fallow once in 4-6 years. This system was adopted mostly following a Canadian traditional system of alternate summer fallow-wheat programs widespread in prairies of the western Canada in those times (Barayev 1958). As distinct from Canadian practices, Kazakhstan grain producers never used alternate fallow-wheat system but practiced longer continuous growing of spring wheat. However, summer fallow was recommended as one of the basic elements of dryland agriculture (Barayev 1960).

Fallow-based grain production systems were also adopted in Western Siberia, South Ural and the Volga area (Suleimenov 2006). The first research results published in the Soviet Union showed that continuously growing spring wheat produced more grain from the total cropland area than recommended rotation of summer fallow with continuous wheat during 3-5 years (Suleimenov 1988).

This conclusion was unanimously rejected by all scientists of the Soviet Union working in dryland agriculture. To understand this one can learn more about the research system in the Soviet Union. The first negative comment was made by the Vice-President of the Soviet Union Academy of Agricultural Sciences Academician Kashtanov (1988). His major point was that in dryland agriculture summer fallow is a must for moisture conservation and weed control. And research should be directed toward improvement of summer fallow management. After this all other researchers just repeated these arguments.

Actually the concept of dryalnd agriculture based on rotation of summer fallow with spring wheat was borrowed from Canadian farming practices. All researchers have been working in dryland agriculture of Soviet Union never doubted the absolute correctness of this concept. In our opinion, methodology of comparison of possibility of summer fallow replacement by growing any crop was also not always right. For example if forages were planted instead of summer fallow a general conclusion was that wheat grain yield sown after forage was lower than that after summer fallow. But nobody paid attention to the fact that additional forage was produced and soil was protected against erosion.

Higher wheat grain yield obtained when sown after summer fallow has been always emphasized. And the directors of the state farms were also happy with higher grain yields after summer fallow because their achievements were evaluated based on grain yields from area sown.

Later on more research was conducted comparing traditional rotation of "summer fallow-wheat-wheat-barley-wheat" with the same rotation but replacing summer fallow with oats (Suleimenov and Akshalov 2007). This comparative study was conducted under three levels of crop management: poor, medium and adequate. The results obtained showed that no-fallow cropping produced more grain from total cropland area under all three levels of crop management. The best result from removing summer fallow, however, was noted under best cultural practices.

This research has also shown that the efficiency of summer fallow in soil moisture accumulation depends, to a great deal, on the management practices. The best water storage was achieved in summer fallow with vegetative short barriers made of mustard to trap snow known in Kazakhstan as "kulissy". This practice, however, when applied on large farm fields, has been causing strong soil erosion by water during runoff of snowmelt water in early spring. The normally tilled summer fallow has no soil cover after a couple of tillage operations, which makes the soil prone to wind erosion. The advocates of summer fallow-based cropping systems recommended strip cropping to control wind erosion (Barayev 1958). This recommendation however has not been adopted by farmers because of many inconveniences: machinery size may not fit to strip width, all tillage operations are done in the same direction, larger crop losses during harvest, and higher risk of soil erosion by water.

Some researchers have changed their conclusions after improved cultural practices on stubble land were introduced in their trials. Mustafayev and Sharipov (2006) in northeast Kazakhstan showed that moisture conservation on stubble land was dramatically improved when harvest technology leaving tall stubble was introduced. Others who earlier favored practicing summer fallow once in three years in northwest Kazakhstan (Dvurechenskiy 2003) recently presented data showing that with introduction of no-till, grain yield did not change during three years of continuous wheat after summer fallow (Dvurechenskiy 2009). In this publication he recommended a 5-year rotation: "fallow-rapeseed-wheat-wheat-wheat".

