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THE EFFECTIVE USE OF IRRIGATED LAND: RESOURCE-SAVING TECHNOLOGIES

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ABSTRACT

The article provides data on aspects of the effective use of irrigated land in southeast Kazakhstan. For this, the authors calculated the effective heat sum needed for crops and the actual values of this parameter in southeast Kazakhstan. Based on this data and the results of field research, aspects of the effective use of irrigated lands in the southeastern region of Kazakhstan were established. For the effective use of irrigated lands and an increase in their productivity, the authors recommend sowing intercrops after the basic crops, which contributed to the increase in the profitability level from 129% to 149%. According to the results of field experiments, the highest net income of 171-197 thousand tenges per hectare was obtained by sowing intercrops after the basic crop (winter triticale). Usage of Sudan grass as an intercrop for the herbage production did not produce any effect.

Keywords: aspects of efficient use, intercrops, rapeseed, mustard, Sudan grass, drip irrigation, triticale, hydrothermal conditions, active temperature.

INTRODUCTION

The effective use of irrigated arable land is of particular importance for the improvement of the productivity of irrigated lands. One of the ways to increase the output of irrigated agriculture and reduce its cost is the introduction of resource-saving technologies.

Resource-saving technologies allow to save labor and energy and reduce the cost of tillage, which is at least 65-75% of the total costs. The use of traditional technology in the cultivation of crops demands 16.5% more than the use of resource-saving technology. Resource-saving technology with minimal tillage can reduce direct costs by 30-40%, reduce fuel consumption 1.5-2 times and increase the profitability of grain production by 20-30%.

The growing deficit of irrigation water, especially during the extreme drought years, forces Kazakh farmers to switch to water- and moisture-saving technologies. In this regard, the Government of Kazakhstan has set the goal to reduce irrigation water consumption to 1.5-2.0 billion m^3 by means of modern irrigation methods and other water-saving technologies and reduction of area watered using strip irrigation from 80% to 5% of all irrigation areas by 2030 (Nazarbaev, 2014).

The development and implementation of new innovative resource and water-saving technologies that contribute to the efficient use of irrigated land is a pressing challenge for the achievement of the abovementioned goals for the development of agriculture in Kazakhstan, especially in irrigated agriculture.

The hydrothermal conditions in the southern and southeastern regions of Kazakhstan, where irrigated agriculture is developed, allow for irrigated lands to be effectively used during the year. However, in practice, farms do not use these opportunities. Thus, after harvesting winter crops (triticale, wheat) and early spring crops (wheat, barley, oats), a lot of time (90-120 days) remains for cultivating intermediate crops. During this period, irrigated lands in farms are empty until late autumn.

In recent years, the ridge sowing technology has become widespread. Therefore, the development and implementation of the ridge technology for cultivating crops, obtaining two crops per year by sowing intermediate crops, methods of minimum and zero tillage and water-saving technologies (drip irrigation) are priorities for agricultural development, contributing to the efficient use of irrigated land.

The scientific novelty of our technology is based on the use of permanent ridges in the cultivation of crops. The essence of the technology is that the ridges formed during the cultivation of the main crop are used for direct sowing (without processing) of intermediate crops. In this case, the sowing of the intermediate culture is carried out directly in the ridges, immediately after harvesting the main crop, followed by moisturizing irrigation using the drip method or along furrows with small norms (200-300 m^3/ha). Thus, a significant reduction in sowing time (by 30 or more days), obtaining simultaneous seedlings of the intermediate culture, and saving irrigation water are achieved (Figures 1 and 2).

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Figure-1. Ridge cutting with simultaneous sowing of winter wheat.

Figure-2. Winter wheat on the ridges.

MATERIALS AND METHODS

According to meteorological data, the duration of the frost-free period in the studied regions ranges from 161-167 days (the Almaty and Zhambyl regions) to 185-190 days (the Turkestan region) with individual deviations during separate years from 118-152 to 210-245 days, respectively. In these regions, the average monthly air temperature during the summer months (June-August) is +22.3 °C with annual variations from 20 to 26 °C (Atakulov *et al*., 2017a; Atakulov *et al*., 2017b; Titov et al., 1978a; Titov *et al*., 1978b; Titov *et al*., 1978c). For the intensive use of irrigated lands from early spring to late autumn, we monitored the hydrothermal conditions in the southeastern region of Kazakhstan and carried out research on the development of new technologies for the efficient use of irrigated lands. Basic crops and intercrops were selected depending on their biological characteristics (Arynov *et al.* 2011; Sydyk *et al*., 2009).

The research was carried out in 2016-2018 at the experimental station of the Kazakh Scientific Research Institute of Agriculture and Crop Farming (the Úsh qońyr demonstration site located in the Ili Alatau foothill irrigated zone (the Almaty region) on light chestnut soils.

