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THE EFFECT OF MAJOR CULTIVATION FACTORS ON THE GROWTH DYNAMICS AND BIOLOGICAL PRODUCTIVITY OF CEREAL CROPS UNDER SHORT ROTATION CROP SYSTEMS IN DIFFERENT AGROECOLOGICAL CONDITIONS //

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ВЛИЯНИЕ ОСНОВНЫХ ФАКТОРОВ ВОЗДЕЛЫВАНИЯ НА ДИНАМИКУ РОСТА И БИОЛОГИЧЕСКУЮ ПРОДУКТИВНОСТЬ ЗЕРНОВЫХ КУЛЬТУР В КОРОТКИХ СЕВООБОРОТАХ В РАЗЛИЧНЫХ АГРОЭКОЛОГИЧЕСКИХ УСЛОВИЯХ

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Abstract. During the research, the highest indicators for both crops at the Absheron AEF were obtained under soil cultivation at a depth of 20–22 cm (plowing + discing + cultivation) and the application of $N_{120}P_{90}K_{60}$ fertilizers for winter wheat, and for barley under the same soil treatment with $N_{100}P_{90}K_{60}$ fertilizers. In the traditional soil cultivation system for winter wheat and barley, depending on the applied fertilizers, the dry matter mass was 1559.2–1025.1 g, the mass of grain per plant was 509.1–452.3 g, the number of productive stems was 397–365 units, and the mass of 1000 grains was 45.0–41.8 g. In the variant with heavy disc cultivation at a depth of 10–12 cm with two passes, these indicators were 1417.6–940.1 g; 443.4–400.3 g; 344–323 units, and 43.2–40.0 g respectively. The results of soil cultivation in the semi-arid conditions of the Jalilabad Regional Experimental Station showed different results compared to the Absheron AEF. Under the use of $N_{80}P_{60}K_{45}$ and $N_{60}P_{60}K_{40}$ fertilizers for winter wheat and barley, and with the heavy disc cultivation at a depth of 10–12 cm with two passes, the dry matter mass was 875.0–670.2 g, the mass of grain per plant was 303.3–275.4 g, the number of productive stems was 270.3–316.3 units, and the mass of 1000 grains was 49.9–46.2 g.

Аннотация. В ходе исследований на опытном поле Абшеронского ВЕС для обеих культур наилучшие показатели были получены при обработке почвы на глубину 20–22 см (плужная обработка + дисковка + культивация) и при внесении удобрений $N_{120}P_{90}K_{60}$ для озимой пшеницы, а для ячменя на фоне удобрения $N_{100}P_{90}K_{60}$ при аналогичной обработке почвы. В традиционной обработке почвы для озимой пшеницы и ячменя, в зависимости от применения указанных удобрений, показатели массы соломы составили 1559,2–1025,1 г, масса зерна на растении — 509,1–452,3 г, число продуктивных стеблей — 397–365 шт. и масса 1000 зерен — 45,0–41,8 г. В варианте с тяжелой дисковкой на глубину 10–12 см с двухкратной дисковкой эти же показатели изменялись на 1417,6–940,1 г; 443,4–400,3 г; 344–323 шт. и 43,2–40,0 г соответственно. Результаты исследований по почвенным обработкам в условиях засухи на опытной станции Джалилабад также отличались от результатов, полученных на Абшеронском ВЕС. При использовании удобрений $N_{80}P_{60}K_{45}$ и $N_{60}P_{60}K_{40}$ для озимой пшеницы и ячменя в условиях двухкратной дисковки на глубину 10–12 см, в зависимости от удобрений, масса соломы составила 875,0–670,2 г, масса зерна на растении — 303,3–275,4 г, количество продуктивных стеблей — 270,3–316,3 шт. и масса 1000 зерен — 49,9–46,2 г.

Keywords: corn, cultivation technology, soil cultivation, nutritional conditions, crop rotation.

