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THE IMPACT OF FERTILIZATION PERIODS ON SOME ANATOMIC AND MORPHOLOGICAL CHARACTERISTICS AND YIELD OF WINTER WHEAT

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Abstract

The impact of fertilization periods on anatomic – morphological characteristics of drought resistance directly depends on the specific conditions of plant nutrition and water supply during the ontogeny period in conditions of the post-forest brown, gravel and carbonated medium-strength soil of the foothills of the Artsakh Republic where the average annual air temperature is 11ºC, the long-term average atmospheric precipitation is 490-550mm and the humus content in the soil is 3,5-4%.

Experimental research has revealed the positive effect of phosphorus-potassium fertilizers applied to the soil before sowing on the development of xerophytic traits in crop plants that provide frost and drought resistance and vice versa, the application of phosphorus-potassium fertilizers along with nitrogen fertilizer has negative impact, it reduces plant resistance to unfavorable external conditions and causes low yields of winter wheat. At the same time, it was found that phosphorus-potassium fertilizers applied before winter wheat, and nitrogen fertilizer when applied to the soil in the spring, provide a balanced ratio of mineral nutrition, development of xerophytic properties and high yield under high atmospheric factors.

***Key words**:* fertilization period, anatomic properties of a leaf, stem and root, xerophytic properties, draft resistance, yield.

Introduction

It is known that drought resistance, in addition to being a special and varietal property of plants, also depends on the conditions of the external environment in which the individual development of the organism takes place. In general, there are a number of ways to fight drought. Among these measures are agro-technical measures which ultimately contribute to the accumulation of moisture in the soil and its efficient use by plants. There is a correlation between drought resistance, winter resistance and morphological features in plants. The peculiarity of these features is better expressed in the leaves. One of the characteristic features of xeromorphs of leaves is the high ratio of volume to the surface. Such leaves are small and thick. This feature is related to such internal features as the large thickness of the mesophyll, the strong, well-developed columnar tissue relative to the spongy tissue, the small volume of the intercellular spaces, the tightness of the nerve system, the high density of the stomas and sometimes the microcellularity.

The dryness of the soil and air, strong light, the lack of nitrogen available to the plant and low temperature contribute to the development of xerophytic features, i.e, an increase in the thickness of the lamina, downiness, an increase in the number of stomas in per unit of surface and producing "columnar" tissue. Under the influence of these same factors, the leaf surface, the size of the cells and the intercellular spaces etc. decrease [1, 2, 3, 4, 5, 8, 9, 10].

Additional soil and air moisture, poor lighting and more nitrogen have the opposite effect on leaves.

Thus, the resistance of plants to unfavorable conditions depends on a number of external factors including the nutrients in the soil. The role of fertilizers in ensuring a high crop yield has been known long before but the destructive effect of external unfavorable factors through fertilizers was mentioned only in the second half of the 19^{th} century.

Numerous literary data confirm that the conditions of external environment, especially at a young age, have a significant impact on the anatomical and morphological features of plants. Stem height depends on moisture, soil fertility, fertilization, plant density and other factors. As a rule, the higher the moisture and soil fertility are, the higher the plant height is. Nitrogen or complete mineral fertilizers also contribute to the growth of straw. Phosphorus-potassium fertilizers have a negligible effect on increasing stem height [6, 7].

Phosphorus-potassium fertilizers along with nitrogen nutrition contribute to the increase of transferring sheaves on unit surface of plant stem and only nitrogen or complete (NPK) fertilizers inserted into the soil reduce the number of transferring sheaves and increase their sizes [6, 7].

According to F.M. Prutskov, the development of the root system of winter wheat depends on the nutrients in the soil and the ratio of separate elements. The richer the soil is in nitrogen and phosphorus, the stronger the roots grow. Intensified one-way nitrogen nutrition contributes more to the accumulation of ground mass than to root growth [11].

Conflict setting

Drought, hail, floods, sharp changes of temperature in atmosphere and other anomalous climatic factors contributing to desertification have recently become more common due to global warming.

In the studied area the biggest natural disaster in agriculture is drought the damage of which costs tens of millions of dollars a year. The extent of the damage caused by the drought depends not only on the decreasing amount of atmospheric precipitation and rising temperature, but also on the lack of appropriate agro-technical measures to fight the stress of atmospheric factors. Therefore, any means of fight against drought is relevant and necessary especially in the conditions of arid agriculture.

