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Dynamics of Soil Moisture Application of Mineral Fertilizers in Rainy Areas, Cereal Crops Grain Quality and Impact on Productivity

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Abstract: The article presents experimental results on the application of mineral fertilizers in the growth phases of soft wheat, Bakhmal-97 variety, durum wheat variety, Yaqut-2014 variety, barley variety, Mushtarak variety, depending on the type and rate of fertilizers, on the dynamics of soil moisture and the rate of crop feeding, grain quality and yield. According to the results, the optimal feeding rate for the application of mineral fertilizers in arable fields depends on the dynamics of soil moisture and for obtaining high-quality yields of soft wheat "Bakhmal-97" variety is N40P40K40 kg per hectare, durum wheat "Yakut-2014" and barley "Mushtarak" varieties The results of the study are presented on the optimal feeding rate of N50P40K40 kg per hectare for obtaining high-quality grain and high yields using mineral fertilizers at different growth phases.

Keywords: Dry lands, mineral fertilizers, fertilizer rate, soil moisture dynamics, soft wheat, hard wheat, barley, grain quality, grain yield, feeding rate.

Introduction: Nowadays, the global warming of the climate has a negative impact on grain quality and productivity, soil fertility and structure, and soil degradation. Improving the food security of the population living in these areas by eliminating these problems in dry areas is considered one of the important and urgent tasks.

Agricultural products grown in Lalmicor regions have a number of advantages in the production of aromatic products rich in protein, amino acids, vitamins, and minerals vital for the human body. At present, corn, leguminous, sugarcane and oil crops are cultivated in dry areas the need for its products is increasing year by year not only in the domestic market, but also in the world market.

Effective use of mineral fertilizers in arid areas allows to grow a stable high-quality crop of grain, legumes, oilseeds and other agricultural crops, and to improve soil fertility and its structure.

According to the results of experiments, in all arable lands of Uzbekistan, the reduction in the amount of organic and mineral nutrients in the soil due to global climate change and anthropogenic factors over the past decades has led to a deep degradation of the soil

structure. The effectiveness of mineral fertilizers in these areas varies depending on the amount of atmospheric precipitation, the depth of soil wetting, the type of predecessors, agrotechnics, and many other factors.

According to experiments conducted in the mountainous and hilly regions of Lalmikor with semi-sufficient rainfall (280-360 mm), the amount of organic matter (humus) in the soil decreases from 1.2-1.3% to 0.58-0.65% (0-20 cm) in the variants where the soil is cultivated with plows to a depth of 20-22 cm and organic and mineral fertilizers are not applied [1,2,3,4,6].

Over the past several decades, the replacement of scientifically based farming systems with grain crops, the reduction of annual and perennial leguminous crops, forage crops, and other crops, and the insufficient use of local and mineral fertilizers and plant protection products have led to a decline in productivity and its quality. This, in turn, creates favorable conditions for a decrease in soil fertility and deterioration of its structure, as well as increased wind and water erosion. Lalmikor's studies have shown that in semi-arid areas of the land, the amount of humus in the soil decreases by 1.2 tons per hectare as a result of 2-3 clean plowings per year [1].

In semi-rainfed arable lands, the fertilizer rate is 40 kg/ha of nitrogen, phosphorus, in mountainous and hilly areas, the rate of these fertilizers is 50 kg/ha, and in years of abundant rainfall (400-600 mm) up to 60 kg/ha (in terms of net active substance) allows increasing the yield by an average of 4-5 quintals [2].

METHODS

The field experiment was conducted in the conditions of loamy soils at the Central Experimental Farm of the Lalmikor Agricultural Research Institute. The experimental materials were soft wheat "Bakhmal-97" variety, durum wheat "Yakut-2014" variety, and barley "Mushtarak" variety. The research was conducted in 9 variants and 3 replicates.

The experimental field is located in a semi-arid, lowland, hilly region of arable land at an altitude of 580 m above sea level, and the soil consists of typical arable gray soils. The soils of the experimental field are moderately sandy, moderately susceptible to water and wind erosion, and their topsoil (0-20 cm) contains 0.55-0.88% humus, 0.18-0.20% total nitrogen, 0.16-0.18% phosphorus, and 1.6-1.8% total potassium, with a soil pH of 7.0. The mineralization of groundwater is 4-8 g/l, and groundwater is located below 10 m and has almost no effect on soil formation processes [3,4].