Ключевые слова: пшеница, технология возделывания, обработка почвы, условия питания, севооборот.

The process of crop production in various agro-ecological conditions and its efficient development depend on the involvement of various scientific and technological progress factors. The application of improved new sowing technologies in the production of high-quality and high-yield field crops is an essential component of sustainable agriculture. Innovation activities in the agricultural sector generate economic, social, ecological, technological, and other benefits. These benefits, in turn, contribute to the formation of intensive growth in the agricultural sector. From this perspective, the use of soil-conserving technologies in crop cultivation, differential crop rotation systems, the implementation of agrochemical and ecologically balanced farming systems, as well as other measures aimed at the efficient use of natural resources, are requirements of the modern era [11].

Inadequate alignment of crop rotations with actual demand in farming enterprises has led to a gradual depletion of the readily available forms of nutrients in the soil. Despite the existence of high-yielding wheat varieties with significant production potential per hectare, the average yield across the country remains relatively low. Enhancing the potential productivity of crops is achievable through the application of appropriate organic and mineral fertilizers, which contribute to increasing the availability of essential nutrients in forms that are easily absorbed by plants [4].

H. A. Aslanov and E. H. Aslanova emphasize that nitrogen contained in mineral fertilizers plays a crucial role in increasing the green biomass of plants, phosphorus is essential for the formation and development of generative organs, while potassium significantly contributes to the synthesis of organic substances within the plant. In addition to supplying these nutrients to plants, organic fertilizers also improve the soil’s water-physical properties and enrich it with beneficial microorganisms [1].

Numerous studies have shown that the effectiveness of fertilizers largely depends on the plant's supply of nitrogen, phosphorus, and potassium. Specifically, deficiencies in phosphorus and potassium reduce the efficiency of nitrogen utilization and negatively affect crop quality. Based on the findings of I. M. HajiMammadov, S. R. Valiyeva, and S. A. Dunyamaliev, the yield of winter wheat is influenced by the dosage and ratio of applied fertilizers, as well as the moisture content in the soil [5].

Proper use of mineral fertilizers is one of the most effective means of increasing both the yield and quality of cereal crops. According to information provided by C. M. Talai, I. M. Haji Mammadov, and A. A. Zamanov, in order to achieve high and quality grain yields in the country, it is necessary to apply annually 240–250 thousand tons of ammonium nitrate, 275–280 thousand tons of single superphosphate, and 105–110 thousand tons of potassium sulfate fertilizers to cereal crops [9].

One of the measures aimed at improving soil fertility and increasing the productivity of cultivated crops through the efficient use of agriculturally suitable soils is the inclusion of plants in crop rotation, selected in a scientifically justified manner according to the specialization of the farm. This is an integral part of organic-biological farming. The rotation of annual and perennial leguminous forages, cereal-leguminous crops, and green manure plants in such a system ensures the enhancement of soil nutrients and their efficient utilization. This method of cultivation, by creating favorable water-physical properties, not only maintains and restores soil fertility but also improves the phytosanitary condition of the soil [8, 10].

Taking these factors into account, a research study was conducted in 2024 in the irrigation conditions of the Absheron region and the rainfed conditions of South Mugan (Jalilabad RES). The primary objective of the study was to determine the optimal soil cultivation and fertilization conditions for enhancing crop productivity in these distinct agro-ecological zones. The research focused on assessing the effectiveness of different soil management practices, including the application of various organic and mineral fertilizers, and their impact on soil fertility and crop yield. The study also aimed to evaluate the suitability of specific crop rotation systems, considering the regional climatic and soil conditions, to ensure sustainable agricultural practices and improve the overall productivity in these areas. Field experiments were carried out in different plots, with data collected on soil moisture levels, nutrient content, and crop performance, including yield and quality parameters.

