

Productivity of various types of spring wheat under the influence of the area and nutrition status in the Pre-Kama of the Republic of Tatarstan

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Abstract. This paper summarizes the experimental data on the results of two years of experiments on the study the effect on the yield and grain quality of spring soft wheat of the Ulyanovskaya 105 variety and emmer wheat (*Triticum Dicocum Schvebl*, spelt) of Runo variety and when applying a full dose of mineral fertilizers (N30-34P49-52K33-35) for pre-sowing cultivation. Natural background without fertilizers was in the control. Four seeding rates were tested at each nutritional level: 4; 5; 6 and 7 million pieces viable seeds per 1 ha. Meteorological conditions during the research years were different. The hydrothermal index (HTI) for the growing season of spring wheat in 2020 was 1.38, growth and development took place in favorable conditions, and in 2021 the HTI was 0.29, which had a very negative impact on the yield of the tested wheat varieties. The highest yield in the research years on both statuses of nutrition in the Ulyanovskaya105 variety was provided when sowing 6 million grains per hectare, in wheat variety Runo spelt (1.95–2.6...2.63–2.75), respectively.

1 Introduction

Grain production remains the main direction in crop production in the state program for the development of agriculture in the Russian Federation. At the same time, the implementation of the predicted parameters is associated with the need to solve a number of scientific and production problems. The most important of them are:

- the increase in the share of products with the highest marks in terms of indicators characterizing the technological, dietary and environmental properties of grain;
- the increase in the diversity of grain crops, including the expansion of the share of cereals and cereal crops unique in the direction of the use of spring wheat (spelt) [4].

The grain of spring soft wheat has a great nutritional value. It contains 12-16% of protein, 63-65% of starch, 1.5% of fiber, 1.7% of ash, as well as various vitamins, enzymes and other substances [2, 3].

Emmer wheat (spelt) occupies a special position among other types of this crop due to the highest quality of grain.

Spelt wheat grain has a high Hardness, which reaches 95% and more. Increased Hardness is explained by a higher content of protein and a mass fraction of gluten. The protein content in spelt grain is 4–6% higher compared to common wheat, and the gluten protein of this culture includes 18 essential amino acids that cannot be obtained from animal food [8, 10].

Emmer wheat (spelt) is an independent botanical variety of *Triticum Dicocum*. It differs from the soft one in a smaller distribution area. In the middle of the twentieth century, it was widespread in the middle Volga

region and in the North Caucasus. With the change in the structure of sown areas, the expansion of spring wheat and tilled crops, the sowing of spelt wheat has sharply decreased [7, 11].

The yield value largely depends on the density of the productive stem before harvesting, which, in turn, is mainly determined by the seeding rate, the completeness of seedlings and the survival of plants during the growing season [1; 4; 9]. A significant part of conditioned seeds do not form shoots after sowing. According to a number of authors, the completeness of seedlings depends on meteorological conditions, soil properties and moisture, as well as agricultural practices [12, 13].

Among the agrotechnical measures that affect the yield and properties of grain, fertilizers occupy an important place. Types, doses and timing of their introduction should be recommended based on their specific conditions of the area and farms, taking into account the requirements of the culture, variety [5, 6].

Under the conditions of Tatarstan, spelt has been little studied. The lack of theoretical data and practical recommendations makes it difficult to develop a unified technology for cultivating this crop in the region [7, 8]. The purpose of this research is to study the influence of various seeding rates and nutritional status on the formation of grain yield and its quality of spring soft and emmer wheat (spelt) in the conditions of the Pre-Kama region of the Republic of Tatarstan.

2 Materials and methods

The field studies were carried out in 2020–2021 on the territory of “Agrobiotechnopark” of Kazan State

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Agrarian University. The soil was gray forest medium loamy with the following agrochemical indicators in the soil layer of 0–20 cm: the content of organic matter (humus) was 3.1–3.4% (according to Tyurin), P₂O₅ – 229–240, K₂O – 84–117 mg/1000 g of soil (according to Kirsanov), the number of absorbed bases was 26.4–32.0 mmol (100 g of soil, pH_{soil} was 6.0–6.3 (acidity was close to neutral). Winter wheat was used as a precursor rye after pure fallow. The area of each plot was 27.5 m² (25 × 1.1), the repetition was 4-fold. The placement of the plots was consistent. The object of the study was the zoned varieties of spring soft wheat Ulyanovskaya 105 and spelt wheat Runo with the generally accepted technology of spring cultivation wheat in the region.