The following observations and measurements were carried out during the years of research: Phenological observations, biometric measurements according to the “Methodology of State Variety Testing of Agricultural Crops” (1985), the number of tubers per 1 sq. m of the plant using 0.25 m2 pads, soil moisture by the thermostat method, according to the humus-Tyurin method, otal nitrogen was determined by the Kjeldahl method, total phosphorus by the Lorentz method, total potassium by a flame photometer, nitrate nitrogen (N-No. 3) by disulfenol reagent, mobile phosphorus and exchangeable potassium by Machigin in a 1% ammonium carbonate solution.

Agrophysical properties and characteristics of the soil: volume weight N.A. Kachinsky method, using a cylinder, specific gravity using the pycnometer method, mechanical composition of the soil N.A. Kachinsky's method, using a pipette, its aggregate composition was studied by Savvinov's method.

RESULTS

One of the main factors limiting the productivity of cereals and other crops and soil fertility in arable fields is the lack of moisture in the soil as a result of the relatively low amount of atmospheric precipitation and its uneven distribution throughout the year. In these areas, the lack of moisture in the soil during the growth and development phases of winter cereals and other crops causes a decrease in physiological and biochemical processes in plants, and in some drought years, their complete cessation.

The arable lands of our republic have unique soil and climatic conditions, which are not found in the arid regions of the world, even in the republics of Central Asia. The climate is sharply variable, with cold winters and hot summers. The amount of precipitation is relatively small (250-400 mm) and is unevenly distributed throughout the year. Its main part (80%) falls on the winter and spring months, and the rest falls on the autumn and summer months [7].

During the years of the experiments, weather conditions during the growing season of cereal crops changed as follows (Table 1).

Table 1

Changes in weather conditions during the growing season of cereal crops in the experimental years, data from the Gallaorol AGMS (2022-2024)

Indicators	Months									Total or average
	X	XI	XII	I	II	III	IV	V	VI	
Precipitation, mm										
Perennial	17,1	35,0	55,0	40,4	52,0	65,0	53,6	35,4	8,4	361,9
2021-2022 yy	-	18,4	13,8	53,4	13,0	173,6	39,3	78,0	5,8	395,3
2022-2023 yy	76,5	53,7	25,3	19,1	106,2	29,3	30,5	23,1	0	363,7
2023-2024 yy	-	45,2	17,0	30,6	34,5	87,2	32,0	67,5	8,	322,1
Air temperature, °C										
Perennial	12,1	5,9	0,3	-4,0	0,4	5,6	12,7	18,4	24,6	8,4
2021-2022 yy	10,0	4,3	3,8	3,4	4,7	4,9	18,2	20,0	25,4	10,5
2022-2023 yy	12,5	7,5	1,4	-7,4	4,7	12,2	14,7	19,9	26,5	10,2
2023-2024 yy.	9,8	3,7	3,0	3,6	1,8	7,6	15,4	19,2	20,6	9,4
Relative air humidity, %										
Perennial	62	73	82	85	82	75	69	59	45	70
2021-2022 yy	52	66	75	86	73	76	63	62	43	64
2022-2023 yy	58	83	87	79	82	69	62	48	32	67
2023-2024 yy	56	82	88	80	81	71	64	49	34	67

In dryland areas, especially in its lower regions, drought is the main natural factor limiting the productivity of all dryland crops. According to the data of the Galla-Arol agrometeorological station, the average monthly temperature in the experimental area is 11.60 ° C, the minimum temperature in January is -25 ° C, and the maximum temperature in June is 45 ° C. The long-term average precipitation is 361 mm. These indicators are 10.10 ° C, -300 ° C, 390 ° C, and 425 mm, respectively, in the mountainous region located at an altitude of 1307 m above sea level [1].

In the 2021-2022 agricultural year, during which the experiments were conducted, the amount of precipitation exceeded the multi-year norm (362mm) by 33.4 mm. However, due to the complete absence of precipitation in October 2021 and the drying of the topsoil, soil cultivation and planting had to be carried out later (10.11.2021). Wheat seeds planted in November and even in winter due to less than normal rain and snow, germinated only in February and March with a strong thinning.

The amount of precipitation in the spring months of 2022 exceeded the long-term norm by 33.4 mm. In the 2022/2023 agricultural year of the study, precipitation was around the multi-year norm (364 mm). October and November, which were much longer than the annual norm, ensured that winter wheat fully germinated until the planting of late October and a steady decrease in air temperature to +5C. However, the relatively low rainfall during the winter wheat earing and grain storage period (May-June) caused soil moisture deficits, which in turn led to a decrease in photosynthesis and crop yield.