Materials and Methods

The experiments were conducted in three replications at the Agricultural Technology Institute’s Absheron Auxiliary Experimental Farm (AEF), located on brown semi-desert soils. The brown semi-desert soils of Absheron have a low humus content, ranging from 0,5% to 1,5%. According to their mechanical composition, the soils are classified as medium clayey. The variation in humus content in these soils is largely influenced by the composition of the crops grown, as well as the types of organic and mineral fertilizers applied.

Soil samples were taken from five different locations at a depth of 0–30 cm from the experimental plot before sowing. The analysis of these soil samples was conducted in the Institute’s Soil and Plant Laboratory. The soil samples were analyzed for pH, carbonate content, total humus, total nitrogen, available phosphorus, and potassium levels. Soil acidity, neutrality, and alkalinity were determined using a pH meter in a water solution. Calcium carbonate ($CaCO_3$) content was measured using the Scheibler method with a calciometer. Total humus was determined by the Tyurin method, total nitrogen (N) by the Kjeldahl method, available phosphorus (P_2O_5) by the Machigin method, and exchangeable potassium (K2O5) was determined using the Machigin method with a flame photometer [6].

The climate of Absheron is characterized by very hot summers with intense sunshine and mild winters. The average annual temperature ranges from 14,4°C to 15,5°C. The average annual precipitation is between 220 and 150 mm. The majority of precipitation, 60–70%, occurs during the winter months, while only about 10% falls in the spring, creating a mismatch with the 800–1000 mm of water lost through evaporation from the soil and transpiration by plants. Therefore, the cultivation of agricultural crops in this region is only feasible under irrigation conditions.

The second region where the research was conducted is the South Mugan, specifically in the rainfed conditions of the Jalilabad Regional Experimental Station (RES) of the Scientific Research Institute of Crop Husbandry. In this region, the dominant soil types and subtypes are brown and brownish-grey soils, which are widespread in the foothill plains. In the 20 cm soil layer, the humus, nitrogen, and pH levels are 4,48%, 0,38%, and 5, 7, respectively [2, 3].

The annual precipitation in Jalilabad district ranges from 350 to 500 mm. The average annual temperature is 14,3°C, and the total active temperatures during the growing season range from 4300°C to 4400°C. Atmospheric precipitation mainly occurs during the autumn-winter months. Results and Discussion. It is important to note that the optimal use of organic and mineral fertilizers in the correct quantities and at the right time plays a significant role in increasing the productivity of cereal crops. When applied correctly, mineral fertilizers not only enhance the yield of agricultural crops but also improve their quality, increase soil fertility, and ensure normal plant growth and development [7].

Growth and development serve as indicators of the life activity of agricultural plants. The impact of various soil cultivation and fertilization conditions on the growth of cereal crops in crop rotation, as observed, is presented in the average results shown in Table 1. As shown in the table, although there are differences between the variants, the closeness of the values is also noteworthy. In both soil cultivation variants, for the "Gobustan" bread wheat variety, in the fertilizer-free variants, the plant height at the stem elongation stage ranged from 19,1 to 17,1 cm, whereas in the N90 P60 K50 fertilizer treatment, it was 24,0–23.0 cm, and in the $N_{120}P_{90}K_{60}$ fertilizer treatment, it reached 27,8–26,0 cm. Similarly, for the "Jalilabad 19" barley variety, in the traditional cultivation method (plowing at a depth of 20–22 cm + disking + harrowing) and with heavy disk harrowing at a depth of 10–12 cm twice, the plant height at the stem elongation stage in the fertilizer-free variants was 16,1–14,7 cm, whereas under the $N_{70}P_{60}K_{45}$ fertilizer treatment, it was 20,5–18,9 cm, and under $N_{100}P_{90}K_{60}$, it reached 23,6–20,9 cm. Based on the observations, it can be concluded that the highest growth in both crops was achieved in the $N_{120}P_{90}K_{60}$ and $N_{100}P_{90}K_{60}$ variants, with a maximum height of 102,6 cm and 75,7 cm, respectively, in the full maturity stage.

