Efficiency of mineral fertilization of spring wheat

Vyacheslav Timofeev*, and *Olga* Vyushina

Scientific Research Institute of Agriculture for Northern Trans-Ural Region - Branch of Federal State Institutions Federal Research Centre Tyumen Scientific Centre of Siberian Branch of the Russian Academy of Sciences. 2, Burlaki street, Moskowskiy, Tyumen district, 625501, Tyumen region, Russian Federation

Abstract. The results of application of Agree`s leaf mineral fertilizer on spring wheat in the system of complex crop protection under conditions of insufficient moisture are presented. Field studies were carried out in the northern forest-steppe zone of the Tyumen region in the experimental fields of the Scientific Research Institute of Agriculture for Northern Trans-Ural Region - Branch of Federal State Institutions Federal Re-search Centre Tyumen Scientific Centre of Siberian Branch of the Russian Academy of Sciences. According to the results of the research, the positive effect of Agree`s NK liquid complex fertilizer in the complex of plant protection products application on the parameters of plant structural elements was revealed. Increase in ear length by 1.4 cm, number of spikelets by 2.5 pieces, number of grains in the ear by 6 pcs, weight of grain from 25 stems by 6-16 g, weight of 1000 grains by 4 g according to variants of agrochemicals application in tillering and earing phases: № 3 Agree`s NK, 2 l/ha + Agree`s NK, 2 l/ha; № 6 Agree`s N, 2 l/ha + Agree`s NK, 2 l/ha; № 7 Agree`s N, 3 l/ha + Agree`s NK, 2 l/ha. Application of agrochemicals in one phase of crop development, maximum rates had no positive effect on spring wheat yield. Application of agrochemical schemes Agree`s NK, 2 l/ha + Agree`s NK, 2 l/ha; Agree`s N, 2 l/ha + Agree`s NK, 2 l/ha; Agree`s N, 3 l/ha + Agree`s NK, 2 l/ha increased yield to 0.6-0.8 t/ha or 24-31%. The application of agrochemical Agree`s in the phase of the beginning of earing contributed to the improvement of technological quality of wheat grain, gluten content was higher than the control by 2-4%. Gluten quality 75-100 units, which is satisfactory. The use of agrochemicals has a clear advantage in the treatment of plants on the leaf in the system of their protection, an integrated approach to the use of agrochemicals is necessary, taking into account the treatment of at least 2 phases of plant development or one, but in the phase of unfolding of the flag leaf and the beginning of earing.

1 Introduction

Obtaining high-quality and chemically balanced agricultural products is currently the main task, the solution of which is possible only through the use of all resources to improve the

* Corresponding author: timofeev_vn2010@mail.ru

productivity and quality of crops, including through the optimization of mineral nutrition. Balanced nutrition with nitrogen, phosphorus and potassium, as well as micronutrients contributes to high yields of spring wheat [1, 2, 3, 4].

Many agricultural producers have recently widely used granular, liquid mineral fertilizers as the main application, as well as leaf fertilizers, the purpose of which is to enhance plant nutrition in certain periods of growth and development during crop cultivation [5, 6, 7]. Preparations of biological origin are used not only as fertilizers but also as plant protection products. They are non-toxic, increase soil fertility and ensure the purity of products [8, 9, 10, 11].

This article presents the results of research on the use of Agree`s liquid complex fertilizer on spring wheat in the system of plant protection application.

Agree`s N contains microelements such as sulfur, selenium, boron, magnesium, molybdenum, etc., allowing the plant to fully form the structure and quality of the crop. Agree`s absorption by plants is 100%. Agree`s contains all necessary components for successful growth, development and formation of quality crop. Agree`s NK is a liquid nitrogen-potassium fertilizer with a full complex of macronutrients and trace elements in chelate form. Participates in carbohydrate metabolism of the plant, provides better tolerance to high temperatures, low humidity and lack of precipitation by improving the work of the stomatal apparatus, increases protein content, strengthens the structure of cell walls, promotes efficient nitrogen assimilation [12].

The purpose of research is to evaluate the effectiveness of Agree's liquid complex fertilizer application in the system of spring wheat protection.

