

The Effect of Opener for Sowing and Fertilizing at Different Depths on the Quality and Yield of Spring Wheat Grain

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Abstract—This article describes the configuration and operating peculiarities of the combined opener for sowing grain crops with mineral fertilizer treatment at different depths. A comparative analysis of two sowing units was carried out: SKP-2.1 series seeder and SKP-2.1M seeder re-equipped with combined opener for mineral fertilizer application at different depths. Different variants of fertilizer application with different rates were studied. The influence of nitrogen fertilizer application method on the following performance elements of spring wheat was found: plant height, tilling capacity, the number of productive stems per unit area. Quality parameters of grain were defined: the content of protein and crude gluten depending on the method of sowing and the rate of mineral fertilizer application. Yield parameters were obtained when sowing using series and re-equipped seeders. Experimental studies revealed that the proposed opener provides mineral fertilizer application below seeding level. At the same time, the yield of cultivated crop and protein content in grain increased by 20 and 10%, respectively, in comparison with the technology of fertilizer application in the same soil horizon.

Keywords—Opener, sowing, grain crop, mineral fertilizers, quality, yield.

I. INTRODUCTION

For agriculture in Western Siberia, resource-saving technologies are required that are based on the measures for optimization the arable land structure, for the transition to minimal tillage, and using of fertilizers, both organic and mineral. An important aspect is the use of plant protection products and also of modern, adapted to the soil and climatic conditions of region tillage and sowing units. The main objective of crop production is to increase the yield of crops.

Solving this problem is most difficult in areas with insufficient rainfall and wind erosion; one of such areas is the Omsk Region [1].

The task, i.e. increasing the yield of farmed crops, is achieved by implementation of new sowing technologies in agricultural production which are based on the use of promising high-yielding varieties, balanced composition of nutrients in soil and ensuring favorable conditions for plant root nutrition with the help of mineral fertilizers.

The most favorable way of fertilizer application together with sowing is separate application of fertilizers and seeds. This method, in comparison with broadcast seeding, allows the most optimal placement of fertilizers in the root layer of soil. Such fertilizing helps the root system of plants to use nutrients to the fullest extent what in turn increases the benefit from using fertilizers.

In modern farming conditions, application at seeding is of current interest when starting fertilizer dose is applied simultaneously with sowing, but in different layers.

This method of placing seeds and fertilizers in different horizons of the upper soil layer eliminates the risk of toxic effects of fertilizer on seeds, as well as enhances the mineral nutrition of plants, especially at the initial stage of root system development what contributes to increased field emergence of seeds and, as a result, increased yield, in comparison with sowing technology when mineral fertilizers and seeds are sown actually in one row.

The novelty of this study is as follows: improving the sowing process using intensive technology due to the development of a combined opener that provides sowing of grain crops and application of the starting dose of fertilizer in different soil horizons.

The purpose of this paper is to develop a combined opener that provides sowing of seeds and fertilizer application in different soil horizons and to conduct research in order to define the influence of mineral fertilizer application method on the quality and yield of spring wheat.

II. RESEARCH METHODOLOGY

To study the issue, i.e. the influence of mineral fertilizer application methods on grain quality and yield of spring wheat in 2017-2018, the experiments were started on the experimental field of "Omsk Agrarian Scientific Center" Federal State Budget Scientific Institution. Two sowing units were compared: a SKP-2.1 series seeder and SKP-2.1M seeder re-equipped with combined openers for multilayer fertilizer application. We considered different variants of fertilizing with different rates. Each of the variants was performed in triplicate. It was a two-factor experiment. The size of plot was 2x30m. The area of one plot was 60 m². The

predecessor was spring wheat. No basic tillage was carried out. Fertilizer – ammonium nitrate – was applied simultaneously with the sowing using a seeder with opener providing different depth fertilizer application of 100, 150 and 200 kg/ha. Sigma 2 spring wheat variety with the mass of 1,000 grains of 33 g, field emergence of 92%. Seed application rate for all experimental plots was the same and amounted to 5.5 million germinating grains per hectare.

III. RESULTS

Agricultural science, innovative approaches and the implementation of effective technologies that are most relevant to the soil and climatic conditions of the region are the basis for agro-industrial complex development [2, 3].

Global development of agricultural machine-building industry, particularly in the field of sowing equipment, is aimed at sowing seeds and fertilizers at different depths, while domestic sowing units and complexes place fertilizers and seeds in one soil horizon [4, 5].

The technology of application of seeds and fertilizers in different soil horizons at different depths and creating a soil layer between them allows the seeds to be placed at the safe distance from fertilizers at the initial stage of their development, since the absorption of ammonia and ammonia which form the part of nitrogen fertilizers from soil can seriously harm plant development. High concentration of ammonia is toxic to plants and can lead to their death and a sharp decrease in field emergency (Fig. 1).