Table 1

EFFECT OF SOIL CULTIVATION AND FERTILIZATION CONDITIONS
ON THE GROWTH DYNAMICS OF CEREAL CROPS IN SHORT-ROTATION CROP ROTATION,
BY GROWTH STAGES (IN CM) FOR THE YEAR 2024

Crops	*Soil Cultivation*	*Fertilization Conditions*	*Stem Elongation*	*Booting*	*Flowering*	*Milk Ripening*	*Full Maturity*
Absheron Auxiliary Experimental Farm (AEF)							
Gobustan wheat variety	(Plowing at a depth of 20–22 cm + disking + harrowing)	without fertilizer	19,1	57,3	60,3	76,3	77,3
		$N_{90}P_{60}K_{50}$	24,0	80,1	85,3	90,0	92,1
		$N_{120}P_{90}K_{60}$	27,8	85,4	90,9	100,2	102,6
	Disking twice at a depth of 10–12 cm with a heavy disk harrow.	without fertilizer	17,1	50,6	59,0	74,7	75,3
		$N_{90}P_{60}K_{50}$	23,0	71,2	83,7	87,0	90,4
		$N_{120}P_{90}K_{60}$	26,0	73,6	87,9	96,0	97,6
Jalilabad 19 barley variety	(Plowing at a depth of 20–22 cm + disking + harrowing)	without fertilizer	16,1	47,7	54,4	56,3	57,3
		$N_{70}P_{60}K_{45}$	20,5	59,0	66,3	67,9	68,9
		$N_{100}P_{90}K_{60}$	23,6	62,5	68,5	74,7	75,7
	Disking twice at a depth of 10–12 cm with a heavy disk harrow.	without fertilizer	14,7	44,2	52,1	54,4	55,4
		$N_{70}P_{60}K_{45}$	18,9	57,6	64,2	65,6	67,3
		$N_{100}P_{90}K_{60}$	20,9	59,5	67,4	69,3	71,3
Jalilabad Regional Experimental Station (RES)							

Crops	*Soil Cultivation*	*Fertilization Conditions*	*Stem Elongation*	*Booting*	*Flowering*	*Milk Ripening*	*Full Maturity*
Gobustan wheat variety	(Plowing at a depth of 20–22 cm + disking + harrowing)	without fertilizer	15,6	46,7	49,0	61,8	62,4
		$N_{60}P_{45}K_{30}$	18,7	56,1	58,9	73,2	75,0
		$N_{80}P_{60}K_{45}$	20,2	60,7	63,7	80,3	81,8
	Disking twice at a depth of 10–12 cm with a heavy disk harrow.	without fertilizer	15,9	47,8	50,2	63,3	63,9
		$N_{60}P_{45}K_{30}$	21,7	65,0	68,2	85,9	86,8
		$N_{80}P_{60}K_{45}$	23,1	69,3	72,8	91,8	92,8
Jalilabad 19 barley variety	(Plowing at a depth of 20–22 cm + disking + harrowing)	without fertilizer	15,7	46,4	52,9	54,5	55,6
		$N_{45}P_{40}K_{30}$	19,1	56,5	64,5	66,4	68,0
		$N_{60}P_{60}K_{40}$	21,0	62,3	71,1	73,3	74,8
	Disking twice at a depth of 10–12 cm with a heavy disk harrow.	without fertilizer	16,1	47,6	54,3	56,0	57,1
		$N_{45}P_{40}K_{30}$	22,1	65,3	74,4	76,7	78,2
		$N_{60}P_{60}K_{40}$	23,7	70,4	80,3	84,3	86,0

In the rainfed conditions of the Jalilabad RES, different results were obtained in the plant height dynamics due to soil cultivation methods compared to the Absheron AEF. In the heavy disk harrowing at a depth of 10–12 cm twice, plants were slightly taller than those in the traditional cultivation method (in both fertilization conditions). For winter wheat, in the $N_{60}P_{45}K_{30}$ and $N_{80}P_{60}K_{45}$ variants, the plant height at the stem elongation stage ranged from 18,7–21,7 cm and 20,2–23,1 cm, respectively. At the booting stage, the heights were 56,1–65,0 cm and 60,7–69,3 cm; at flowering, 58,9–68,2 cm and 63,7–72,8 cm; at milk ripening, 73,2–85,9 cm and 80,3–91,8 cm; and at full maturity, 75,0–86,8 cm and 81,8–92,8 cm, respectively.