Based on the above mentioned, we have set the task of finding out the effect of fertilization periods on such anatomic and morphological properties of vegetative parts (leaf, stem, root) of winter wheat of "Bezostaya-1" variety on the basis of field experiments and laboratory researches in the conditions of zero soil cultivation which the resistance of plants to unfavorable environmental factors is conditioned by.

Material and method of research

The research was carried out using laboratory and field method in 2018-2020 at the chair of Agronomy of Shushi University of Technology.

The field experiments were thrice held in the post-forest brown, limestone carbonated soils of medium-strength in Ivanyan village of Askeran region. The estimated area of the experimenting site was 100 m^2. Winter wheat of "Beostostaya 1" served as an object of study.

The following variants were studied:

1. Testing (without fertilization)
2. $P_{90}K_{60}$ before sowing
3. N_{90} before sowing
4. $P_{90}K_{60}N_{90}$ before sowing
5. $P_{90}K_{60}N_{120}$ before sowing
6. $P_{90}K_{60}$ N_{90} before sowing, in spring in the form of nutrition
7. $P_{90}K_{60}$ before sowing, N_{120} in spring in the form of nutrition

Double superphosphate was used as phosphorus-potassium fertilizer, potassium chloride was used as potassium and potassium nitrate was used as nitrogen. The sown furrow was used as predecessor during all time of research.

The seeding was done in mid November by СЗУ-3,6 narrow blade seed driller. The norm comprised 4,5 mln. germinated seed grain per hectare. The main activities of soil cultivation and sowing were done according to the norms of zero cultivation.

The moving forms of nutrients were determined in the plow land (0-15 cm) before the experiment every year. According to these data, the experimental site was well provided with potassium and weakly provided with nitrogen and phosphorus during all years of experiment before fertilization. Consequently, phosphorus and especially nitrogen fertilizers play decisive role in increasing the yield of winter wheat in these areas. For studying field germination, winter resistance, general and efficient bushing plants were registered during vegetation. Phenological observations and biometric measurements were done during vegetation. Typical plants were chosen for anatomic observations from each species in different stages of vegetation. The leaves of the same level were compared for anatomic research. The cuttings were taken from the middle of the leaf near the central nerve. At least 20 preparations from 10 lower and 10 upper epidermis were prepared from 10 plants of each experiment in all periods of testing during the piping and suberating stages. The number of stomas and their length were determined in 10 places in the field of view of the microscope of each preparation. The number of stomas was recalculated in the field of view of a microscope, the area of which was calculated according to the radius of the circle measured in ocular micrometers depending on the magnification of the microscope. The length of the stomas was measured using an ocular micrometer and expressed in microns. Anatomical examinations of the stem were performed on the second node of the main branch during the stages of earing and full maturation. During the anatomical examination of the stem, the number of vessels of transferring sheaves and in one sheaf were calculated. With the help of an ocular micrometer, the diameters of the vessels and the stem (without the tubular part) were measured in microns.

For anatomical examination of the root and expansive cuttings of the root formed from the node of bunching were taken, the diameters of the central cylinder and the root cortex were measured and the number of vessels in the xylem was calculated.

The preparations were stained with fuchsine.

The grain yield was determined by the method of collecting and weighing the yield of each variety and repetition. Yield data were subjected to mathematical processing by the method of dispersion analysis [12].

Research results

The research results of the impact of fertilization periods on the number and sizes of stomas of leaves of winter crop are given in Table 1.

Table 1

The impact of fertilization periods on the number and sizes of stomas of leaves of winter crop (average for three years)

Varieties	Stage of tubering						Stage of suberation					
	Number of stomas on 1 mm^2			Length of stomas mc			Number of stomas on 1 mm^2			Length of stomas mc		
	In upper epidermis	In lower epidermis	Total	In upper epidermis	In lower epidermis	Average ա	In upper epidermis	In lower epidermis	Total	In upper epidermis	In lower epidermis	Average
1	60,2	48,1	108,3	55,98	53,34	54,66	72,8	52,7	125,5	42,34	39,26	40,80
2	63,7	52,3	116,0	55,01	55,00	55,00	71,5	55,4	126,9	42,78	41,81	42,29
3	46,3	38,4	84,7	60,75	57,21	58,98	56,8	46,6	103,4	47,86	43,22	45,54
4	53,2	45,2	98,4	57,54	57,19	57,36	68,7	43,2	111,9	44,10	41,46	42,78
5	48,7	41,3	90,0	61,26	57,25	59,25	60,2	41,5	101,7	48,48	46,74	47,61
6	55,2	43,7	98,9	56,97	54,02	55,49	70,3	58,5	128,8	4627	41,85	44,06
7	49,4	41,8	91,2	58,25	58,05	58,15	66,3	50,0	116,5	47,12	42,92	45,02