The amount of precipitation in the 2023/2024 agricultural year of the experiment (322.1 mm) was 39.9 mm below the multi-year norm and 42.0 mm below the previous year. Due to the very low rainfall in October 2023, plowing and sowing of winter wheat seeds were carried out in the second 10 days of November (14.11.23). Compared to last year, spring months (March-May) were cooler than last year, allowing favorable soil moisture and feeding regime to occur.

In the experimental years, the average monthly air temperature was +1-2.1 °C higher than the multi-year norm (8.4 °C warmer), and 0.3-0.8 °C lower than the previous 2022/23 agricultural year. Relative air humidity was 6% lower than the multi-year norm (70%)

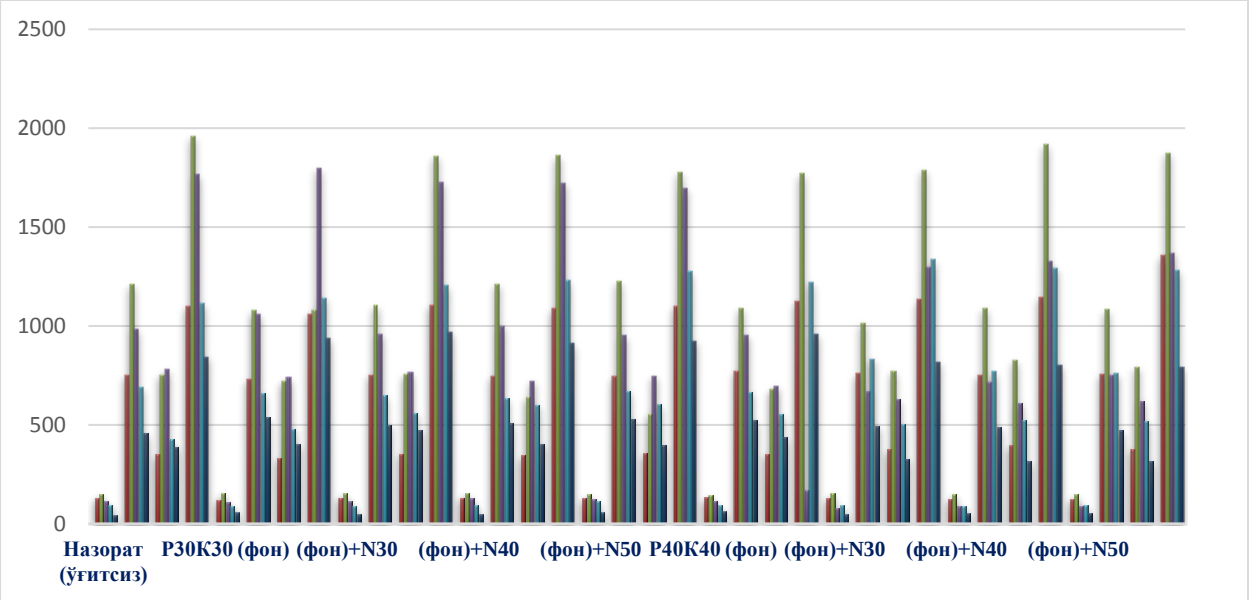
in the 2021/22 agricultural year, and 3% lower in 2022/23 and 2023/24. In the second half of the winter wheat growing season in the arable fields, the precipitation deficit in most years reaches 290 mm, and the moisture coefficient is 0.25-0.30. By this time, the lack of moisture in the soil significantly reduces the productivity of photosynthesis [8].

The effect of mineral fertilizers on the dynamics of total and physiological moisture in the soil was studied in the 0-100 cm layer of soil during the pre-sowing (October), tillering (March, tillering (April), heading (May), milk-wax and full ripening stages of winter wheat in 2022-2024 (Figure 1).

Figure 1

Dynamics of total soil moisture depending on the rate of mineral fertilizers

Average for 2022-2024



It is known that soil moisture and air temperature are important during the flowering stage of winter wheat in dry areas. Winter wheat planted at the end of October and the first ten days of November due to rainfall in the autumn and winter months of 2022 being below the multi-year average "Bakhmal-97" and "Mushtarak" varieties of barley germinated in the second ten days of February, and "Yakut-2014" variety of durum wheat germinated in the third ten days of February.

According to the results of the study, the highest moisture reserve in the 1 m layer of soil (2431 m3/ha) was reached by the stage of winter wheat accumulation.