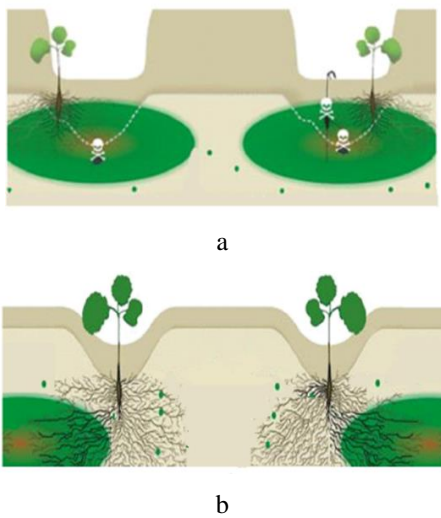


Fig. 1. Placing seeds and fertilizers four weeks after sowing: a – sowing at one depth; b – sowing at different depths

Four weeks after sowing, the width of the band of nitrogen fertilizers increases to 20 cm, the nitrogen assumes the form of useful nitrate. Nitrogen concentration is reduced, and salting effect on plants decreases. Plants start recovering and gaining strength, Fig. 1a.

Placing seeds and fertilizers in different soil horizons contributes to the accelerated development of plant root system. Fertilizers applied this way have a lower concentration at this stage and pose a lower risk to plants. Root system develops in the direction of feeding source becoming powerful and branching. Fig. 1b [6, 7, 8].

To obtain a high yield of crops, the feeding area for each plant should be optimal [9, 10]. Creation of such conditions

for plant growth (fertilizing below seeding level, rational feeding area, uniform seeding depth) depends, first of all, on the work of openers installed on a seeder [11-15].

Based on the studies, a combined opener was developed (Figure 2).

This proposed combined opener performs pre-sowing loosening of soil, cutting weeds and fertilizing and sowing at different depths for one working pass.



Fig. 2. General view of an experimental combination opener

Technological process of sowing and fertilizing with the developed opener is carried out as follows: when the opener moves, the point of opener tine cuts the soil forming a space for the opener. The tine, moving along it, spreads the soil and forms a groove. At the same time, sweeps located on both sides of tine cut weeds and loosen the topsoil. Fertilizers are applied in the soil, to the bottom of the furrow made by the chisel through the front channel located behind the tine. With further movement, the opener closes fertilizer with a layer of moist, tight soil, onto which seeds flow via seed drill tube. Thus, fertilizers are placed deeper than seeds [16].

During this field experiment, the following parameters were defined: field emergence, uniform distribution of seeds over the plot area, yield and grain quality by variants. The experiments were performed and analyzed according to generally accepted methods.

To conduct studies in defining the quality parameters of grain before harvesting, sheaves were taken from an area of 1 m² of each plot. Quality parameters include: plant height, tilling capacity, the number of productive stems per unit area (Figure 3). Results are shown in Table1.

TABLE I. EFFECT OF NITROGEN FERTILIZER APPLICATION METHODS ON THE PRODUCTIVITY ELEMENTS OF SIGMA 2 SPRING WHEAT (2017-2018)

Type of opener and fertilizer application method	Fertilizer application rate kg/ha	Height of stems, cm	Tilling capacity	The number of productive stems, pcs / m ²
Standard together with seeds (control)	0	85	1,38	397
	100	90	1,43	412
	150	102	1,56	436
	200	94	1,44	423
Experimental placement at different depths	0	90	1,53	412
	100	86	1,70	447
	150	92	2,02	475
	200	89	1,91	458

The number of productive stems varied depending on the method of application and amount of nitrogen fertilizer applied when sowing using SKP-2.1 series seeder from 397 pcs/m² in the control area without fertilizers up to 475 pcs/m² using seeder with an experimental opener with application of 150 kg/ha of fertilizers. In addition, control variant demonstrated decreased height of stems and tilling capacity.

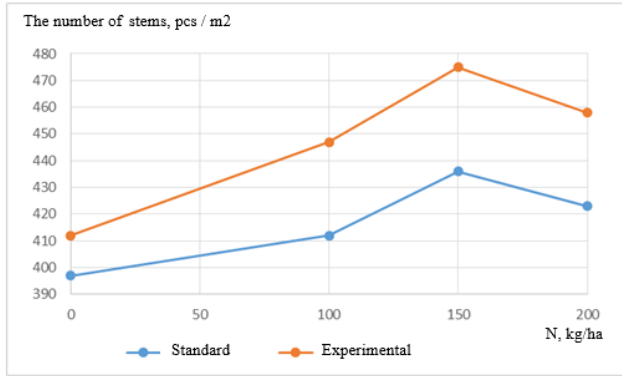


Fig. 3. The number of productive stems depending on the type of opener, method and rate of fertilizer application

The main indicator of grain quality is amount of protein (Figure 4) and crude gluten (Figure 5); data are shown in Table 2.