We have shown that replacement of summer fallow with pulses produced more grain from the total area as compared to traditional rotation of grains with summer fallow, but less than rotation with oats. Pulses became widespread in western Canada in the late 1990s, occupying 20-25% of the cropland in the black soil zone (Miller *et al*. 2002). Pea was found to be the highest yielding pulse crop as compared to chickpea and lentil which corresponds with data published for the northern Great Plains (Miller *et al*. 2002). The grain yield of spring wheat sown after pulses in our study was lower than sowing after oats. A study in western Canada has shown the advantage of pea as a preceding crop rather than continuous wheat (Gan *et al*. 2003), which was explained by the higher moisture left after the pulse crop. This observation was also noticed in our study in 2007 and 2008; however, crop management of pulses was not adequate to control weeds sufficiently, which made pulses not the best preceding crop to wheat compared to oats.

The grain quality of wheat sown after pulses was better than in continuous wheat or wheat after summer fallow, which again corresponds with the Canadian study (Gan *et al*. 2003).

In the present study we did not undertake an economical analysis because input and output prices have been fluctuating quite frequently. For example, the price for 1 ton of wheat grain during the recent three years reduced from US$ 350 in 2007 to US$ 120 in 2009 (Ministry of Agriculture). As for pulses, these crops still are grown on small areas only, and there are no well established market prices for them. The world market prices for chickpea and lentil are known to be two-to-three times higher than wheat prices, which will make growing these crops economically efficient provided that an access to the world market is established. Studies in western Canada have shown the economic advantage of crop rotations of grains with pulses compared to continuous grain growing (Zentner *et al*. 2002).

Although scientists in Western Siberia did not recommend reduce summer fallow area, one of the best farmers of the region Shnider (2002) was the first farmer in the region of West Siberia and North Kazakhstan to adopt both no-fallow and no-till farming practices since 1995. Adoption of research recommendations by grain producers in north Kazakhstan varies from farm to farm and depends on the size of the operation and on the availability of resources. Small farmers have been practicing more traditional spring wheat growing in rotation with summer fallow once in 3-5 years. Large companies with more resources practicing minimum tillage and no-till have been showing a trend to reduce summer fallow areas. The total area under summer fallow in Kazakhstan reduced from 4 million ha in 2005 to 3.6 and 3.3 million ha in 2008 and 2009, respectively and 80% of this reduction occurred in two northern oblasts Akmola and North Kazakhstan (Ministry of Agriculture). The high rate of reducing summer fallow area in one year by 300,000 ha was noted in 2009 for the first time in 50 years. The share of cropland under summer fallow in the large grain-producing companies in the north is now between zero and 10%.

In many regions of Russia the practice of sowing forages or green manure instead of summer fallow has become quite popular (Savostyanov 1995; Demarchuk 2006; Nemtsev 2006). These practices are known as occupied fallow or green manure fallow. This shows how some scientists are dedicated to fallow although it has been replaced by forages or green manure. The practice of so-called occupied fallow was successfully tested in research at the Shortandy site in the early 1960s (Kopeyev 1963) but it was not adopted by grain producers because of rather high weed infestation. The green manure practice was also successfully tested in North Kazakhstan long ago (Magazhanov 1975) but it was not adopted because everybody was happy with clean summer fallow.

Growing of pulses is in an initial stage, as the producers are not sure about the markets and are not ready to shift to new crops. Again, the first growers of pulses are larger companies concerned about crop diversification. Some of them have sown pea on 10% of cropland in 2009. Pulses area in Kazakhstan in 2006, 2007 and 2008 made 32,400, 37,800 and 44,700 ha respectively (Agriculture, forestry and fishery of Kazakhstan 2006-2008). Lack of seeds is one of the major constraints. Pea has a larger cropping area followed by chickpea. Lentils, however, are almost not known in the region. In the near future, we can expect pulses to occupy 10-15% of the cropland area in Northern Kazakhstan.

Thus, the best tested crop rotation for highest grain production proved to be "oats-wheat-wheat-barley". The replacement of summer fallow by food legumes was also a success and might become more economical compared to rotation with oats if Kazakhstan has access to world food legume markets.

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