INFLUENCE OF INCREASING DOSES OF NITROGEN FERTILIZERS ON THE YIELD AND QUALITY OF WINTER WHEAT GRAIN IN THE SOUTHEAST KAZAKHSTAN

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ABSTRACT

Winter wheat grain is most important food and a source of vegetable protein. To achieve high yields of high-quality grain of winter wheat, balanced nutrition of plants with nitrogen and phosphorus is necessary during the growing season. The results of the research showed that application of a wide variation of nitrogen fertilizers (from 30 to 90, 120 kg/ha) on soils with different levels of supply with mobile phosphorus promotes an increase in productive tillering of wheat plants for 0.4-0.8 pcs. The grain mass in the ear on the secured phosphoric background increased by 17.7-31.9 %. It has also been established that in Light Chestnut soil, the effectiveness of nitrogen fertilizers is manifested depending on the availability of soil with mobile phosphorus, while the yield of grain is increased in the treatments with optimal doses (N_{60} and N_{90}) to 4.33 and 3.92 t/ha.

Keywords: winter wheat, fertilizer, productivity, mobile phosphorus, exchangeable potassium, organogenesis

INTRODUCTION

The development of agricultural production in the republic for the near future is associated with the innovative renewal of the industry and the further development of agrarian sciences with focus on the increase in the production of wheat grain, which is the leading grain crop of Kazakhstan.

Wheat is the most important food product and a source of vegetable protein, where it has a significant role in the feed balance of the Republic. Kazakhstan annually produces 13-20 million tons of grain. Although spring wheat accounts for the bulk of the total grain production, an important role is played by the production of winter wheat in the south and south-east of the republic. Among the grain crops in these regions, winter wheat has become

most widespread. The natural and climatic potential of the south and south-east suits to the biological possibilities of the culture, which puts it in the category of valuable and most promising crops for the region.

In the agricultural production of the Republic, more than 70% of farmers use extensive technologies, almost with no use of scientific achievements, advanced domestic and foreign experience, mineral fertilizers and plant protection measures (Kaliev, 2013). Over time, with such a system of production, especially in irrigated lands, soil is depleted, yields are reduced and product quality deteriorates. In this connection, in irrigated lands of the southeast, fertilizers are one of the main factors of soil and plant fertility conservation, as evidenced by the results of the actual agrochemical state of the region's soils. To achieve high yields of high-quality grain of winter wheat, balanced nutrition of plants with nitrogen and phosphorus is necessary during the growing season.

Rational use of nitrogen fertilizers, the choice of optimal doses, timing and methods of their application as well as the optimal ratio with other elements allow to have a guaranteed increase in high-quality products. The improvement of nitrogen nutrition in the main stages of the development of culture contributes to the mobilization of the physiological resources of the plant and increases the yield increases, increasing the yield of protein in average for 20-50% (Abugalieva et al., 2001; Sarycheva, 2002).

The paper presents the results of nitrogen nutrition of winter wheat in a long-term experiment at different phosphorus supply irrigated soils. The experiment was conducted in 2015 and studied increasing doses of nitrogen fertilization (N30, N69, N90, N90+30) which was applied at different stages of plant ontogenesis. The authors studied the accumulation of biomass elements of winter wheat depending on the applied doses of nitrogen fertilizer.

The novelty of the research is the study of the yield and quality of winter wheat grains with a wide variation in the doses of nitrogen fertilizers (from 30 to 120 kg/ha) adapted for the technologies of different levels of intensification. The application of fertilizers is conducted based on systematic observations of the growth and development of plants and the records of the crucial stages of organogenesis.

MATERIALS AND METHODS

The experiment was set up in the long-term experimental station of the Department of Mineral Nutrition and Agroecology of the Kazakh Research Institute of Agriculture and Plant Growing, near Almaty. The soil of the experimental plots is Light Kastanozem (World

reference base for soil resources 2006) with a low content of humus and a different content of mobile phosphorus and a medium content of exchangeable potassium.