Research scheme. To study the purpose of the research, the experiment was carried out in the crop rotation link: bare fallow - winter rye - spring wheat according to the following nutritional statuses. Factor A (fertilizers):

1. Natural background (control);
2. NRK calculated per 3 tons of grain per hectare of Factor B (seeding rate). Four seeding rates were tested on each nutritional status: 4 million germinating seeds per ha; 5 million; 6 million and 7 million pieces per ha.

Fertilizers were applied in the form of ammonium nitrate, Azofoska N₁₆ R₁₆ K₁₆ and potassium chloride. In both years of research, after pre-sowing cultivation, sowing was carried out at the optimally early time (the 1st decade of May) with seeds of the 1st class. Sowing was carried out with a seeder Wintersteiger to a depth of 4–5 cm. The calculated sowing rates deviated from those actually sown by 1.5–3.0 percent.

Crop care was performed in accordance with the requirements of advanced technology. The yield was determined by plots after threshing in the phase of full ripeness with a SAMPO-500 combine.

3. Results and discussion

During the study, the weather conditions in the growing season were not the same, both in terms of the amount of precipitation and the temperature regime. In 2020, soil moisture under the crops of the studied objects was quite high at the optimal temperature regime (HTI-1.38),

which had a positive effect on the future yield of spring wheat agrocenosis.

The meteorological indicators of the growing season in 2021 were characterized as extremely unfavorable for the formation of spring wheat productivity. The months of May and June were extremely dry, HTI was 0.29. Precipitation in July (57% long-term norm) did not have a significant impact on the yield.

Our observations in both years of research showed that seedlings of spring soft wheat and emmer wheat (spelt) appeared in all variants of the experiment together on the 10th and 11th days after sowing. On a fertilized background, seedlings had a more intense green color compared to plants on a natural background (control). The density and completeness of seedlings in both types of wheat were significantly affected by seeding rates, regardless of the status of nutrition. Thus, on average, for two years, spring soft wheat on both statuses of nutrition at a rate of 4 million per 1 ha, or 400 pcs. per 1 m² on an area of 1 m² there were 331–334 plants, with an increase in the seeding rate to 7 million, or 700 pcs. per 1 m² the number of seedlings increased by 217–222 pcs and amounted to 548–556 plants per 1 m². In wheat, spelt, respectively: 338–353; 225–234 pcs and 563–587 plants per 1 m². If with the increase in the sowing rate in both types of wheat, the number of plants increased, then the completeness of seedlings decreased to some extent (by 4.1–4.5%). In general, it remained at a high level (78.3–82.8; 79.4–83.5%) in soft wheat and 80.4–84.5; 83.8–88.3% in emmer wheat (spelt).

At all levels of nutrition in both types of wheat, as the seeding rate increased, the fall of plants to full ripeness from the number of seedlings increased by 7.9–10.5 percent. Consequently, the sowing rate is a very significant factor in the regulation of the density of the stem and one of the main elements of the cultivation technology, both spring soft wheat and spelt.

The weather conditions during the years of research on various levels of nutrition and seeding rates determined the characteristics of plant growth and development, the yield and grain quality of spring soft wheat and spelt wheat (Diccoicum).

At all the levels of nutrition, with the increase in the seeding rate, the yield increased. However, the proportionality of the increase in seeding rates was noted only up to a certain limit (Table 1).

Table 1. Productivity of various types of spring wheat depending on the level of nutrition and seeding rates, t/ha.