TABLE II. QUALITATIVE PARAMETERS OF SIGMA-2 SPRING WHEAT GRAIN DEPENDING ON THE TYPE OF OPENER AND THE RATE OF NITROGEN FERTILIZER APPLICATION

Variant	Series opener (control)		Experimental opener	
	Protein, %	Crude gluten, %	Protein, %	Crude gluten, %
Sowing without fertilizers (control)	12.06	24.3	12.77	25.6
Ammonium nitrate 100 kg/ha	13.99	28.3	13.97	27.8
Ammonium nitrate 150 kg/ha	14.37	28.6	14.25	29.1
Ammonium nitrate 200 kg/ha	13.97	27.8	13.65	28.3

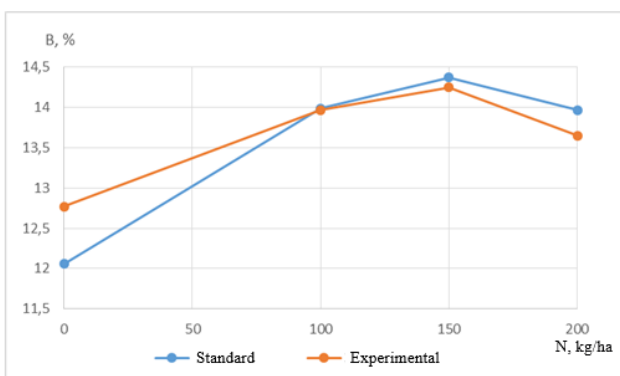


Fig. 4. Protein content depending on the type of opener, method and rate of fertilizer application

Minimal protein (12.06%) and crude gluten (24.3%) content was observed in the control variant. In all variants with ammonium nitrate, the content of protein and crude gluten increased.

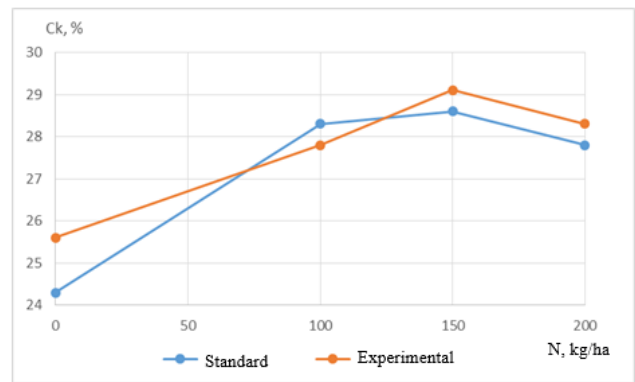


Fig. 5. Crude gluten content depending on the type of opener, method and rate of fertilizer application

Maximal values were obtained when sowing using experimental opener, with 150 kg of fertilizer per hectare.

Harvesting was carried out using Hehe-125 seed combine. The yield (Figure 6) of grain was converted in the terms of standard moisture content of 14%. Results for two years are shown in Table 3.

TABLE III. AVERAGE GRAIN YIELD IN T/HA DEPENDING ON THE METHOD AND RATE OF FERTILIZER APPLICATION (2017-2018)

Type of opener and fertilizer application	Fertilizer application rate, kg/ha	Yield, t/ha		
		2017	2018	average
Standard together with seeds (control)	without fertilizers (control)	2.84	1.67	2.26
	100	3.48	1.84	2.66
	150	3.47	2.01	2.74
	200	2.75	1.72	2.24
Average over experiment		3.14	1.81	2.48
Experimental placement at different depths	without fertilizers (control)	3.53	1.91	2.72
	100	3.67	2.05	2.86
	150	3.76	2.38	3.07
	200	3.42	2.01	2.72
Average over experiment		3.60	2.09	2.84

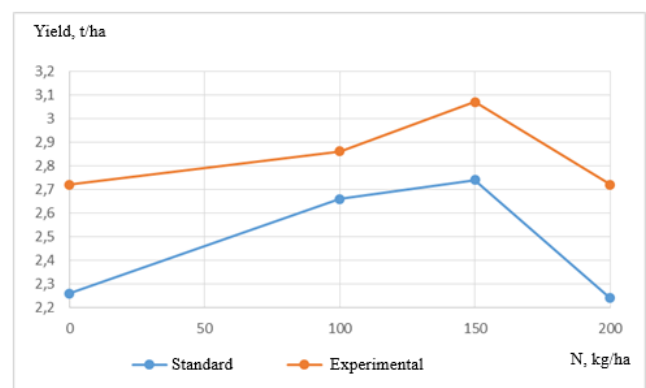


Fig. 6. Average grain yield depending on the type of opener, method and rate of fertilizer application

As shown by the results obtained, grain yield depended on the method and rate of nitrogen fertilizer application; it varied in different years from 1.67 t/ha when sowing with a series seeder to 3.76 t/ha when sowing with an experimental opener with application of 150 kg/ha of ammonium nitrate.

IV. CONCLUSION

Performed researches have shown that the proposed design of developed combined opener is efficient and provides a method of sowing seeds and fertilizing at different depths. The analysis of grain quality results during field experiments in comparison with the control when sowing seeds and fertilizers in one horizon showed that protein content in grain increased by 10%, and the increase in grain yield amounted to 20%.

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