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Potential Productivity Analysis of the Timiryazevskaya 42 New Spring Triticale Cultivar at Nitrogen Fertilizer Application

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***Abstract*—In this work we bring the results of the new Timiryazevskaya 42 triticale cultivar potential productivity analysis at different amount of nitrogen fertilizer application. Field experiments held in between 2016 and 2018 on podzol soil showed that increase of fertilizer dose led to the increased yield from 14% to 140%. Timiryazevskaya 42 variety is responsive to the high levels of mineral fertilizer. Dose equal to 150 kg of active ingredient (AI) per 1 hectare (ha) applied during sowing forms an average 12,5 tons per hectare yield of grain. Analysis showed that by using two parameters - spike realization coefficient (SRC) and spike mass in the bloom, one can predict the yield maximum and the level of plant potential realization in the middle of vegetation period. Wherein, under favorable weather conditions, the dependence of the studied parameters and the obtained biological productivity at different doses of nitrogen fertilizers is much higher. In 2018, Timiryazevskaya 42 showed the greatest dependence (r = 0.82) of yield on SRC. A study of the formation of crop structure elements showed that the highest correlation (average for three years) was found between biological productivity and the amount of grain per spike (r = 0.62), and between biological productivity and productive bushiness (r = 0.89).**

Keywords*— *spring triticale, potential productivity, biological productivity, nitrogen fertilizers, spike realization coefficient

I. INTRODUCTION

An increase in world population's demand for grain production contributes to an increase in the intensity of crops cultivation, in particular cereals, which are the main source of nutrients for humans and animals. Progressive production of cereals should occur under high ecological standards to save environment and natural resources. Therefore, an increase in yield should be ensured by increased potential productivity of new crop varieties but not through the development of virgin lands, which overnight turned into a certain way to solve problems with food production [1].

II. EXPERIMENTAL

At all times it was an important task for agriculture not only to maintain the achieved level of development, but also to increase it constantly. Thus, appears an urgent need to improve methods for crop productivity prediction for its' successful implementation in industry.

The sown area of triticale in Russia is 100 times less than wheat [2]. This crop is considered to be relatively new and is not well-known across manufacturers, therefore, is not widely used. In order to introduce triticale along with other crops, it becomes necessary to determine the parameters that will positively effect on the quality of the future crop, as production should have a stable indicator, regardless of the influence of any external factors on the culture.

Recently, in Russia, the economic conditions have developed so that to solve the problems of import substitution, it is necessary to intensify the work on creating new high-yielding varieties, and it is also necessary to accelerate the process of their transfer into industry. New varieties should have significant biological productivity potential and the ability to maximize its implementation, high plasticity, ensuring crop stability under varying weather conditions [3]. But to assess the cultivar in the state commission for cultivar testing, and then grow it in various regions, many years of testing and obtaining data on its

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actual yield obtained over a number of years are vital. In order to push this process, it is necessary to know the variety potential due to which yield productivity elements are formed. Moreover, farmers would like to acquire new highly productive varieties with already known agricultural technology pathway as well as reaction to certain elements of it [4]. Therefore, it is necessary to develop modern effective methods for assessing the potential and analyzing the real productivity of new varieties influenced by exact technological processes.

The purpose of the studies conducted in 2016-2018 is to investigate the features of the potential productivity formation and its implementation when different doses of nitrogen fertilizers are applied in a new cultivar of spring triticale Timiryazevskaya 42.

The object of the research was the spring triticale cultivar Timiryazevskaya 42, developed by the authors from RSAU-MTAA n.a. K.A. Timiryazev (Soloviev A.A., Dudnikov M.V., Ruban A.S., Knyazev A.N., Gushin A.V.). The variety was obtained by crossing the primary and secondary forms of hexaploid triticale S2 / k-1242 // k-1185 and subsequent individual selection. The cultivar is hexaploid, the heading time is average, has strong pubescence of the neck, lower spikelet scales are present, the grain is very dark. It is resistant to powdery mildew, leaf and stem rust and ergot as well.

In a field experiment, we studied the effect of various doses of nitrogen fertilizers applied in increments of 30 kg of AI per hectare, from 30 to 150 kg, in pre-sowing cultivation, as well as the effect of fractional application of nitrogen fertilizers. Dry fertilizers were spread across the field without embedding in the soil.

The experimental design included 8 variants for applying nitrogen fertilizers:

1. N_0 (control);
2. N_{30};
3. N_{60};
4. N_{90};
5. N_{120};
6. N_{150};
7. $N_{90} + N_{30}$;
5. $N_{90} + N_{60}$.

The experiments were based on 3x repetition, the placement of variants was randomized. The accounting area of the experimental plot was 5 m².

The experimental plot soil is podzolic, illuvial-ferruginous, loamy, with the following agrochemical indicators: humus content - 1.9%; mobile P_2O_5 —283.0 mg/kg; exchangeable K_2O - 134 mg/kg; pH_{KCl} - from 4.8.