Type and variety of spring wheat (A)	Status power (V)	Seeding rate, mln.pcs/ha (C)	Year		Average for 2 years	Increase	
			2020	2021		from status power	from seeding rates
Soft wheat – Ulyanovskaya 105	Natural - background (control)	4	2.16	1.44	1.80	–	–
		5	2.79	1.59	2.19	–	0.39
		6	2.38	1.79	2.09	–	0.29
		7	2.39	1.82	2.07	–	0.29
	NRK per 3 tons of grain per hectare	4	3.05	2.0	2.53	0.73	–
		5	3.14	2.2	2.67	0.48	0.14
		6	3.67	2.4	3.04	0.95	0.51
		7	3.62	2.5	2.91	0.84	0.38

Emmer wheat (spelt) Runo	Natural background (control)	4	2.13	1.77	1.95	–	–
		5	2.35	1.89	2.02	–	0.07
		6	2.30	1.95	2.13	–	0.18
		7	2.31	1.96	2.07	–	0.12
	NRK per 3 tons of grain per hectare	4	2.49	2.17	2.33	0.38	–
		5	2.79	2.32	2.56	0.44	0.23
		6	2.95	2.63	2.79	0.66	0.46
		7	2.96	2.69	2.68	0.61	0.35

The maximum reliable yield in 2020, favorable for weather conditions for both types of wheat was obtained when sowing 5 million germinating seeds per hectare on a natural background, and 6 million on fertilized background.

In the extremely dry year 2021, on both backgrounds of nutrition, soft wheat and spelt had higher yields (2.09–3.04 t/ha and 2.02–2.79 t/ha) at a sowing rate of 6 million seedlings. seeds per 1 ha.

Fertilizers applied at a yield of 3.0 t/ha actually provided 3.05–3.62 t/ha in 2020 and 2.0–2.2 t/ha in the extremely dry 2021. In wheat, spelt, respectively: 2.49–2.86 and 2.17–2.49 tons per hectare.

The data in the table show that fertilizers had a significant effect on yields on both types of wheat. In average for 2 years, depending on the seeding rates, with the application of fertilizers, the excess yield over the control in soft wheat was 0.73–0.84 t/ha, and spelt wheat was 0.38–0.61 t/ha.

The content of protein in the grain, the mass fraction of gluten, and the weight of 1000 grains decreased in both statuses of nutrition in the studied varieties of spring wheat, with the increase in the sowing rate from 4 to 7 million germinating seeds per hectare (Table 2).

Table 2. Technological qualities of spring wheat and emmer wheat (spelt) depending on the main elements of cultivation technology (cf. 2020-2021).

Type and variety	Status of nutrition	Seeding rate, million/ha	Weight of 1000 grains, g	Nature, g/l	Hardness, %	Protein content, %	Content of the mass fraction of gluten, %	Quality of the mass fraction of gluten, %
Soft wheat Ulyanovsk 105	Natural background (control)	4	33.	74	44.	12.	27.1	69
		5	0	2	7	8	27.0	68.
		6	32.	74	45.	12.	26.3	7
		7	4	2	3	7	26.3	68.
		32.	74	45.	12.		0	
		1	4	2	7		67.	
		32.	74	45.	12.		6	
	NRK per 3 tons of grain per hectare	4	33.	74	46.	14.	31.2	75.
		5	4	8	9	2	30.7	4
		6	33.	75	47.	14.	30.4	75.
		7	1	0	3	0	30.0	4
		32.	75	48.	13.		75.	
		9	3	0	1		0	
		32.	75	48.	13.		75.	
Emmer wheat (spelt) Fleece	Natural background (control)	4	28.	–	68.	13.	28.6	90.
		5	4	–	0	9	28.4	0
		6	28.	–	68.	13.	28.4	90.
		7	2	–	0	6	28.4	0
		28.		68.	13.		90.	
		0		0	5		0	
		27.		68.	13.		90.	
		9		0	3		0	

	NRK per 3 tons of grain per hectare	4	29.	–	81.	15.	33.0	85.
		5	3	–	0	8	32.3	0
		6	29.	–	81.	15.	31.7	85.
		7	0	–	0	3	31.4	0
			28.		81.	15.		85.
			7		0	0		0
			28.		81.	15.		85.
			4		0	0		0

The changes in the level of nutrition with the introduction of calculated doses of mineral fertilizers had a positive effect on some indicators of grain quality. The protein content in the grain of spring soft wheat increased by 0.4% at a sowing rate of 6 million pieces seeds per hectare, weight of 1000 grains per 0.8 g and grain Hardness increased by 2.8%. In emmer wheat (spelt) these indicators were 1.5%; 0.7 g and 13% respectively.