The objects of our research were as follows: light chestnut soils, drip irrigation, ridge-direct planting of the basic and intercrops. Basic crops included winter wheat, winter triticale, spring barley and oats. The drip irrigation method was used to attain soil moisture of 70% of field moisture capacity. Determination of soil moisture, monitoring of the growth, development of crops and accounting for productivity were carried out using generally accepted methods (Dospekhov, 1985; Kostyakov, 1960; Kurichev, and Pannov, 1980; Machigin, 1975; Rukovodstvo po kontrolyu i obrabotke nablyudenii za fazami razvitiya selkhoz kultur, 1982; Rudnev, 1950; Savvinov, 1975; Tyurin, and Arinushkina, 1970; Vazhenin, 1975; Zalyagina, 1975).

RESULTS AND DISCUSSIONS

For cultivation of any crop, it is necessary to know the effective atmospheric heat sum in the area during the vegetative season and the effective heat sums required for ripening of the crop. Based on this, we calculated the effective heat sums for the months of the vegetative season of crops in the studied regions where irrigated agriculture is developed. The effective heat sum during the vegetative season (April-October) was calculated at four locations in the southeastern region of Kazakhstan: Almaty (foothill zone) - 3,650.3 °C, Taldykorgan - 3,475 °C, Jambyl (Taraz) - 3,697.6 °C, Turkistan (Southern zone) - 4,176.8 °C. We also calculated the effective heat sums required for the ripening of the basic crops that are cultivated on the irrigated lands of southeastern Kazakhstan (Table-1).

Table-1. The effective heat sums required for the ripening of the crops.

Agricultural crop	Required effective heat sum, °C		Number of days
	From	To	
Corn for grain	2,300	2,600	120-130
Corn for silage	1,830	1,950	70-88
Rapeseed	1,600	1,800	110-120
Mustard	730	1,825	65-90
Buckwheat	1,350	1,845	70-90
Sudan grass for hay	1,840	2,070	90-110
Sorghum	2,250	2,500	100-130
Pea	1,350	1,585	70-80
Soy	2,450	2,878	110-130

As can be seen from the provided data, the effective heat sums in the studied regions are sufficient for the ripening of the basic crops, as well as for the second yield of intercrops.

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Field studies in the foothill zone of the Almaty region demonstrated the possibility of obtaining a guaranteed yield of intercrops after winter wheat that was grown on ridges. At the same time, intercrops were directly sowed on the ridges immediately after harvesting winter wheat, followed by moisturizing irrigation with the use of the drip method with a low application rate. This way, we significantly reduced the period between harvesting the basic crop and sowing intercrops (approximately 20-25 days) and achieved even sprouts of the intermediate crops. In our field experiments on the efficient use of irrigated land conducted in 2016-2018, cultivation of winter crops without the use of intercrops was used as a control; winter wheat, winter triticale, spring barley and oats were used as basic crops and corn, rapeseed, mustard and Sudan grass were used as intercrops.

In 2015 and 2016, winter triticale was harvested on May 22-23 and the following intercrops were directly sowed on May 23-24: corn, rapeseed, mustard, Sudan grass. Moisturizing irrigation with a low rate of 200-300 m^3/ha was carried out after sowing. Winter wheat and early spring crops (oats and barley) were harvested on July 3-5 and the same intercrops were directly sowed on July 4-6, followed with moisturizing irrigation.

Observations of winter triticale growth and development during the heading phase showed that the average height of the plants was 140 cm; they accumulated 2,673 grams of fresh weight and 1,470.3 grams of dry weight on an area of 0.3 m^2. Moreover, they left 60-90 kg/ha of organic mass in the arable layer of the soil, which enriches the soil with nutrients, thereby contributing to increased soil fertility.

In our study, the intercrops were sown at two time points: the first one was after the harvesting of winter triticale on May 23-24 and the second one was after the harvesting of winter wheat, oats and barley on July 4-6. Intercrops were sowed with the following seeding rates: 12 kg/ha for mustard, 35 kg/ha for corn, 12 kg/ha for rapeseed, 30 kg/ha for Sudan grass.

Figure-3. Measurement of the triticale plant height.

Figure-4. Determination of the amount of crop residue.

The results of field experiments demonstrated that corn crops sown for grain after winter triticale was harvested for herbage on May 22-23 ripened and grain yields averaged 72.7 c/ha, while rapeseed and mustard yields averaged 19.8 c/ha and 18.1 c/ha, respectively. Sudan grass was cut for herbage 2-3 times and the average yield was 510.7 c/ha. Intercrops that were sown after winter wheat, barley and oats did not ripen (they reached only milky ripeness), so they were harvested for herbage. Herbage yields ranged from 295 c/ha for mustard to 390.3 c/ha for corn silage (Table-2).

We carried out economic calculations to determine the effectiveness of obtaining two yields per year from the same area. Based on these calculations, we found that the highest conditional net income of 110.1-197.5 thousand tenges/ha and the highest profitability level of 78.2-149.5% were obtained in the case of sowing corn, rapeseed and mustard after the harvesting of the winter triticale herbage. These calculations take into account yields of winter triticale and intercrops and costs of the cultivation of basic and intercrops.

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Table-2. Efficiency of the intensive use of irrigated land (average data).