To determine biological yield and yield structure of spring triticale during field research in 2016-2018, test sheaves were collected from each plot before harvesting. Biological productivity shows both the level which crop can reach and losses which are added if proper agricultural practices are not followed.

Analysis of the yield structure was carried out according to the method of Gossortseti (1981). Mathematical processing of the research results was carried out by the variance, correlation and regression analyzes according to the methods described by B. A. Dospekhova (1985).

In 2016, weather conditions, which were not favorable enough, significantly affected the biological productivity of spring triticale. The average temperature of the vegetation period was equal to 16.4 °C, was above the norm by 2.2 °C. Uneven rain, in the second decade of July (61.5 mm) and August (96.8 mm), which is 2 and 4 times higher (normally 30 and 23 mm respectively). Hydrothermal coefficient (HTC) for the April – August period was equal to 1.2. In May and June, the HTC was below 1, which indicates the presence of adverse conditions for plants growth and development. In July and August, conditions could also negatively effect on the crop growth due to uneven distribution and intensity of rain.

Analyzing the meteorological conditions of the 2017 growing season, we can say that due to the cold and prolonged spring, sowing was carried out at a later date. The increase in air temperature from the second decade of July to the second decade of August was accompanied by a three-fold decrease in the amount of precipitation, which affected the formation of grain and its quality. Precipitation in the third decade of August and the first decade of September, two times higher than the long-term average values, delayed the harvesting period by almost three weeks, the grain in the spikes began to sprout, which further affected its quality.

Meteorological conditions of the 2018 vegetation period were generally favorable for the growth and development of spring triticale. The air temperature during almost all vegetation period, except for the first ten days of June, was 2-4 degrees higher than the mean annual values. Precipitation was uneven. In the second decade of May and the third decade of July precipitation was two times higher than the mean annual values. In August precipitation was almost completely absent. On the one hand, it negatively affected the formation of grain, on the other, harvesting was performed without any problems.

III. RESULTS AND DISCUSSION

There are various definitions of the plant productivity concept in literature sources [5]. Biological productivity is often understood either as biomass of aboveground and underground organs of a whole plant or grain yield per area unit (per 1 m^2 or 1 ha). The potential yield of a cultivar is the actual maximum grain yield obtained under experimental or production conditions (table I).

To determine the biological yield and yield structure of spring triticale during field studies, trial sheaves were selected from each plot before harvesting. It should be noted that this work presents only biological productivity obtained after manual threshing of the test sheaves, it can exceed the harvester yield results up to 30% or more, because grain losses during threshing and transportation are practically eliminated, the threshing is carried out more carefully, which is impossible when harvest is automated. Biological productivity shows what level a crop can reach and what crop losses develop if the correct agricultural technology is not used [6].

In 2016, as a result of a short-term drought during plant stem extension, Timiryazevskaya 42 formed the maximum biological yield equal to 12.5 t/ha when 90 kg/ha of nitrogen were applied. When nitrogen in the form of organic matter was introduced in the dose of 150 kg/ha, plant inhibition was observed, which lead to a decrease in biological productivity to 10 t/ha.

In 2017, Timiryazevskaya 42 formed a biological yield of 1.5-2 t/ha less than in 2018. The maximum yield on average in 2017 was recorded on the variant N_{150} - it was 9.6 t/ha, i.e. 40% higher than in the control. The effect of fractional application was observed only in the case of applying 90 kg/ha during pre-sowing cultivation and 30 kg/ha during plant stem extension.

As a result of the prevailing weather conditions in 2018, Timiryazevskaya 42 showed the highest biological productivity – 12.2 t/ha in N_{150} application during sowing and with fractional application. The control showed the lowest yield, which amounted to almost 5 t/ha. Statistical analysis of the data showed the reliability of the all studied variants, except for the N_{30} variant.

Two methods were chosen to predict the effect of nitrogen fertilizers and weather conditions on the triticale yield: the spike realization coefficient and the spike weight measurement in the flowering phase [7].

Using the spike realization coefficient (SRC) as a yield criterion, one can predict yield by variants in any given year [8]. This indicator is defined as the ratio of the increase in mass of the spike from flowering to harvesting to its mass in the flowering phase.

In 2016 a strong direct dependence of the yield on the spike realization coefficient was obtained, it amounted in 0.97, but at the same time, the SRC among the variants was statistically unreliable. By measuring the mass of the spike during the flowering phase, it is possible to more reliably predict the yield of triticale, depending on the applied agricultural technologies.

