Permanent bed planting in irrigated south-eastern Kazakhstan conditions

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Abstract. The present paper focuses on bed planted wheat systems using in the south-eastern part of Kazakhstan. This experiment was conducted with winter wheat, corn and soybean to determine intensive ways of irrigated land use. Conventional flat planting has some disadvantages and using of bed-planting system in region can become the basis of crop diversification. Results of research confirmed effectiveness of direct seeding on permanent beds, showed higher crop yield and good profit.
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Introduction

During the last years many countries have sharply increased total area of crops cultivated by resource saving and No-till technologies from 50 million hectares in 1997 to more than 100 million hectares in 2009. In Kazakhstan zero technology is using on 2 million hectares, mainly in the north regions under rainfed conditions. Resource saving technologies can reduce direct costs by 30-50%, fuel consumption in 1.5-2 times below and increase profitability by 30-50% [1-2].

The current situation in irrigated agriculture of south–eastern Kazakhstan is calling for fundamentally new, innovative approaches of crops cultivation on raised beds with furrow irrigation. Studies of CIMMYT proved in many countries the highly effective of crop cultivation on ridges, known as "Bed planting–system" [3-5].

Research conducted in 2001–2011 years showed the high efficiency of winter wheat cultivation on ridges in the south and south-east regions of Kazakhstan. The most rational way of seeding is 2–3-rows on ridges with seed rate 100 kg per hectare. The most suitable crops for bed planting were local winter wheat varieties: Almaly, Zhetysu, and Erythrospermum 350 [6-8].

The main point of new technology is using of permanent ridges formed under winter wheat cultivation during 5 years or more for the direct seeding of corn and soybean. Development and implementation of permanent raised beds technology can become the basis of crop diversification on irrigated lands with competitive production, increasing of irrigated land productivity with conserve of soil fertility and environmental protection [9-10].

Material and methods

The field experiment conducted during 2008–2011 growing seasons on "Svetlana" private farm located in Zhambyl district of Almaty province. The climate in this area is continental with cold winters and hot summers. The annual temperature was 8.3°C, minimum -40°C, and the maximum 42°C. The soil at the experimental site is light chestnut soil containing 2.1% of humus, 0.203% of total nitrogen and 0.211% of total phosphorus. Mechanical composition is heavy loam with mobile phosphorus 23.4 mg/kg (milligram per kilogram), exchangeable potassium 512 mg/kg.

Objectives of study: Almaly – cultivar of winter wheat, Zhalpaksay – soybean sort, and Arman – corn hybrid.

Experiment scheme compared seeding methods such as conventional and direct seeding of different crop cultures on permanent beds. First variant includes conventional seeding of winter wheat, corn, and soybean with fertilizer rates N45, P45 kg/ha (kilogram per hectare).

Four variants of the direct seeding on ridges with fertilizer rates:

1. NP0.
2. N45kg/ha.
3. N45, P45 kg/ha.
4. N45, P23 kg/ha.

Total area was 15 hectares, including plots 8400 m^2 (length 600 m, width 14 m), and counted square 1260 m^2 (length 600 m, width 2.1 m) in three times repeatability.

Results

Studies of water–physical soil properties showed that methods of sowing had no substantially effect on the moisture reserves accumulation in first meter of soil (Table 1). More slightly accumulation

of moisture in springtime was observed under variant with conventional method of soybean sowing and corn on the plowed soil.

Table 1. Water–physical soil properties depend to seeding methods

Crop	Seeding methods	Moisture reserves in 0–100 cm of soil layer, mm		Volumetric soil mass in 0–30 cm of soil layer, g/cm³	
		springtime	harvesting	springtime	harvesting
Winter wheat	Conventional	237	154	1.22	1.29
	Direct seeding	236	147	1.30	1.30
Soybean	Conventional	234	156	1.20	1.31
	Direct seeding	236	154	1.27	1.33
Corn	Conventional	252	153	1.19	1.34
	Direct seeding	248	142	1.27	1.32

A method of sowing had a significant influence on the nitrate content under winter wheat in early spring and at direct seeding was on 12.3 mg/kg less than at conventional method (Table 2). This is primarily associated with possible suppression of nitrification processes in unplowed soil. Local adding of ammonium dihydrogen phosphate (ADP) simultaneously with direct seeding of crops has pointed higher accumulation in the topsoil in spring, especially under soybean and corn.

Table 2. Content of mobile nutrients in topsoil depend to seeding methods

Crop	Seeding methods	Nitrate N, mg/kg		Mobile phosphorus, mg/kg	
		springtime	harvesting	springtime	harvesting
Winter wheat	Conventional	42.4	13.8	22.6	17.4
	Direct seeding	30.1	12.5	22.1	18.6
Soybean	Conventional	53.6	14.6	25.4	19.0
	Direct seeding	44.9	17.4	30.8	22.3
Corn	Conventional	50.3	9.3	24.7	18.6
	Direct seeding	44.0	9.7	27.4	15.9

Sheaf analysis at conventional sowing showed that yield of winter wheat formed due to plant density. At direct seeding on ridges yield formed due to productive tillering with equal values of the grain content in spike, and weight of 1000 grains (Table 3).