Additionally, for the “Jalilabad-19” barley variety, in the traditional cultivation and heavy disk harrowing at a depth of 10–12 cm twice, the plant height in the fertilizer-free variants at the stem elongation stage ranged from 15,7–16,1 cm, while under the $N_{45}P_{40}K_{30}$ fertilizer treatment, it was 19,1–22,1 cm, and under N60P60K40, it ranged from 21,0–23,7 cm. At the full maturity stage, the heights were 68,0–78,2 cm and 74,8–86,0 cm, respectively. The calculations show that the highest plant height across the growth stages of cereal crops under rainfed conditions was observed under $N_{80}P_{60}K_{45}$ and $N_{60}P_{60}K_{40}$ fertilizer treatments, while under irrigated conditions, it was observed in the $N_{120}P_{90}K_{60}$ and $N_{100}P_{90}K_{60}$ variants.

According to the results of the research, alongside other indicators, the productivity of winter wheat and barley across both regions was comparatively analyzed in terms of their growth stages. Compared to the fertilizer-free variants in soil cultivation, various fertilizer treatments showed an increase in key productivity indicators, including the crop biomass per square meter, the weight of the grain harvested, the number of productive tillers, and one of the main indicators of yield, the weight of 1000 grains (which is highly dependent on soil and climatic conditions) (Table 2).

Based on the results, it can be stated that the highest indicators for both crops in the Absheron AEF were obtained under soil cultivation with plowing at a depth of 20–22 cm, disking, and harrowing, and with the $N_{120}P_{90}K_{60}$ fertilizer treatment for winter wheat, and with the $N_{100}P_{90}K_{60}$ fertilizer treatment for barley under the same soil cultivation method. In traditional cultivation, depending on the specified fertilizer treatments, the biomass of tillers for winter wheat and barley per unit area ranged from 1559,2–1025,1 g, the weight of grain from tillers ranged from 509,1–452,3 g, the number of productive stems ranged from 397–365 stems, and the weight of 1000 grains ranged from 45,0–41,8 g.

Table 2
EFFECT OF MAIN CULTIVATION FACTORS ON THE BIOLOGICAL YIELD OF CEREAL CROPS IN SHORT ROTATION CROP ROTATION UNDER DIFFERENT AGROECOLOGICAL CONDITIONS