The data show that the amount of fertilizers and the period of fertilization had a significant effect on the number and size of stomas of the leaves of winter crop. Those plants which got only nitrogen (variety 3) or full NPK fertilizers before sowing (varieties 4 and 5), compared to unfertilized plants, decreased the number of stomas in per leaf surface and significantly increased in size. In case of only phosphorus-potassium fertilizer before sowing (variety 2), compared to the control version, the number of stomas per leaf area increases and their size decreases to some extent. Compared to the control, the number of stomas per leaf area does not decrease, vice versa, it increases in the cases when phosphorus-potassium fertilizers are used before sowing and the plants receive nitrogen in spring as nutrients.

Thus, 2 and 6 varieties had most stomas (upper and lower epidermis together). They were the least on the leaves of those plants that received the full amount of nitrogen before sowing (3, 4, 5 varieties).

Therefore, if nitrogenous or complete fertilizers applied before sowing contribute to the development of mesophytic traits, then the absence of fertilizers or especially phosphorus-potassium fertilizers before sowing contribute to the development of xerophytic traits. Xerophytic properties can be developed in plants when phosphorus-potassium fertilizers are applied to the soil before sowing and the equivalent amount of nitrogen is applied to the soil in the spring as nutrition.

The same table shows the results of a similar study conducted during the suberation of winter wheat. The data show that in plant leaves which have received different fertilizers during the suberation, the difference in the number and size of stomas is smoothed. This can be explained by the fact that plants of all varieties, especially those that receive nitrogen before sowing, acquire a natural drought resistance in summer under high atmospheric pressure. Despite the reduction in the difference between the number and size of stomas, their number per leaf remains high in those varieties that did not receive nitrogen before sowing.

Due to the fact that mineral fertilizers have a significant effect on the anatomical and morphological features of the plant stem, we have set the task of identifying the effect of the regime of mineral nutrition on several indicators of the anatomical-morphological structure of the stem of winter wheat.

Our research has shown that the stem of cereals has loose, free-scattering sheaf carriers. The carrier sheaves are arranged in two circles like chess.

Table 2

The impact of fertilization periods on some anatomic peculiarities of stem of winter crop (average for three years)

Fertilization	Tubering								Complete maturation					
	Stem surface without hole, mm	number of carrier sheaves on 1 mm^2	Vessel number in 1 mm^2	Number of sheaves on one stem	Number of vessels of one plant	Average diameter of one vessel mc	Sum of diameters of vessels in 1 mc^2	Stem surface without hole, mm	number of carrier sheaves on 1 mm^2	Vessel number in 1 mm^2	Number of sheaves on one stem	Number of vessels of one plant	Average diameter of one vessel mc	Sum of diameters of vessels in 1 mc^2
1	8.4	10.3	21.7	86.5	182.2	30.35	659	8.1	12.4	44.2	100.4	358.0	24.34	1076
2	8.9	11.0	35.1	97.9	312.3	26.12	917	8.5	14.5	60.5	123.2	514.2	19.12	1157
3	10.2	7.9	18.9	80.5	192.7	36.41	688	9.6	9.2	25.1	88.3	240.9	34.21	859
4	11.2	8.5	19.9	95.2	222.8	36.52	727	10.9	9.8	36.8	106.8	401.1	31.24	1150
5	11.5	6.8	18.3	78.2	210.4	38.28	701	11.0	8.7	27.3	95.7	300.3	33.15	905
6	12.9	10.2	27.3	131.5	352.1	32.21	879	11.5	13.4	56.4	154.1	648.6	24.22	1366
7	13.1	10.1	22.4	132.3	293.4	32.25	722	11.5	11.7	45.3	134.5	520.9	27.33	1288

The data in Table 2 show that fertilizers had a significant effect on the number of carrier sheaves and vessels of the stem unit surface during both periods of research. The diameter of the vessels and the thickness of the stem changed under the influence of mineral nutrition.