The SRC in 2017 on the Timiryazevskaya 42 has a strong correlation with productivity - r = 0.6, meaning that

TABLE I. BIOLOGICAL PRODUCTIVITY AND YIELD STRUCTURE ELEMENTS VALUES OF THE SPRING TRITICALE TIMIRYAZEVSKAYA 42 IN AVERAGE FOR 2016-2018

Variant	Grain mass		SRC*	Blooming spike mass, г	Yield, t/ha	
	Main spike, g	*1000 gr., g*			*biological*	*actual*
1. Control	2,64	51,4	1,05	2,74	7,78	4,32
2. N_{30}+ N_0	2,39	43,3	1,23	1,02	6,53	4,27
3. N_{60}+ N_0	3,43	47,8	1,25	1,22	10,2	5,26
4. N_{90}+ N_0	3,20	53,0	1,10	3,25	10,1	5,85
5. N_{120}+ N_0	2,81	46,9	1,31	1,23	9,64	5,66
6. N_{150}+ N_0	3,52	52,7	1,28	2,85	12,5	6,62
7. N_{90}+ N_{30}	2,47	49,0	1,30	1,26	8,96	5,64
8. N_{90}+ N_{60}	2,71	54,6	1,15	3,16	9,99	6,30
LSD_{05}	0,46	2,20	0,13	0,51	1,87	0,83

*SRC – SPIKE REALIZATION COEFFICIENT

there is a clear correlation between changes in the spike realization coefficient relative to yield.

The value of the SRC in 2018 has a strong correlation with biological productivity (r = 0.8). Consistent changes in biological yields relative to SRC are observed. The differences are significant in all cases.

According to a number of researchers, the weight of a spike in the flowering phase can characterize the potential productivity of plants [9]. Under favorable conditions, the final mass of spike and grain is directly proportional to the starting mass of the spike; under adverse conditions, this proportionality breaks.

In 2017, the dependence of the biological yield of the variety Timiryazevskaya 42 on the weight of the spike in the flowering phase has a weak correlation dependence (r = 0.33). With a maximum value of the spike weight of 1.26 g on the N_{90} variant, the yield has an average value of 5.7 t/ha, while the highest yield value was formed on the N_{150} variant with a spike weight of 1.17 g during the flowering phase. Statistical analysis showed the reliability of all variants except N_{30}.

In 2018, the yield on the spike mass during the flowering phase has a weak correlation and with a maximum spike weight of 1.49 g on option N_{60}, the yield is 11.4 t/ha, while the highest yield was formed on the option N_{150} with the weight of the spike in the flowering phase equal to 1.25 and 1.35 g during one-time and fractional application respectively.

Using two indicators, the spike realization coefficient and the spike weight in the flowering phase, we can make a prediction on which of the experimental variants the yield will be the highest in the middle of the growing season and, thus, we will understand if the plants realized their potential in future.

Biological productivity can be formed due to several elements of productivity – productive bushiness, quantity and weight of grain per spike, weight of 1000 grains [10]. All these indicators contribute to the overall productivity of crops. Knowing the contribution magnitude of the individual productivity element depending on agricultural practices, it becomes reasonable to analyze appropriateness of the studied techniques [11].

The number of shoots per plant characterizes the role of tillering in crop formation. According to this indicator, productive bushiness is determined.

It was found during research that bushiness of spring triticale increased with a high rate of nitrogen fertilizer application. In 2017 the correlation of bushiness and productivity was 0.4 - this indicates that the yield this year depended in equal proportions on productive bushiness and on the mass and amount of grain per plant. The Timiryazevskaya 42 plants were able to grow more strongly when 120 kg/ha of nitrogen were added.

In 2018 a higher productive bushiness was formed compared to 2017. In 2018, the correlation between bushiness and productivity is strong - 0.98. This suggests that under weather conditions happened in 2018, the yield strongly depended on this parameter. Most bushing plants were found in N_{60} variant.

The yield of spring triticale may also depend on the main spike grain mass. With this methodology for predicting potential yields, only main spike grain mass was taken into account, and the rest was ignored.

Studies have shown that in 2017 main spike grain mass and biological yield of Timiryazevskaya 42 plants had a high correlation dependence (r = 0.89). The maximum biological yield was formed on the N_{150} variant, while the largest grain mass from the main spike (3.8 g) was obtained on the N_{90} variant. This confirms our previous thoughts that this year biological productivity depended on several factors. It should be noted that in 2017 were obtained higher main spike grain mass values than in 2018.

In 2018 analysis showed an average correlation equal to 0.69. The maximum grain weight was 2.65 g with a biological yield of 11.4 t/ha, while the highest yield value of 12.2 t/ha in two variants (N_{150} with one-time and fractional application) corresponds to different spike weights in the flowering phase – 2.55 g and 1.99 g.

One of the most reliable elements showing the formation of spring triticale grains is the mass of 1000 grains. Under favorable conditions, cereals form full-bodied grains, which make a significant contribution to productivity. This indicator is most strongly affected by nitrogen fertilizers applied during the second half of the growing season.