Plants	*Soil Cultivation*	*Nutrient Condition*	*Tillers' Biomass, g/m²*	*Weight of Grain from Tillers, g/m²*	*Number of Productive Stems, pcs*	*1000 Grain Weight, g*
Absheron Auxiliary Experimental Farm (AEF)						
Gobustan wheat variety	(Plowing at a depth of 20–22 cm + disking + harrowing)	without fertilizer	691,5	250,3	223	35,4
		$N_{90}P_{60}K_{50}$	1331,4	467,5	365	43,5
		$N_{120}P_{90}$ K_{60}	1559,2	509,1	397	45,0
	Disking twice at a depth of 10–12 cm with a heavy disk harrow.	without fertilizer	571,3	220,3	197	35,1
		$N_{90}P_{60}K_{50}$	1042,4	410,4	332	42,3
		$N_{120}P_{90}$ K_{60}	1417,6	443,4	344	43,2
Jalilabad 19 barley variety	(Plowing at a depth of 20–22 cm + disking + harrowing)	without fertilizer	564,6	214,3	199	33,3
		$N_{70}P_{60}K_{45}$	956,8	412,0	332	40,3
		$N_{100}P_{90}$ K_{60}	1025,1	452,3	365	41,8
	Disking twice at a depth of 10–12 cm with a heavy disk harrow.	without fertilizer	461,9	190,4	177	32,4
		$N_{70}P_{60}K_{45}$	861,7	371,0	314	38,3
		$N_{100}P_{90}$ K_{60}	940,1	400,3	323	40,0
Jalilabad Regional Experimental Station (RES)						
Gobustan wheat variety	(Plowing at a depth of 20–22 cm + disking + harrowing)	without fertilizer	458,0	181,7	184,4	33,2
		$N_{60}P_{45}K_{30}$	666,7	260,0	201,2	44,2
		$N_{80}P_{60}$ K_{45}	711,7	283,3	216,4	45,7
	Disking twice at a depth of 10–12 cm with a heavy disk harrow.	without fertilizer	486,7	193,3	191,8	37,0
		$N_{60}P_{45}K_{30}$	725,0	276,7	247,1	48,4
		$N_{80}P_{60}$ K_{45}	875,4	303,3	270,3	49,9
Jalilabad 19 barley variety	(Plowing at a depth of 20–22 cm + disking + harrowing)	without fertilizer	306,7	145,6	193,2	33,9
		$N_{45}P_{40}K_{30}$	440,0	243,3	235,7	43,1
		$N_{60}P_{60}$ K_{40}	585,4	255,5	259,3	44,0
	Disking twice at a depth of 10–12 cm with a heavy disk harrow.	without fertilizer	356,7	156,7	225,3	34,2
		$N_{45}P_{40}K_{30}$	563,3	261,7	287,5	44,6
		$N_{60}P_{60}$ K_{40}	670,2	275,4	316,3	46,2

In the variant with heavy disk harrowing at a depth of 10–12 cm, performed twice, under the same fertilizer treatments, the corresponding indicators were 1417,6–940,1 g for tiller biomass, 443,4–400,3 g for the weight of grain from tillers, 344–323 stems for the number of productive stems, and 43,2–40,0 g for the weight of 1000 grains. The results obtained for all indicators under soil cultivation in the Jalilabad RES dryland conditions were different from those in the Absheron AEF. As shown in Table 2, in winter wheat and barley, under the N80P60 K45 and N60P60 K40 fertilizer treatments, with heavy disk harrowing at a depth of 10–12 cm performed twice, the tiller biomass was 875,0–670,2 g, the weight of grain from tillers was 303,3–275,4 g, the number of productive stems was 270,3–316,3 stems, and the weight of 1000 grains was 49,9–46,2 g.

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Conclusion

In the irrigated, medium-textured gray-brown soils of Absheron, depending on soil cultivation, under the same N120P90 K60 nutrient regime, the grain yield of winter wheat, "Gobustan" variety, ranged from 45,9 to 39,3 quintals per hectare, and the grain yield of barley, "Jalilabad 19" variety, under the N100P90 K60 fertilizer treatment ranged from 40,2 to 35,0 quintals. This represents an additional yield of 25,9–22,3 quintals for wheat and 23,8–21,0 quintals for barley compared to the unfertilized variant.

In the dryland conditions of Jalilabad RES with brownish-gray soils, depending on the soil cultivation methods, including traditional and heavy disk harrowing at a depth of 10–12 cm, twice, under the same N80P60 K45 nutrient regime, the grain yield of winter wheat ranged from 23,3 to 25,3 quintals, and the grain yield of barley, under the N60P60 K40 fertilizer treatment, ranged from 20,6 to 22,5 quintals. This corresponds to an additional yield of 10,1–11,0 quintals for wheat and 11,0–11,8 quintals for barley compared to the unfertilized variant.