In modern conditions, along with agronomic efficiency, it is even more important to assess the impact of the area and status of nutrition of various types of spring wheat in the Pre-Kama region of the Republic of

Tatarstan in terms of such indicators as the yield of additional products in value terms, the amount of profit per unit area and the level of profitability [15].

The calculations of the economic efficiency of the use of the tested rates of fertilizer application, at different seeding rates of spring soft wheat of the Ulyanovskaya 105 variety in conditions of gray forest soil are shown in Table 3.

Table 3. Economic efficiency of the use of various rates of application of mineral fertilizers, sowing, in crops of spring soft wheat (the average number for 2020–2022).

Indicators	Status of nutrition and seeding rates, mln/ha							
	Natural, without fertilizers (control)				Average fertilizer rates (for 3 tons of grain/ha)			
	4 million	5 million	6 million	7 million	4 million	5 million	6 million	7 million
Productivity, t/ha	1.80	2.19	2.09	2.07	2.53	2.67	3.04	2.91
Yield increase, t/ha	–	–	–	–	0.73	0.48	0.95	0.84
Additional products, rub.	–	–	–	–	9673	6360	12587	11130
Additional costs - total, rub.	–	–	–	–	7013	7094	7386	7212
Including:								
Fertilizer, rub.	–	–	–	–	6856	6856	6856	6856
Depreciation, rub.	–	–	–	–	38	38	38	38
Salary, rub.	–	–	–	–	19	19	19	19
Fuel, rub.	–	–	–	–	25	25	25	25
Motor transport works, rub.	–	–	–	–	75	75	75	75
Additional profit, rub.	–	–	–	–	2660	2660	5201	3918
Profitability level of additional costs, %	–	–	–	–	37.9	37.9	70.4	54.3

* Legend: At the beginning of 2020, the average selling price of wheat grain of the third class was 13.250 rubles.

The cost of additional production was calculated according to the size of the increase in yield and the average selling price of 1 ton of grain of the third class at the beginning of 2020 (13,250 rubles). Mineral fertilizers at average rates at the optimal sowing rate (6 million germinating seeds per 1 ha) gave a very significant increase in marketable products: the cost of additional products from which they increased by 12,587 rubles/ha, respectively.

Additional costs for the use of fertilizers, including harvesting and finalizing the increase in grain, were calculated according to the flow charts for the cultivation of spring wheat, developed by scientists of Kazan State Agrarian University on a self-supporting assignment of the Ministry of Agriculture and Food of the Republic of Tatarstan. The use of mineral fertilizers at average rates

during sowing with a seeding rate of 6 million seeds per hectare increased the cost of the cultivation of spring wheat by 7,386 rubles per hectare, respectively. Despite this, the use of mineral fertilizers at rates calculated in order to obtain 3.0 t/ha of spring wheat at an optimal seeding rate turned out to be economically justified. As we can see, the additional profit from each hectare from the introduction of average fertilizer rates at a seeding rate of 6 million amounted to 5201 rubles. This is also proved by the relative indicator of the economic efficiency of the use of fertilizers – the level of profitability: the use of average fertilizer rates at a sowing rate of 6 million seeds per hectare provided profitability at the level of 70.4%.

Thus, the use of mineral fertilizers in the norms established by the calculation-balance method to obtain

3.0 t/ha of spring wheat grain during sowing 6 million germinating seeds per 1 ha, taking into account local delivery coefficients and use of NRK from soil and fertilizers in conditions of gray forest soil was agronomically and economically beneficial and provided additional profit per hectare in the amount of 5201 rubles.

4 Conclusion

According to the research results, we can draw the following conclusions:

Mineral fertilizers applied according to the calculation method is an effective method for the increase in the yield of both types of wheat in the conditions of the Pre-Kama zone of the Republic of Tatarstan.

Despite the fact that the yield of the studied wheat varieties in both years of research increases to a seeding rate of 7 million pcs. seeds per hectare, depending on the status of nutrition, the norms are more effective - 5-6 million viable seeds per hectare.

Fertilizers and optimal seeding rates provide high quality food grains.

The use of mineral fertilizers at the optimal seeding rate established by the calculation-balance method to obtain 3.0 t/ha of spring wheat grain, in conditions of gray forest soil, was agronomically and economically beneficial and provided additional profit per hectare in the amount of 5201 rubles.

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