The fact that the amount of moisture in the 0-100 cm layer of the soil by the tuber stage of winter wheat is 1648-1798 cubic meters per hectare depending on the rate of mineral fertilizers in the options planted in 3 years, As a result of the uneven distribution of precipitation, the weather conditions in the autumn and winter months were drier than the long-term norm, by early spring, when the grain grasses began to germinate, the depth of soil moisture was only 40-50 cm. In such conditions, the moisture in the 0-100 cm layer of the soil (1834 m3/ha) was a cubic meter.

The headage period of winter cereal crops in arable fields is the most critical period, as it is at this time that the reproductive organs (ears) of the wheat begin to form. At this stage, as a result of the decrease in precipitation, a sharp increase in air temperature (35-38 °C), and a decrease in relative air humidity by 40-50%, soil and air drought begins. Under these conditions, the photosynthetic productivity of grain crops decreases.

In the experiments conducted, the average moisture content in the 1 m layer of soil at the earing stage of winter wheat was 110-1230 m3/ha, depending on the rate of mineral fertilizers in the experimentally planted variants. By the peak stage of crops in the 2023-2024 agricultural year, the moisture reserve in the 0-100 cm layer of the soil is 950-1080, respectively, in the above options; It was 910-1082 and 1400-1507 m3/ha.

According to the results of the experiment, the amount of moisture in the 0-100 cm layer of the soil in the phase of milk-wax ripening, i.e. grain collection, was 1096-1138 m3/ha according to the options. It was determined that the moisture reserve in the 1 m layer of the soil during the milk-wax ripening stage of winter

wheat was 843-1120 m3/ha, depending on the rate of fertilizers.

In the semi-rainfed plain-hilly region, the bulk density or density of the soil was found to be 1.17-1.25 g/cm3 in the 80-100 cm layer of soil in the autumn (before sowing) plowed to a depth of 20-22 cm, reaching 1.23-1.42 g/cm3 at the full ripening stage and increasing by 0.12-0.17 g/cm3.

According to the results of the research, the rates of absorption of nutrients in different growth phases of soft wheat "Bakhmal-97", hard wheat "Yakut-2014" and barley "Mushtarak" are different. It was found that soft wheat variety "Bakhmal-97" has a high demand for nutrients. During the research, the following parameters were analyzed: ear length, number of grains per ear, grain weight per ear, 1000-grain weight, yield, gluten content in the grain, and IDC.

According to the results of the study, the plant height was from 99.0 cm to 114.8 cm, the spike length was from 9.5 cm to 9.9 cm, the number of spikelets was from 15.5 to 16.5, the number of grains was from 30 to 38, and the grain weight was from 1.30 g to 1.58 g. The 1000-grain weight was from 39.6 g to 41.5 g, and the yield was 13.2-16.7 c/ha. In the control (without fertilizer) variant, the 1000-grain weight was 39.6 g, and the yield was 13.2 c/ha. The highest indicator in the experiment was achieved by variant 8 N40R40K40, with a 1000-grain weight of 41.5 g and a yield of 16.7 c/ha.

One of the main indicators indicating the breadiness of wheat grain is the amount of gluten in the grain and the index of IDK, the amount of gluten in the grain belonging to the highest class is 36%, 1-32%; 2- 28%; 3-23% and 4- higher than 18% and the IDK indicator should be from 45 to 75 for the higher class, in wheat grains of the 1st grade, the dough is considered to be satisfactorily soft when the index is from 76 to 110, and satisfactorily hard when this index is from 15 to 45. Experiments have shown that the bakeability of such grains is unsatisfactory when the index is below 15 and above 110.

In the variants we analyzed, the gluten content and the IDC indicator in the control (without fertilizer) variant (28.0%, IDC 87.4) were the highest, while variant 9 was the lowest (30.7%, IDC 72.9).

In the conducted experiments, the nutrient absorption ratios of the durum wheat variety "Yakut-2014" differed at different growth phases (Table 2).

According to the results of the study, the plant height in our no-fertilizer variant was 95,8 cm, in $P_{30}K_{30}$ (background) 97,1 cm and (background) +N_{50} 102,4 cm, and in $P_{40}K_{40}$ (background) 101,2 cm, in our $P_{40}K_{40}$+N_{50} variant the highest indicator was 103,0 cm, and the spike length in our no-fertilizer variant was 7,1 cm, $P_{30}K_{30}$

Table 2

The effect of mineral fertilizer rates on yield and grain quality indicators of soft wheat variety "Bakhmal-97" (Gallaorol-2022-2024).