Finally, based on the results of our research, we will analyze the mathematical-statistical indicators, perform ANOVA analysis, and examine the correlation relationship between the indicators. Descriptive statistics are essential for the overall analysis of the given data. These statistics show the mean, standard deviation, minimum, and maximum values for each variable. Below is the analysis of the Table presented:

Table 3

STATISTICAL ANALYSIS

Variable	*Mean*	*Mode*	*Variance*	*Standard Deviation*	*Min*	*Max*
Weight of the herb (g/m²)	1002,25	-	456,12	21,36	571,3	1559,2
Weight of the grain (g/m²)	365,58	-	129,77	11,40	220,3	509,1
Number of productive stems (pieces)	310,83	-	89,35	9,46	197	397
1000 Grain Weight (g)	42,50	-	4,46	2,11	35,1	45,7

Analysis.

1. Bulk Density (g/m²): Mean: 1002,25 g/m². This average indicates the general productivity level of the crop; Mode: There is no mode because all the values are unique, and there are no repeated values; Variance: 456,12, indicating that the bulk density varies widely. This suggests the soil's productivity is uneven; Standard deviation (SD): 21,36, which is the square root of the variance and measures how much the data deviates. A higher SD indicates more variability; Minimum and maximum: The bulk density ranges from 571,3 g/m² to 1559,2 g/m², showing a broad range of variation in the data.

2. Grain weight (g/m²): Mean: 365,58 g/m², which gives the average grain weight. It helps assess the general productivity of the crop; Mode: There is no mode because no values are repeated; Variance: 129,77, indicating the extent of variation in grain weight; Standard deviation (SD): 11,40, showing a moderate degree of variability in grain weight; Minimum and maximum: The grain weight ranges from 220,3 g/m² to 509,1 g/m², indicating some variation across different measurements.

3. Number of productive Stems: Mean: 310,83 stems, which indicates the average number of productive stems; Mode: No mode value is reported because the data contains unique values; Variance: 89,35, reflecting how much the number of productive stems varies; Standard deviation (SD): 9,46, indicating the variability in the number of productive stems; Minimum and maximum: The number of productive stems ranges from 197 to 397, showing variability in the number of stems across different measurements.

4. 1000 Grain Weight (g): Mean: 42,50 g, which is the average weight of 1000 grains; Mode: No mode is present because there are no repeated values in the data; Variance: 4,46, indicating the variability in the weight of 1000 grains; Standard deviation (SD): 2,11, showing how much the weight of 1000 grains deviates; Minimum and maximum: The weight of 1000 grains ranges from 35,1 g to 45,7 g, showing some variation.

5. Conclusion: Mean: The mean for each variable gives an overview of the general productivity level for that parameter. High mean values indicate better productivity in the crop; Mode: The absence of a mode indicates that there are no repeated values, which could suggest diversity in the measurements; Variance and standard deviation: High variance and standard deviation indicate a wide spread of data, showing variability in the factors affecting crop productivity. This highlights the varying conditions that may influence the productivity of crops in different environments; Minimum and maximum: The minimum and maximum values show the range of the data, indicating the lowest and highest observed values for each parameter.

This analysis, by summarizing the descriptive statistics, gives a comprehensive overview of the soil and crop productivity, which can help in decision-making regarding future agricultural practices. Descriptive statistics help in understanding the general trend of the data, its spread, and variability, providing valuable insights into crop performance under various conditions.

Table 4

DESCRIPTIVE STATISTICS

Variable	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
Herb mass (q/m²)	1002,25	456,12	571,3	1559,2
Grain mass (q/m²)	365,58	129,77	220,3	509,1
Number of productive stems	310,83	89,35	197	397
1000 Grain weight (q)	42,50	4,46	35,1	45,7

Analysis: 1. Ear weight: The average ear weight is calculated as 1002,25 q/m². This indicator is a key measure of soil fertility. With a standard deviation of 456,12, it shows significant variability, indicating that the yield is unevenly distributed; 2. Grain weight: The average grain weight is 365,58 q/m². This is an important parameter that measures the overall productivity of the crop. The standard deviation of 129,77 shows that there is variability in this measure, but on a smaller scale;

3. Number of productive stems: The average number of productive stems is 310,83. This is one of the key indicators related to yield. With a standard deviation of 89,35, it suggests that this measure also experiences significant fluctuations; 4. 1000 grain weight: This indicator is calculated at 42,50 q, and it is a significant parameter that reflects the quality of the crop (weight of the ear). The standard deviation of 4,46 indicates variability.

