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ORIGINAL ARTICLE

Influence of row spacing and seeding rate on crop yields cultivated by “No-Till” technology in Kulunda steppe (Altai Region)

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The long-term field experience has been carried out in the LLC Farm Enterprise “Partner”, Mikhailovsky District of the Altai Region, one of the basic sites of the “Kulunda” project. The field experience was founded in 2013, implemented over the next four years in a similar way; the alternation of crops was carried out in accordance to the crop rotation. In total, there were four sets of experiments in eight variants in triple number of replications. There were four variants of row spacing implemented: 25.0 cm, 33.3 cm, 37.5 cm, and 50.0 cm. We also used two seeding rates for every crop: spring wheat - 75 and 120 kg/ha; rapeseed – 2 and 4 kg/ha; peas – 140 and 180 kg/ha. The sowing was made with an expimental grain seeder “Cornor-DMC” with chisel-shaped copying coulters, the “Amazone” company production. Combine harvesters “Lexion” (peas and rapeseed) and “Sampo” (wheat) carried out harvesting in August-September. As an object of research, the technological process of cultivation of agricultural crops in the crop rotation of spring wheat–pea–spring wheat–rape was considered. The influence of the row spacing and the seeding rate on the yield was evaluated. An increase in row spacing from 25 cm to 50 cm leads to an almost linear decrease in the yield of crops. The increasing of the seeding rate in the studied limits leads to the yield enhancement. The obtained data will allow substantiating the rational row spacing, design of the sowing complex and seeding rate. This is extremely important for introducing the “No-Till” technology in the arid steppe of the Altai Region.

Key words: Row spacing; Seeding rate; Crop yield; “No-Till” technology; Agriculture

Introduction

The technologies of saving agriculture are becoming more and more widespread under the conditions of the arid steppe of the Altai Region. One of them is “No-Till”, which provides a significant reduction of anthropogenic impact on the soil, saving energy resources, preserving and restoring soil fertility in the long terms. This is an actual problem. Improving the efficiency of land use depends a lot on the correct choice of crops, their alternation in crop rotations and the substantiation of the seeding rate. When designing the parameters of sowing complexes, the row spacing is important. It is determining the parameters of the sowing complex during seeding, the distribution of seeds on the field, the further development of plants, the soil water regime and the yield. All these issues were studied in the framework of the International Russian-German Research Project "Kulunda" in 2011-2016 (Belyaev et al., 2014, 2016, 2017a, 2017b, 2017c).

Materials and methods

Study site

The long-term field experience has been carried out in the LLC Farm Enterprise “Partner”, Mikhailovsky District of the Altai Region, one of the basic sites of the “Kulunda” project (Figure 1). The field experience was founded in 2013, implemented over the next four years in a similar way; the alternation of crops was carried out in accordance to the crop rotation. In total, there were four sets of experiments in eight variants in triple number of replications.

Figure 1. Experimental plots, LLC Farm Enterprise “Partner”, Mikhailovsky District of the Altai Region (from: www.kulunda.eu).

Crop and agrotechnical characteristics
There were four variants of row spacing implemented: 25.0 cm, 33.3 cm, 37.5 cm, and 50.0 cm. We also used two seeding rates for every crop: spring wheat - 75 and 120 kg/ha; rapeseed 2 and 4 kg/ha; peas 140 and 180 kg/ha. The sowing was made with an experienced grain seeder “Cornor-DMC” with chisel-shaped copying coulters, the “Amazone” company production (Figure 2). Combine harvesters “Lexion” (peas and rapeseed) and “Sampo” (wheat) carried out harvesting in August-September.

Figure 2. Experimental grain seeder “Condor-DMC”, “Amazone”, for sowing field experiments.

The variety of spring wheat "Altaiskaya-105": mass of 1000 grains 37.9 g, laboratory germination rate 93.8%. Sowing was performed at the end of the second – in the beginning of the third decade of May. The dose of fertilizer during sowing was 100 kg/ha of ammonium nitrate. Before sowing the wheat the plots were treated by the preparation “Aristotel” at a dose of 2 L/ha (100 L of water + 480 g active substance). During the growing season the plots was treated with mixture (100 L of water, 0.25 L/ha “Toptun” + 20 g/ha “Status Grand” + 0.7 L/ha “Avansis”). The variety of peas “Jamalskiy”: mass of 1000 grains 170.0 g, laboratory germination rate 84.5%. Sowing was performed at the second decade of May. The dose of fertilizer during sowing was 50 kg/ha of ammonium nitrate in physical weight. The variety of rapeseed “Sidalgo”: mass of 1000 grains 4.4 g, laboratory germination rate 94.5%. Sowing was performed at the second decade of May. The dose of fertilizer during sowing was 100 kg/ha of ammonium nitrate in physical weight. During the growing season the pea and rapeseed plots was treated with the preparation “Forward” at a dose of 1 L/ha.