In 2016 close correlation was obtained between biological productivity and a mass of 1000 grains (0.92). At the same time, fractional application of nitrogen fertilizers did not bring a noticeable effect.

Variety Timiryazevskaya 42 in 2017 showed an average correlation between productivity and a mass of 1000 grains. We can make an unambiguous conclusion that the nitrogen application during shoot extension favorably affected the mass of 1000 grains in 2017. The highest yield value of 9.6 t/ha on variant N_{150} corresponds to a mass index of 1000 grains - 47.6 g.

In 2018, the yield has an average correlation dependence on the mass of 1000 grains and it is 0.49. Decrease in the mass of 1000 grains occured in variants N_{120} and N_{150}, which are 45.9 g and 47.4 g, however, the yield does not have a corresponding decrease in the values of these options. It means that in this case the plant potential was realized due to the productive bushiness and graveness of the spike.

The decisive importance in the formation of biological productivity can acquire the number of grains in spikelets and the total graveness.

In 2016, a strong correlation was observed between biological productivity and the number of grains per spike - 0.9. Ascending and descending on all options occur in direct proportion to the amount of grain in the spike.

The maximum number of grains per spike was obtained in 2017; it averaged 46 grains per spike with the application of nitrogen fertilizers at a dose of 150 kg/ha. There was a weak correlation between biological productivity and the number of grains in a spike (r = 0.33).

In 2018, the maximum number of grains per spike was obtained in the N_{150} variant; it averaged 41 grains per spike, which corresponds to one of the highest yield values - 12.2 t/ha. This year, a strong correlation between biological productivity and the number of grains in a spike was observed (r = 0.81). Increases and decreases in yields on all options occur in direct proportion to the amount of grain in the spike. The data is reliable in all variants.

IV. Conclusion

According to the results of our research, all traits have a positive relationship with the grain yield of spring triticale. However, the highest correlation was found between biological productivity and the amount of grain per spike and productive bushiness. Potential biological productivity can be predicted, in the middle of the growing season, according to the spike realization coefficient.

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References

[1] N.I. Sokolenko, “Studying the world collection of spring triticale in the zone of unstable moisturizing in the Stavropol region”, New fodder crops in the Stavropol region, Stavropol, pp. 62-67, 1982.

[2] H.K. Abdelaal, E.S. Enzekrei, A.A. Soloviev, O.A. Schuklina et al. “Grain and green mass productivity of new spring triticale variety “Timiryazevskaya” as affected by different rates of nitrogen fertilizers in the Central Non-Chernozem region”, Feed production, № 2. pp. 18-22, 2019 .

[3] O.A. Schuklina, E.S. Enzekrei, “Prediction of potential yields of spring triticale”, Innovative activity in the modernization of the agro-industrial complex: Materials of the International scientific-practical conference of students, graduate students and young scientists. Kursk: KSAA n.a. professor I.I. Ivanov, 2016 , pp. 163-165.

[4] S.E. Skatova, A.M. Tyslenko, Spring triticale: Cultivation in the Non-Chernozem Zone of Russia. Editors: S.M. Lukin, L.I. Ilyin. FGBNU VNIIOU. Vladimir: Trinsit-X, 2017, p.3.

[5] A.M. Tyslenko et al., Innovative varieties and technologies for the cultivation of spring triticale. Ivanovo: PresSto, 2017, p. 295.

[6] O.A. Schuklina et al., “The productivity of a new variety of spring triticale (Timiryazevskaya) under the conditions of the CRNZ”, Collection of articles of the international scientific and practical conference dedicated to the 129th anniversary of the birth of academician N.I. Vavilova. Saratov: Saratov State Agrarian University named after N.I. Vavilov, 2016. pp. 156-157.

[7] V.V. Okorkov et al., Highly productive resource-saving technologies for the cultivation of spring triticale on soils of the Upper Volga. Federal Agency of Scientific Organizations; Federal State Budgetary Institution "Vladimir NIISH". Suzdal, 2015, p.3.

[8] D.N. Pryanishnikov, Selected Works: In 3 vols. T.1: Agrochemistry, 767 p., T.2: Private farming: Field crop plants. 708 p., T.3: General issues of agriculture and chemicalization, 639 p. M.: Kolos, 1965.

[9] I.G. Orlova, L.K. Petrov , The effect of mineral fertilizers on the yield of green mass of fodder triticaleю Proceedings of the Stavropol Research Institute of Agriculture, № 42, 1979.

[10] V.I. Kochurko, V.N. Savchenko, “Yield, quality and feed value of spring triticale”, Agrarian science, № 9, pp. 14-15, 2000.

[11] B. Skovmand, P.N. Fox, R.L. Villareal, "Triticale in commercial agriculture: progress and promise", Adv. Agron. vol. 37, pp. 1-45. 1984.