The object of the study was a winter wheat variety “Almaly”. The placement of the treatments was a randomized, with four repetitions for each treatment, on the experimental area of 120 m^2. Individual plot area was 27.2 m^2. Nitrogen fertilizer was applied in the form of ammonium nitrate, the effect of which was studied on a high background of mobile phosphorus (46-47 mg / kg) created with prolonged application of phosphate-potassium fertilizers in a long-term experiment on soils with an average P_2O_5 content (19-20 mg/kg soil).

The scheme for application of nitrogen fertilizers is presented in Table 1. Nitrogen fertilizer according to the scheme of experiment was applieed at the III-stage of organogenesis in the critical period of development of winter wheat, which largely determines the yield of grain. To improve the grain quality, in one of the treatments, an additional 30 kg/ha of nitrogen fertilizer was added during the formation of the ear (V-stage of organogenesis).

In the field experiments, the phenological and biometric observations and an assessment of the growth and development of the plants for the main phases of the winter wheat growth was performed. The height of the plants and the dynamics of biomass accumulation were determined by selecting 20 plants, measuring the height, followed by weighing, air drying, and determining the biological mass of plants.

The crop structure was estimated accounting the total number of plants from trial sheaves, plant height, number of ears, number of seeds in them and their mass. Harvesting was carried out using a SAMPO combine harvester.

RESULTS AND DISCUSSIONS

The positive effect of increasing doses of nitrogen fertilizers on winter wheat plants was observed already at the early stages of its development. On soils that were characterized by a higher phosphorus content, winter wheat responded better to the application of nitrogen fertilizers. The dry biomass of 10 plants in N_{30} treatment amounted to 0.51 g, in N_{60} - 0.58 g, in N_{90} - 0.64 g and in N_{90+30} - 0.66 g, which was higher for 0.17, 0.24, 0.30 and 0.32 g, comparing to the control (background) respectively (Table 1).

Table 1. Influence of increasing doses of nitrogen fertilizers on the accumulation of biomass and elements of productivity of winter wheat.

Treatments	Tillering			Booting		Yield		
	Tillers, pcs	Leaves, pcs	Dry weight of 10 plants, g	Tillers, pcs	Dry weight, g	Productive tillers, pcs	Grain weight from an ear	Weight of 1000 grains, g
Higher content of available phosphorus (46-47 mg/kg)								
Control (PK)	1,3	3,8	0,34	2,7	8,4	3,8	1,41	39,0
N_{30}	1,4	4,4	0,51	2,9	12,9	4,0	1,66	39,0
N_{60}	1,4	4,2	0,58	2,8	15,4	4,0	1,75	38,5
N_{90}	1,4	4,8	0,64	3,4	15,7	4,4	1,83	40,0
N_{90+30}	1,4	4,4	0,66	3,3	15,3	4,2	1,86	41,7
Lower content of available phosphorus (19-20 mg/kg)								
Control (no fertilizer)	1,1	2.5	0,25	2,0	4,3	2,1	1,04	38,0
N_{30}	1,1	4,0	0,29	2,1	10,8	3,0	1,13	38,9
N_{60}	1,2	4,0	0,35	2,1	11,0	3,2	1,29	38,9
N_{90}	1,4	4,0	0,38	2,7	12,2	3,5	1,37	38,0
N_{90+30}	1,4	4,0	0,38	2,8	13,0	3,5	1,46	37,9

The application of nitrogen fertilizer on soils with a low phosphorus content in the doses N_{30}, N_{90}, N_{90+30}, also contributed to an increase in the dry biomass of winter wheat. The dry biomass of winter wheat in this experiment ranged from 0.29-0.38 g per 10 plants, on the control (without fertilizer) it was 0.25g, which is 16-52 % lower than on nitrogen fertilized treatments.

Observations of changes in the accumulation of biomass during the vegetation showed that the effectiveness of nitrogen fertilizers, depending on the availability of mobile phosphorus in soil, was more pronounced. So, depending on the doses of nitrogen fertilizers, the dry weight of 10 plants in the V-stage of organogenesis was 12.9-15.3 g, while in the control treatment it was 8.4 g. This trend was also observed in the treatments with a low content of mobile phosphorus, where the biomass of winter wheat in the treatments N_{30}, N_{60}, N_{90}, N_{90+30} was, respectively 10.8, 11.0, 12.2, and 13.0 grams per 10 plants. The lowest biomass of winter wheat was observed on the treatment without fertilizer - 4.3 g, against 8.4 g, which is 1.95 times less than in the RK treatment, which ultimately was reflected on the productivity of winter wheat.