№	Options	Plant height, cm	Key spike indicators				1000 grains weight, g	Productivity, ts/ha	Gluten amount (%)	IDK
			Length cm	number of spikes, pcs	number of grains, grains	grain weight, g				
1	Control (no fertilizer)	99,0	9,5	15,5	40	1,30	39,6	13,2	28,0	87,4
2	$P_{30}K_{30}$	99,5	9,5	15,5	41	1,31	39,6	13,7	28,6	83,3
3	$P_{30}K_{30}$+N_{30}	103,6	9,6	15,7	41	1,31	40,3	14,2	29,4	72,7
4	$P_{30}K_{30}$+N_{40}	105,2	9,7	16,5	46	1,42	40,5	15,4	29,7	72,9
5	$P_{30}K_{30}$+N_{50}	112,2	9,7	16,5	46	1,45	41,0	15,8	30,3	87,4
6	$P_{40}K_{40}$ (фон)	101,4	9,5	15,6	42	1,32	40,8	14,3	29,8	93,3
7	$P_{30}K_{30}$+N_{30}	101,9	9,6	16,2	47	1,48	41,0	14,9	29,6	82,7
8	$P_{30}K_{30}$+N_{40}	114,8	9,9	16,5	48	1,58	41,2	16,7	30,7	72,9
9	$P_{30}K_{30}$+N_{50}	113,6	9,8	16,5	48	1,56	41,5	16,3	30,0	77,4

(background) 7,4 cm and (background)+N_{50} 7,7 cm and $P_{40}K_{40}$ (background) 7,5 sm, in our $P_{40}K_{40}$+N_{50} variant

the highest indicator was 8,5 cm, the number of spikelets in our no-fertilizer variant was 16,1, $P_{30}K_{30}$ (background) 16,1 and (background)+N_{50} 18,5 and $P_{40}K_{40}$ (background) 17,9, in our $P_{40}K_{40}$ +N_{50} variant the highest indicator was 18,8 cm, the number of grains in our version without fertilizer is 48, $R_{30}K_{30}$ (background) 48,1 and (background) + N_{50} 56 and $R_{40}K_{40}$ (background) 51,5, the highest indicator in our version of $R_{40}K_{40}$ + N_{50} is 58,3 grains, the grain weight in our version without fertilizer is 1,2 g, $P_{30}K_{30}$ (background) 1.3 g and (background) + N_{50} 1.4 g and $R_{40}K_{40}$ (background) 1,3 g, the highest indicator in our version of $R_{40}K_{40}$ + N_{50} is 1.5 g, the weight of 1000 grains in our version without fertilizer is 40.8 g, $P_{30}K_{30}$ (background) 40,8 g and (background) + N_{50} 42,0 g, and P40K40 (background) 41.0 g, in our $P_{40}K_{40}$ +N_{50} variant the highest indicator was 42,8 g, the yield was 20,1 c/ha, in the control (without fertilizer) variant the weight of 1000 grains was 40,8 g, the yield was 16,0 c/ha. In the experiment, the highest indicator was shown by the 9th variant $P_{40}K_{40}$ N_{40}, the weight of 1000 grains was 42,4 g, the yield was 19.7 c/ha (Table 3).

Table 3

The effect of mineral fertilizer rates on the yield indicators of durum wheat variety "Yakut-2014" (Gallaorol-2022-2024).

№	Options	Plant height, cm	Key spike indicators				1000 grains weight, g	Productivity, ts/ha
			Length cm	number of spikes, pcs	number of grains, grains	grain weight, g		
1	Control (no fertilizer)	95,8	7,1	16,1	48,0	1,2	40,8	16,0
2	$P_{30}K_{30}$	97,1	7,4	16,1	48,1	1,3	40,8	16,0
3	$P_{30}K_{30}$+N_{30}	100,2	7,6	16,4	48,5	1,3	41,3	16,5
4	$P_{30}K_{30}$+N_{40}	100,4	7,7	18,5	52,0	1,4	41,5	17,7
5	$P_{30}K_{30}$+N_{50}	102,4	7,7	18,5	56,0	1,4	42,0	17,9
6	$P_{40}K_{40}$ (фон)	101,2	7,5	17,9	51,5	1,3	41,0	16,5
7	$P_{30}K_{30}$+N_{30}	102,2	8,1	18,6	56,1	1,3	41,3	18,1
8	$P_{30}K_{30}$+N_{40}	103,0	8,5	18,8	58,3	1,5	42,1	19,3
9	$P_{30}K_{30}$+N_{50}	106,4	8,9	20,1	60,4	1,7	42,8	20,4