2 Materials and Methods

Field studies were carried out in the conditions of 2021, on the experimental fields of the Scientific Research Institute of Agriculture for Northern Trans-Ural Region - Branch of Federal State Institutions Federal Re-search Centre Tyumen Scientific Centre of Siberian Branch of the Russian Academy of Sciences., Tyumen region, Northern forest-steppe zone. The soil of the experimental plot is dark gray forest soil, heavy loamy, with favorable physical and chemical properties. Humus horizon has low density (1.22 g/cm^3). The humus content is 4.3%. Hydrologic acidity decreases depending on the depth of the section. Soil nitrate nitrogen content is low (1.36 - 2.38 mg/100 g soil), phosphorus is average (8.25 - 14.1 mg/100 g soil), potassium is above average (6.65 - 8.9 mg/100 g soil), and pH salinity is 5.1-6.0.

Counts and observations were carried out according to standard methodological guidelines adopted in the State Variety Network, Plant Production and Plant Protection [12]. Mathematical processing of data was carried out according to B.A. Dospekhov and using the application program package SNEDECOR V5 [14, 15].

Development and prevalence of common root rot according to the method [16] were determined twice during the growing season in the tillering phase and before harvesting. Field germination of seeds, plant survival rate and structural analysis of yield were carried out according to generally accepted methods [17, 18].

The development of aerogenic infections (brown leaf rust, septoriosis, powdery mildew) was counted from tillering phase to milk ripeness. Ten leaves of a certain tier were sampled at ten locations, then the degree of disease coverage of leaf surface was determined using universal scales expressed in percent [19].

Crop infestation was counted according to the methodology of SRIA of South-East (1969) with consideration of additions of VIZR (1985) by quantitative-weight method. Determination of grain quality indicators was carried out in the center of analytical research and technological evaluation of grain according to GOST 12042-80, GOST 10840-64, GOST 13586.1-68.

Yield was taken into account by the method of continuous threshing by a combine harvester Sampo 130, brought to standard moisture content and purity according to GOST 1386.5-93 and 30483-97. Determination of grain quality indicators was carried out in the center of analytical research and technological evaluation of grain according to GOST 12042-80, GOST 10840 - 64, GOST 13586.1-68.

The experiment was laid in a large-division format, plot area 9000 m2, accounting of the main indicators was carried out in 4 repetitions, spring wheat variety Grenada of the Northern Trans-Urals NIISKh selection was used in the experiment. The precursor is fallow. Sowing spring wheat with seeding rate of 6.5 million germinating grains per 1 ha. Scheme of the field experiment:

Background 1 tillering phase (Herbicides - Tribenuron-methyl, 0.02 kg/ha, Phenoxaprop-P-ethyl +

Flucarbazone sodium + Cloquintoset-mexyl, 0.6 l/ha, insecticide Alpha-cypermethrin, 0.15 l/ha)

Background 2 Early earing phase (fungicide Cresoxim-methyl + Epoxiconazole + Diphenoconazole, 0.6 l/ha)

Table 1. Application scheme

Option	Tillering phase	Earing phase
1	control Background 1	-
2	Background 1+ Agrochemical Agree`s NK, 2 l/ha	Background 2
3	Background 1+ Agrochemical Agree`s NK, 2 l/ha	Background 2+ Agree`s NK, 2 l/ha
4	Background 1+ Agrochemical Agree`s NK, 3 l/ha	Background 2
5	Background 1+ Agrochemical Agree`s NK, 3 l/ha	Background 2 + Agree`s NK, 2 l/ha
6	Background 1+ Agrochemical Agree`s N, 2 l/ha	Background 2 + Agree`s NK, 2 l/ha
7	Background 1+ Agrochemical Agree`s N, 3 l/ha	Background 2 + Agree`s NK, 2 l/ha

According to the indicator of preciitation availability agricultural year 2021 can be characterized as insufficiently provided with precipitation 39.6% of the norm, GTC = 0.34, well provided with heat with exceeding the mean annual temperatures by 20% and an increase in the sum of effective temperatures >50C by 130% of the norm.

3 Results and Discussion

In the experiment during the growing season, dry hot weather, lack of moisture had a negative impact on plant growth, which provoked uneven sprouting, and later the rapid emergence of a significant number of perennial weeds overtaking spring wheat plants in growth, so in the experimental plots clumps up to 20 pcs/m^{2}- Cirsium arvensse, 0.4-2 pcs/m^2. – Taraxacum officinale, Sonchus arvensis, Eguisetum arvense, Elytrigia repens, from annuals primary weak sprouts of 0.1 pcs/m^2 were observed – Echinochloa crusgalli, Viola auvensis, Capsella bursa-pastoris, Bromopsis inermis field bromegrass. Herbicide application reduced the number of annual dicotyledonous and cereal weeds by 100% with initially insignificant numbers. Against perennial weeds the efficiency was 77-91.6%, with high efficiency of preparations containing 2.4-D ester and florasulam. The efficiency of herbicides against the whole complex of weeds was 95-98%. The damage of plants by leaf-stalk diseases was insignificant, so helminthosporiosis spotting (15%), septoriosis spotting (8%) on the

background of no fungicides application.