The yield of grain depends on the number of plants per unit area and the productivity of a single plant. Productivity consists of separate elements: the number of productive stems, the mass of grains from one ear, the mass of a thousand grains. The use of nitrogen fertilizers on soils with different levels of mobile phosphorus had a significant effect on the elemental change of the yield structure. Thus, the application of increasing doses of nitrogen fertilizers on a low phosphorous background increased the number of productive stems of wheat to 3.0-3.5 pieces per one plant, which is 1.4-1.66 times higher, respectively, than on the treatment without fertilizer.

The highest density of productive stems (4.4 pcs.) was noted in the treatments where nitrogen fertilizers were applied in the dose of 90 kg at one step. Against a background with a high content of mobile P_2O_5, the increase in stem stature with respect to the background without fertilizer was 0.6 units.

An important indicator of yield is the mass of grain in the ear. On the control treatments, this indicator was 1.04-1.41g. Application of nitrogen fertilizers on an increased background of phosphorus, develops the mass of grain in the ear that varied from 1.66 to 1.86 g, which is 17.7-31.9 % higher, than on the background. With a low P_2O_5 content in the soil, an increase in the mass of grains from one ear was 1.13-1.46 g, that is higher than in the control for 8.7-40.3 %.

Our annual studies have established that, depending on the doses of nitrogen fertilizers, the yield of winter wheat had increased from 3.03 to 4.70 t/ha. (Table 2). In the treatments with a high background of phosphorus, the yield of winter wheat was from 3.80 to 4.70 t/ha, while at low phosphorus content in the soil the effect of nitrogen fertilizers persisted, but the yield of winter wheat was somewhat lower.

Table 2. Influence of increasing doses of nitrogen fertilizers on productivity of winter wheat

Treatments	Yield, t/ha	Increment, t/ha	Increment %	Row protein content, %	Yield of row protein, t/ha	Gluten, g
Higher content of available phosphorus in soil (46-47 mg/kg)						
PK background	3.54	-	-	11.1	0.39	31,4
N_{30}	3.83	0.29	7.6	11.1	0.43	32,4
N_{60}	4.33	0.79	18.2	13.5	0.58	34,0
N_{90}	4.67	0.13	24.2	13.5	0.63	34,2
N_{90+30}	4.70	1.16	24.7	14.5	0.69	36,6
Lower content of available phosphorus in soil (19-20 mg/kg)						
Control (n/f)	2.61	-	-	10.8	0.28	32,6
N_{30}	3.03	4,2	13.9	11.1	0.34	35,8
N_{60}	3.50	8,9	25.4	13.6	0.48	37,4
N_{90}	3.92	13,1	33.4	13.4	0.53	38,4
N_{90+30}	4.03	14,2	35.2	13.9	0.56	36,6

Content of the row protein content in both the high and low phosphorus backgrounds the treatment of applying nitrogen fertilizers at a dose of 120 kg/ha, where 90 kg/ha of nitrogen was applied during the critical period of crop formation (organogenesis stage III) and 30 kg/ha at the V-stage of organogenesis was the highest. The protein content in this treatment was 13.9-14.5% versus 10.8-11.1% in the control.

CONCLUSION

Thus, the annual data of the experiments show that the application of nitrogen fertilizers in a wide ranges of doses (from 30 to 90, 120 kg/ha) on the soils with different levels of supply with mobile phosphorus promotes an increase in productive tillering of the wheat plants by 0.4-0.8 units. The weight of grain in the ear on a high phosphorus background increased by 17.7 - 31.9 %.

Under the conditions of Light Chestnut soil the effectiveness of nitrogen fertilizers manifested as a function of the availability of soil with mobile phosphorus. An increased grain yield was observed in the treatments N_{60} and N_{90} up to 4.33 and 3.92 t/ha, respectively.

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