According to the results of the study, the plant height of the "Mushtarak" variety of barley in our version without fertilizers is 75.8 cm, the productive cluster is 2.4 grains, the number of grains in one spike is 21.6 grains, the length of the spike is 7.5 cm, the weight of the main spike 1.8 g, 1000 grain weight 48.8 g, yield 15.1 c/ha, R30K30 (background) plant height 76.8 cm, productive set 2.5 grains, number of grains per spike 22.0, spike length 8.1 cm, main spike weight 1.8 g, 1000 grain weight 48.8 g, yield 15.7 c/ha, (background)+N30 plant height 78.2 cm, productive set 2.5 grains, number of grains per spike 22.2 grains, spike length 8.1 cm, main spike weight 1.9 g, 1000 grain weight 49.3 g, yield 16.6 c/ha, (background)+N40 plant height 78.4 cm, productive set 2.7 grains, number of grains per spike 23.5 grains, spike length 8.5 cm, main spike weight 2.0 g, 1000 grain weight 49.5 g, yield 18.9 c/ha, (фон)+N_{50} ўсимлик бўйи 78,4 см, маҳсулдор тупланиш 2,7 дона, бир бошоқдаги дон сони 23,5 дона, бошоқ узунлиги 8,7 см, асосий бошоқ оғирлиги 2,2 г, 1000 дона дон оғирлиги 50,0 г, ташкил этди (4-жадвал).

Table 4

The effect of mineral fertilizer rates on the yield indicators of the barley variety "Mushtarak" (Gallaorol-2022-2024).

№	Вариантлар	Plant height, cm	Key spike indicators				1000 grains weight, g	Productivity, ts/ha
			Productive accumulation, grain	number of grains in one ear, pcs	Spike length, cm.	Main spike weight, г		
1	Control (no fertilizer)	75,8	2,4	21,6	7,5	1,8	48,8	15,1
2	$P_{30}K_{30}$	76,1	2,5	22,0	8,1	1,8	48,8	15,7
3	$P_{30}K_{30}+N_{30}$	78,2	2,5	22,2	8,1	1,9	49,3	16,6
4	$P_{30}K_{30}+N_{40}$	78,4	2,7	23,2	8,5	2,0	49,5	18,9
5	$P_{30}K_{30}+N_{50}$	78,4	2,7	23,5	8,7	2,2	50,0	20,7
6	$P_{40}K_{40}$ (фон)	76,2	2,5	22,0	8,4	1,9	49,0	16,6
7	$P_{30}K_{30}+N_{30}$	78,2	2,5	22,2	8,5	1,9	49,3	16,6
8	$P_{30}K_{30}+N_{40}$	78,8	2,7	23,5	8,7	2,2	50,1	20,7
9	$P_{30}K_{30}+N_{50}$	78,8	2,7	23,5	8,7	2,3	50,3	21,7

Grain yield was analyzed on average 20.7 c/ha, P40K40 (background) plant height 76.2 cm, productive cluster 2.5 grains, number of grains per spike 22.0 grains, spike length 8.4 cm, basic spike weight 1.9 g, 1000 grain weight 49.0 g, yield 16.6 c/ha, (background)+N30 plant height 78.2 cm, productive cluster 2.5 grains, number of grains per ear 22.2 grains, ear length 8.5 cm, main ear weight 1.9 g, 1000 grain weight 49.3 g, yield 16.6 c/ha, (background)+N40 plant height 78.8 cm, productive cluster 2.7 grains, number of grains per ear 23.5 grains, ear length 8.7 cm, main ear weight 2.2 g, 1000 grain weight 50.1 g, yield 20.7 c/ha, (background)+N50 plant height 78.8 cm, productive cluster 2.7 pieces, number of grains in one spike 23.5, spike length 8.7 cm, main spike weight 1.3 g, weight of 1000 grains 50.3 g, yield 21.7 ts/ha.

Conclusion

According to the results of the conducted research, it was observed that the application of mineral fertilizers in pure form at the rate of N40P40K40 kg per hectare to ensure optimal nutrition standards for soft wheat "Bakhmal-97" variety at different growth phases in the conditions of typical gray soils of the mountainous region of the arable land showed high results in experiments.

It was found in experiments that the application of mineral fertilizers at the rate of N50P40K40 kg per hectare in pure form to ensure optimal nutrition and high yields during the growth phases of durum wheat "Yakut-2014" and barley "Mushtarak" showed high results.

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