Root rot damage is promoted by the presence of infection on seeds and in the soil, and the intensity of root system damage can vary under the influence of weather conditions (precipitation, temperature), agronomic measures of soil preparation.

In sowing, the lesion of root rot in the control variant amounted to 2.4% with a spread of up to 10% at the beginning of vegetation and an increase in these indicators by the end of vegetation up to 5.3% - 15%. The applied scheme of seed and plant protection in the initial period of vegetation limited the disease development by 100% in the tillering phase and by 78-81% at the end of vegetation.

According to the results of research, the use of Agree`s liquid complex fertilizer in different phases of crop development had a positive effect on the structure of wheat plants and its yield. When analyzing the yield structure of spring soft wheat varieties, a strong positive relationship between the weight of grains in the ear and grain yield was established, a medium positive relationship was found between the weight of 1000 grains, the number of grains in the ear and grain yield. Weak positive relationship of grain yield was observed with the number of spikelets in the ear and ear length.

Stem length varied by variants of the experiment within 75-80 cm, the distinctive stem length was marked by variants of Agree`s NK, Agree`s N application in the phases of tillering and the beginning of earing. Spikelet length was 7.2-8.6 cm and was not affected by plant protection products, number of spikelets varied from 12.3-14.8 cm, number of grains in the spikelet 28-34 pcs, weight of grain from 25 stems 24-36 g, weight of 1000 grains 39-43 g, biological yield 4.9-6.5 t/ha. Increase in the majority of parameters of development of structural elements of the ear were allocated variants: № 3 Agree`s NK, 2 l/ha + Agree`s NK, 2 l/ha; № 6 Agree`s N, 2 l/ha + Agree`s NK, 2 l/ha; № 7 Agree`s N, 3 l/ha + Agree`s NK, 2 l/ha (Table 2).

Table 2. Structural analysis of spring wheat plants

Option	Spikelet length, cm	Number of spikelets in an ear, pcs	Number of grains per ear, pcs	Weight of grain with 25 stems, g	Weight of 1000 grains, g	Spikelet density, units	Grain size of the ear, units	Grain weight per ear, g	Weight of grain per sheaf, g	Biological yield, t/ha
1. control	7.50	13.04	28.36	27.67	40.00	17.39	2.17	1.13	199.26	5.67
2 background 1 + Agree`s NK, 2 l/ha +background 2	7.90	13.44	29.24	27.82	39.30	17.01	2.18	1.15	272.94	5.75
3. background 1 + Agree`s NK, 2 l/ha + background 2+ Agree`s NK, 2 l/ha	**8.04**	**13.64**	**31.04**	**33.28**	**43.88**	16.97	**2.28**	**1.36**	358.11	**6.81**
4. background 1 + Agree`s NK, 3 l/ha +background 2	7.22	12.34	25.36	24.33	39.05	17.10	2.06	0.98	281.58	4.95
5 background 1 + Agree`s NK, 3 l/ha +background 2+ Agree`s NK, 2 l/ha	7.71	13.08	28.10	**32.79**	**42.40**	16.97	2.15	1.01	303.60	5.96
6. background 1 + Agree`s NK, 2 l/ha + background 2 + Agree`s NK, 2 l/ha	**8.18**	**13.88**	**30.86**	**32.79**	**42.40**	16.97	**2.22**	**1.31**	323.18	**6.54**

7. background 1 + Agree`s NK, 3 l/ha + background 2 + Agree`s NK, 2 l/ha	**7.98**	**13.64**	30.24	**30.57**	41.72	17.09	**2.22**	**1.26**	391.50	**6.31**