Measured parameters
As an object of research, the technological process of cultivation of agricultural crops in the crop rotation of spring wheat-pea-spring wheat-rape was considered. The influence of the row spacing and the seeding rate on the yield was evaluated.

Statistical analysis
The average data and the correlation between the yield of spring wheat, the row spacing and the seeding rate were designated.

Results and Discussion

Weather conditions

The weather conditions of the growing season over the years of research are described in detail in other articles (Belyaev et al., 2014, 2016, 2017a). The analysis shows that in the period of May – August the amount of precipitation ranged from 123.0 to 180.0 mm with average value of 148.2 mm. This is lower than the multi-year mean by 20.4 mm (12.1%). Principally, less precipitation during the growing season was observed in June (24.7 mm or almost in 2 times lower than the norm). The average monthly temperatures for 4 years of research were at the level of long-time average, except for May, where the decrease was 1.7°C. The sum of the temperatures of the growing season was 38°C (1.7%) lower than the long-time average.

Yield of crops

Table 1 shows the average data of crop yield for the compared variants of the row spacing and the seeding rate in 2013-2016. As the analysis shows, the yield of cultivated crops largely depends on the studied factors. Thus, depending on the crops and fore crops, the average yield was within from 11.5 centners/ha (rapeseed) to 15.9 centners/ha (spring wheat for peas). An increase in the seeding rate for all crops sown led to an increase in yield by from 2.0 centners/ha (peas and rapeseed) to 4.7 centners/ha (spring wheat for peas). In addition, with an increase in the row spacing from 25.0 cm to 50.0 cm, the crop yield decreased by 2.7 centners/ha (peas), 4.9 centners/ha (spring wheat after rape), and 7.2 centners/ha (spring wheat after peas). On the plots with spring wheat after peas the maximum yield was with the row spacing of 33.0 cm (13.1 centners/ha), and the minimum - with the row spacing of 50.0 cm (10.2 centners/ha).

Table 1. Average yield in the variants with different row spacing and seeding rates, 2013-2016.

Sowing parameters			Yield, centners/ha			
№	Row spacing, cm	Seeding rate*	Peas	Wheat after peas	Rapeseed	Wheat after rapeseed
1	25.0	1	15.0	21.5	12.5	19.0
2	25.0	2	12.2	16.5	11.4	14.3
3	33.0	1	13.6	18.8	14.3	17.6
4	33.0	2	12.8	15.5	11.9	14.4
5	37.5	1	12.7	18.3	11.4	16.1
6	37.5	2	11.2	13.3	10.2	13.3
7	50.0	1	12.3	14.4	11.9	14.4
8	50.0	2	9.4	9.2	8.5	9.2

* - the numbers 1 and 2 are the lower and upper levels of the seeding rate.

Linear equations

Processing of field experience data allowed us to obtain the following linear equations of the connection of the physical yield of crops depending on the studied factors:

1. Peas: $Y_f = 12.3-1.45V_1+1.00V_2$, R=0.94 (1)
2. Wheat after peas: $Y_f = 15.6 -3.64V_1 + 2.31V_2$, R=0.99 (2)
3. Rapeseed: $Y_f = 11.4 -1.11V_1 + 1.01V_2$, R=0.82 (3)
4. Wheat after rapeseed: $Y_f = 14.6 -2.52V_1 + 1.99V_2$, R=0.97 (4)

Where: Y_f - Physical yield, V_1 - Row spacing, V_2 – Seeding rate, R - Correlation coefficient.

The analysis shows that in the studied range of the row spacing (25.0-50.0 cm) the greatest yield decrease with an increase in the row spacing was obtained on the plots with spring wheat sowings after peas (3.64 centners/ha for every 12.5 cm of spacing increase) and the minimum on plots with rapeseed (1.11 centners/ha). With an increase in the seeding rate, the highest yield growth was observed on the plots with spring wheat sown after peas and rapeseed (2.31 centners/ha and 1.99 centners/ha, respectively, by every 22.5 kg/ha of seeding rate). The minimum was observed on the plots with peas (0.01 centners/ha for every 20 kg/ha of seeding rate) and with rapeseed (0.01 centners/ha for every 1.0 kg/ha of seeding rate).

Conclusion

The results of the field experiment indicate a high significance of the influence of all the studied factors on the crop yield. An increase in the inter-row spacing from 25 cm to 50 cm leads to an almost linear decrease in the yield of crops. The increasing of the seeding rate in the studied limits leads to the yield enhancement. The obtained data will allow substantiating the rational row spacing, and, consequently, the design of the sowing complex, as well as the seeding rate of crops, taking into account the impact on yield and economic efficiency indicators when introducing the “No-Till” technology in the arid steppe of the Altai Region.

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