Experiment variants, Basic crops	Average yield, c/ha	Experiment variants, Intercrops	Average yield, c/ha	Total product costs, thousand tenges/ha	Total costs, thousand tenges/ha	Conditional net income, thousand tenges/ha	Profitability level, %
Winter wheat (control)	50.2	-	-	175.7	115.0	60.7	52.8
Winter triticale (herbage)	653.0	Corn (grain)	72.7	250.8	140.7	110.1	78.2
		Rapeseed (grain)	19.8	329.6	132.1	197.5	149.5
		Mustard (grain)	18.1	304.1	132.6	171.5	129.3
		Sudan grass (herbage)	510.7	45.6	135.4	-	-
Spring barley	49.6	Corn (silage)	390.3	138.7	126	12.7	10.0
		Rapeseed (herbage)	350.8	216.8	132.1	84.5	64.0
Oats	55.4	Mustard (herbage)	295.2	202.7	132.6	70.1	53.1
		Sudan grass (herbage)	315.4	136.8	133.4	3.4	2.6

In addition, it was found that after the harvesting of winter triticale for herbage, cultivation of Sudan grass for herbage turned out to be unprofitable. Therefore, after the winter triticale, which is early harvested for herbage, it is necessary to cultivate highly profitable intercrops. Cultivation of spring barley for grain and harvesting of rapeseed and mustard intercrops for herbage contributed to the efficient use of irrigated land during the vegetative season and provided high incomes of 70.1-84.5 thousand tenges/ha with high profitability of 53.1-64.0%.

Based on the monitoring of hydrothermal conditions in the south and southeast of Kazakhstan, the calculations of the effective heat sums for different regions and the results of research work carried out by us and other research institutions, we compiled recommendations for the effective use of irrigated land in the southeast region of Kazakhstan (Table-3).

At the same time, we recommend direct sowing of all intercrops (without soil cultivation), except industrial and vegetable ones. We recommend moisturizing irrigation with a low application rate (200-300 m^3/ha) after sowing, preferably using the drip irrigation method with an irrigation rate of 150-160 m^3/ha. Such resource-saving technologies help reduce costs and irrigation water consumption (Atakulov *et al.*, 2012a; Atakulov *et al.*, 2012b).

Table-3. Recommended basic and intercrops.

Studied locations	Basic crops	Harvest time	Time of intercrops direct sowing	Recommended intercrops
Almaty (foothill zone)	Winter wheat, early spring barley and oats	03.07	04.07	Corn for silage, pea for seeds or herbage, Sudan grass for herbage, mustard, sorghum for silage
	Winter triticale (for herbage)	22.05	23.05	Corn for grain or silage, soy for grain, rapeseed for grain, mustard for grain, potato, vegetable crops
	Oats + vetch (for herbage)	17.06	18.06	Corn for silage, Sudan grass, potato, vegetable crops, rapeseed, buckwheat, sorghum for silage
Taldykorgan	Winter wheat, early spring barley and oats	05.07	06.07	Corn for silage, Sudan grass, sorghum for silage
	Winter triticale (for herbage)	27.05	28.05	Corn for grain or silage, barley, oats, potato, vegetable crops
	Oats + vetch (for herbage)	19.06	20.06	Corn for silage, barley, oats, Sudan grass
Jambyl (Taraz)	Winter wheat, early spring barley and oats	01.07	02.07	Corn for silage, Sudan grass, rapeseed
	Winter triticale (for herbage)	20.05	21.05	Sugar beet, corn for grain, potato, vegetable crops
	Oats + vetch (for herbage)	15.06	16.06	Corn for silage, Sudan grass, sorghum for silage, barley, oats, vegetable crops
South Kazakhstan (Shymkent, Turkestan)	Winter wheat, early spring barley and oats	26.06	27.06	Corn for silage, Sudan grass, potato, vegetable crops
	Winter triticale (for herbage)	18.05	19.05	Cotton plant, corn for grain, potato, cucurbits crops, vegetable crops
	Oats + vetch (for herbage)	13.06	14.06	Corn for silage, annual grasses, Sudan grass

We believe that our field experiments in the irrigated piedmont zone, obtained data, and calculations of the hydrothermal conditions of the southeastern zone of Kazakhstan convinced farmers about the possibility of introducing innovative technologies, obtaining two crops per year and, thereby, effectively using irrigated land.

Using this data, any farmer or farm director in different regions can choose both basic and intercrops they need to get two yields per year and thereby effectively use irrigated land and receive high incomes.

CONCLUSIONS

a) Monitoring of hydrothermal conditions in the southeast of Kazakhstan, calculation of the effective heat sums and the results of field studies demonstrated that in the Almaty, Jambyl and Turkestan regions, it was possible to increase the productivity of irrigated lands by the introduction of new resource-saving technologies and sowing intercrops.

b) The effective use of irrigated land by sowing intercrops made it possible to obtain two yields of agricultural crops per year and reduced the cost of production of one ton of grain.

c) Calculations of the economic efficiency of obtaining two yields per year showed that the highest net income of 171.5-197.5 thousand tenges/ha was obtained by sowing intercrops after the basic crop (winter triticale). Cultivation of Sudan grass for herbage as an intercrop did not give any effect. Therefore, after the winter triticale, which is early harvested for herbage, it is necessary to cultivate highly profitable intercrops.

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