Spring wheat yield was 2.6-3.4 t/ha depending on the background of application of protection agents and agrochemicals. In the control variant the yield amounted to 2.6 t/ha, application of variants #3 Agree`s NK, 2 l/ha + Agree`s NK, 2 l/ha - 0.69 t/ha or 26.6%; No. 6 Agree`s N, 2 l/ha + Agree`s NK, 2 l/ha - 0.64 t/ha or 24.7%; No. 7 Agree`s N, 3 l/ha + Agree`s NK, 2 l/ha - 0.82 t/ha or 31.6% showed a yield increase of 0.6-0.8 t/ha. The most interesting combination was obtained when applying Agree`s N 3 l/ha in the tillering phase and Agree`s NK, 2 l/ha in the phase of the beginning of earing, where a higher gain was observed, which is confirmed by both structural analysis, of plants and bunker yield. Application of Agree`s NK 3 l/ha in tillering phase in the conditions of the year was unacceptable because the plants were in constant stress and could not fully use high rates of fertilizer in the early phases of crop development. The use of agrochemicals had a weak effect in the conditions of the year when used only in one phase of crop development, a greater effect was achieved when used in two phases of crop development and with increasing rates of application of agrochemicals. The main influence on yield gain in the experiment relative to standard protection is the use of fungicides, which provided 0.3-0.4 t/ha, agrochemicals 0.15-0.35 t/ha (Table 3).

Table 3. Crop yield, t/ha

Option	Yield		
	t/ha	± to control	
1. (control)	2.59	-	-
2. background 1 + Agree`s NK, 2 l/ha +background 2	2.72	0.13	5.0
3. background 1 + Agree`s NK, 2 l/ha + background 2+ Agree`s NK, 2 l/ha	3.28	**0.69**	**26.6**
4 background 1 + Agree`s NK, 3 l/ha +background 2	2.81	0.22	8.4
5. background 1 + Agree`s NK, 3 l/ha +background 2+ Agree`s NK, 2 l/ha	2.90	0.31	11/9
6. background 1 + Agree`s NK, 2 l/ha + background 2 + Agree`s NK, 2 l/ha	3.23	**0.64**	**24.7**
7. background 1+ Agree`s NK, 3 l/ha + background 2 + Agree`s NK, 2 l/ha	3.41	**0.82**	**31.6**

One of the main indicators of wheat grain quality, which is closely related not only to the nutritional value of bread, but also to technological and flour-breading qualities, is the protein content in the grain. The protein content varied 11-13.9% and did not depend on the applied protection systems and additional mineral nutrition. Grain natura is high 760-780 g/l, gluten content is very high, which was promoted by conditions of dry hot weather with no significant disease damage. The amount of gluten varied 27.6-32.5% and the gap between the variants is insignificant depending on the conditions of vegetation and ripening and to a lesser extent on the use of plant protection products and agrochemicals. Application of Agree`s liquid complex fertilizer in the complex of plant protection products contributed to the highest gluten content in the phase of earing initiation, where the increase was 2-4% relative to the control. Gluten quality was 75-100 units, which is satisfactory (Table 4).

Table 4. Technological quality of grain

№	Option	Protein, %	Nature, g/l	Gluten, %	gluten deformation index
1	control	12.82	759	30.20	90
2	background 1 + Agree`s NK, 2 l/ha +background 2	12.12	774	28.69	95
3	background 1 + Agree`s NK, 2 l/ha + background 2+ Agree`s NK, 2 l/ha	11.68	768	31.12	100
4	4 background 1 + Agree`s NK, 3 l/ha +background 2	12.82	770	28.92	90
5	5. background 1 + Agree`s NK, 3 l/ha +background 2+ Agree`s NK, 2 l/ha	13.96	781	32.52	90
6	background 1 + Agree`s N, 2 l/ha + background 2 + Agree`s NK, 2 l/ha	13.11	774	32.60	90
7	background 1 + Agree`s N, 3 l/ha + background 2 + Agree`s NK, 2 l/ha	12.57	776	31.20	90

4 Conclusion

In conditions with insufficient moisture of the vegetation period the positive effect of liquid complex fertilizer - Agree`s N, NK leaf fertilizer in the system of crop protection on the parameters of structural elements of the plant was determined. Application of agrochemical schemes Agree`s NK, 2 l/ha + Agree`s NK, 2 l/ha; Agree`s N, 2 l/ha + Agree`s NK, 2 l/ha; Agree`s N, 3 l/ha + Agree`s NK, 2 l/ha increased yield to 0.6-0.8 t/ha or 24-31 %. Application of agrochemical Agree`s in the phase of the beginning of earing contributed to the improvement of technological quality of wheat grain, gluten content was higher than the control by 2-4%. Gluten quality was 75-100 units, which is satisfactory.

Acknowledgements

The work was carried out by the Research Institute of Agriculture of the Northern Trans-Urals Region - Branch of Federal State Institutions Federal Research Centre Tyumen Scientific Centre of Siberian Branch of the Russian Academy of Sciences (FWRZ-2021-0015).

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