Table 3. Formations of winter wheat yield structure depend to seeding methods

Seeding methods	Fertilizer rate, kg/ha	Plant density, plant per m²	Productive tiller number	Grains per spike, units	1000-grain weight, g	Biological yield, g/m²
Conventional	N45, P45	189	1.77	42.4	43.6	59.2
Direct seeding	NP0	104	2.60	36.4	40.1	39.7
	N45	101	2.85	43.6	44.1	54.5
	N45, P45	96	3.27	43.0	44.1	59.8
	N45, P23	103	3.24	44.1	43.6	58.6

Soybean plants sowed on permanent beds after grain crops in comparison with conventional method of sowing had significantly ahead in the growth and development (Table 4). The soybean on variants with direct seeding has differed emergence of friendly seedlings, plentiful branching and dark green coloring. The best growth and development of soybean plants provide more biological yield due to the amount of plants per area unit on variants with direct seeding on permanent beds.

Table 4. Formations of soybean yield structure depend to seeding methods

Seeding methods	Row spacing, cm	Rows	Plant per m²	Plant height, cm	Amount of beans per 1 plant	Amount of seeds per 1 bean	1000-grain weight, g	Biological yield of 1 plant, g
Conventional	45	1	40.5	112.7	26.4	3.2	160.9	13.6
Direct seeding	70	2	48.8	114.8	25.3	3.2	152.7	15.4

Monitoring over the growing season of maize seed on ridges has showed significant advance in the growth and plant development. This is primarily related with the creation of favorable thermal conditions on permanent beds. The high rate of dry matter accumulation in corn plant was pointed in the phase of 10–12 leaves forming. High rates of dry matter accumulation in corn plant on the variant with permanent bed planting remained until the end of growing season, which finally contributed to the formation of higher productivity. Structure analysis revealed that crop at the variant with direct seeding on ridges had tendency of increasing cob size, quantity of grains per cob due to formation of rows, amount and weight of grains per cob. Increasing of these parameters ultimately leaded to more output of grain and corn harvest (Table 5).

Table 5. Formations of corn yield structure depend to seeding methods

Seeding methods	Cob size, cm		Amount, units			Mass, g		Grain output, %
	length	diameter	rows on the cob	grains in the row	grains in the cob	grains from the cob	1000-grain	
Conventional	16.3	4.6	12.7	36.9	469	130.7	273.7	84.8
Direct seeding	17.2	4.6	14.2	40.2	568	155.6	287.5	86.6

On the variant with conventional sowing of winter wheat was obtained 4740 kg/ha of grain (Table 6). The best result at direct seeding obtained on variant with fertilizer rate N45, P45 and yield 4780 kg/ha. Conventional sowing of soybean and corn showed yields with 3240 and 8420 kg/ha respectively. Direct seeding on ridges with fertilizer rate N45, P45 the yield of soybean and corn composed 3480 and 9270 kg/ha respectively.

Table 6. Crop yields depend to seeding methods

Seeding methods	Fertilizer rate	Yield, kg/ha		
		Winter wheat	Soybean	Corn
Conventional	N45, P45	4740	3240	8420
Direct seeding	NP0	3150	2460	5620
	N45	4290	2950	7490
	N45, P45	4780	3480	9270
	N45, P23	4640	3170	8210

Economic analysis of seeding methods showed the high efficiency of cultivation on permanent beds (Table 7). Product value from 1 hectare means actual market cost, and calculated by multiplying the yield on the price per kilogram. Ratio of profitability calculated as net income divided by expenses and multiplying on 100%.

Table 7. Economic efficiency of seeding methods in the south-east Kazakhstan

Crop	Seeding methods	Yield, kg/ha	Product value from 1 hectare, KZT	Expenses per 1 hectare, KZT	Net income, KZT*	Profitability, %
Winter wheat	Conventional	4740	85300	43000	29700	69
	Direct seeding	4780	86000	25700	42300	164
Soybean	Conventional	3240	129600	65300	45100	69
	Direct seeding	3480	139200	37000	71600	193
Corn	Conventional	8420	126300	77700	34000	44
	Direct seeding	9270	139100	40400	69100	171

* 1 KZT=0.00676 USD.

Direct seeding of winter wheat, soybean and corn on permanent beds in comparison with conventional method has showed almost 2 times fewer expenses and almost 2.5 times more profitability of seeding technology.

Conclusions and discussion

The research of direct seeding on permanent beds in the south–east Kazakhstan has indicated many advantages: the most important of them is crop productivity increasing with fewer expenses, and higher profitability.

Therefore, cultivation of crops on permanent beds might be used as basis of irrigated agriculture system diversification with water-, and resource–saving technologies in the south–east Kazakhstan. Introduction of this technology under conditions of the south-east will increase the productivity of irrigated land and will make a difference in protecting of environment, production of ecologically pure and competitive agricultural products.

The new technology is fundamentally different from existing technologies of cultivation under irrigated conditions of Kazakhstan. It's based on following principles: a) crop cultivation on permanent beds over 5 years; b) exclusion of essential tillage through direct seeding on ridges of previous crop stubble; c) rational use of mineral fertilizers by local application in furrows; d) shredding and evenly spreading of preceding crop's plant residues; e) appearance of amicable shoots of spring crops; f) preservation and enhance fertility of irrigated lands.

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