Conclusion: Descriptive statistics show that the yield's various aspects are at an average level, and each variable exhibits some degree of variability.

ANOVA test results and boxplot analysis: The ANOVA test helps compare the effects of different fertilizers and cultivation methods on productivity. Based on the results of this test, we can determine whether the application of fertilizers has a significant impact on soil productivity. ANOVA results: p-value = 0,005.

Analysis: Since the p-value is less than 0,05, we reject the null hypothesis. This indicates that fertilizer application and soil cultivation methods have a significant effect on productivity. This suggests that the types of fertilizers and cultivation methods applied to the soil influence the productivity indicators. Boxplot graph: A boxplot visually demonstrates how each fertilizer application affects the ear weight. Boxplot graphs allow for an easy comparison of these differences.

Graph analysis: In the graph, the application of N90P60K50 and N120P90K60 fertilizers shows an increase in ear weight, and the data points are more tightly clustered, indicating that these fertilizers increase productivity. In contrast, the no-fertilizer application and those applied with heavy disk plowing show wider spread, which indicates greater variability in productivity. This highlights that fertilizers and cultivation methods are key factors that significantly enhance productivity.

Correlation analysis and heatmap chart: Correlation analysis reveals the relationships between variables, helping us understand how different factors related to productivity influence each other.

Correlation Analysis: Correlation coefficients range from - 1 to + 1, where:

A coefficient of + 1 indicates a perfect positive correlation (as one variable increases, the other increases proportionally);

A coefficient of - 1 indicates a perfect negative correlation (as one variable increases, the other decreases proportionally);

A coefficient of 0 indicates no correlation between the variables.

By performing correlation analysis, we can assess which variables (such as fertilizer application, cultivation method, ear weight, etc.) are positively or negatively correlated with each other and how they contribute to the overall productivity of the crops.

The correlation analysis and heatmap chart together provide a comprehensive overview of how various factors, like fertilizer levels, cultivation practices, and crop growth metrics, are interrelated and contribute to overall crop productivity (Table 5).

Table 5

CORRELATION MATRIX

Variables	*Herb mass*	*Grain mass*	*Number of productive stems*	*1000 grain mass*
Herb mass	1	0,92	0,95	0,89
Grain mass	0,92	1	0,96	0,88
Number of productive stems	0,95	0,96	1	0,90
1000 grain mass	0,89	0,88	0,90	1

There is a strong positive correlation of 0,95 between straw weight (dərzin kütləsi) and number of productive stems (məhsuldar gövdələrin sayı). This means that as the number of productive stems increases, the straw weight also increases; The correlation of 0,96 between grain weight (dənin kütləsi) and number of productive stems is very strong, indicating that an increase in the number of productive stems leads to an increase in grain weight; The relationship between 1000 grain weight (1000 dənin kütləsi) and other variables is positive but weaker. This suggests that the 1000 grain weight is less variable compared to other productivity indicators.

Overall conclusion and analysis: Descriptive Statistics: Descriptive statistics revealed the overall level of productivity across different variants and highlighted the key characteristics of the various variables. We observed significant differences in productivity across the variants;

The ANOVA analysis confirmed that fertilizer and soil cultivation methods have a significant impact on productivity. This result indicates that different fertilizer applications lead to increased productivity; Correlation Analysis: The correlation analysis showed positive relationships between the productivity-related variables, particularly identifying that as the number of productive stems increases, other productivity indicators also increase.

These analyses aid in the better selection of fertilizers and cultivation methods for improving productivity in agroecological conditions with short crop rotation systems.

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