Observations have shown that nitrogen fertilizers applied to the soil before sowing, both separately and in combination with phosphorus-potassium, help to reduce the number of vessels per unit surface and carrier sheaves and to increase the diameter of the vessels. Only in the variant which received phosphorus-potassium fertilization, an increase in the number of vessels and sheaves and a decrease in their sizes were observed. Plants with phosphorus-potassium fertilizing and an equivalent amount of nitrogen nutrition (version 6, 7) keep xerophytic properties.

According to the data in the table, increasing the amount of nitrogen nutrition contributes to the development of mesophyte properties in the stalk of winter wheat even in the presence of phosphorus-potassium fertilizer.

Hence, the number of vessels and carrier sheaves per unit surface of the stem is small in plants that have received the full amount of nitrogen before sowing (Versions 3, 4, 5). Most carrier sheaves and vessels were control in plants of 2 and 6 variants.

The results of our detailed research show that, as a rule, not only the number and diameter of vessels changes under the influence of mineral fertilizers but also the total surface area of all vessels per unit surface of the stem. In this case, the highest value of this indicator was observed in plants that received only phosphorus-potassium fertilization. This indicates that xerophytic features of the stem of winter wheat develop under the influence of phosphorus-potassium fertilizers. At the same time, plants with only nitrogen or complete NPK fertilization showed a decrease in the total surface area of all vessels before sowing. The total surface area of all vessels at 1 mm^2 was significantly higher than in the control varieties where phosphorus-potassium fertilizers were applied to the soil before sowing and nitrogen was applied in the spring as a nutrient.

The data in Table 3 show that the thickness of the crust of the root of winter wheat and central tube and the number of vessels and their diameter increases under the influence of phosphorus-potassium fertilizers.

Table 3

The impact of fertilization periods on some anatomic peculiarities of stem of winter crop in the stage of complete maturation (average for three years)

Variety	Crust thickness, mc	Diameter of central tube, mc	Number of vessels, 1 mm^2	Average diameter of 1 vessel, mc	Sum of diameters of vessels, 1mc
1	307,18	475,78	31,4	33,29	1045
2	366,86	498,82	34,7	36,14	1245
3	217,68	298,46	19,5	44,82	874
4	332,64	439,65	25,8	42,49	1096
5	319,76	430,52	23,7	43,84	1039
6	369,14	487,65	33,9	36,75	1246
7	376,16	450,56	27,1	43,16	1170

In autumn the thickness of the root crust and the central tube and the number of vessels decreases only in plants with nitrogen fertilizer compared to the control variant but the diameter of the vessels increases.

Nitrogen fertilizers contribute to the thickening of the root crust and the central tube and the increase in vessel diameters in sufficient phosphorus-potassium fertilizer available to plants with the

nitrogen nutrient. It should be noted that the total diameter of the vessels remains high compared to the control variant under the influence of complete fertilizers although the number of vessels per unit surface decreases. According to the average data of the three-year study, in the plants where the nitrogen was fed in the spring, the thickness of the root crust and the central tube increased significantly as well as the number of vessels and their diameters resulting in the total diameter of the vessels per unit surface of the central tube. An increase in the total diameter of all vessels in 1 mm^2 is considered to be the result of increase of both their number and their diameters. The average diameter of all vessels per unit surface of root can be considered as an indicator of root water and carrying potential capacity of the salts dissolved in it.

During all the years of the study, the sum of the diameter of the vessels per unit surface of the root was the highest in the plants that received phosphorus-potassium fertilizers before sowing and nitrogen in the spring as a nutrient. This indicates that phosphorus-potassium fertilizers applied to the soil before sowing contribute to the development of a strong xerophytic root system in plants and further nitrogen nutrition in the spring does not significantly affect the anatomical and morphological features of the root. The variant received only the nitrogen shows the smallest sum of vessel diameters per unit surface in autumn.

Purposeful use of mineral fertilizers plays an important role in the complex of agro-technical measures to achieve a high and sustainable crop of winter wheat. In this case it is necessary to take into account the biological characteristics of the plant which will help to develop measures to increase the efficiency of the application of unit fertilizer.

Nitrogen fertilizers are given priority in increasing the yield of winter crops. There is much material in the scientific literature on the effects of nitrogen fertilizers on accumulated yields depending on the periods of their application to the soil. However, there is no common opinion on this issue. Some authors argue that nitrogen fertilizers are best applied before sowing to increase crop yields of winter crop, others argue that nitrogen fertilizers should be applied before fertilization and many argue that in order to use nitrogen more completely, it should be applied into the soil with fragmented way.

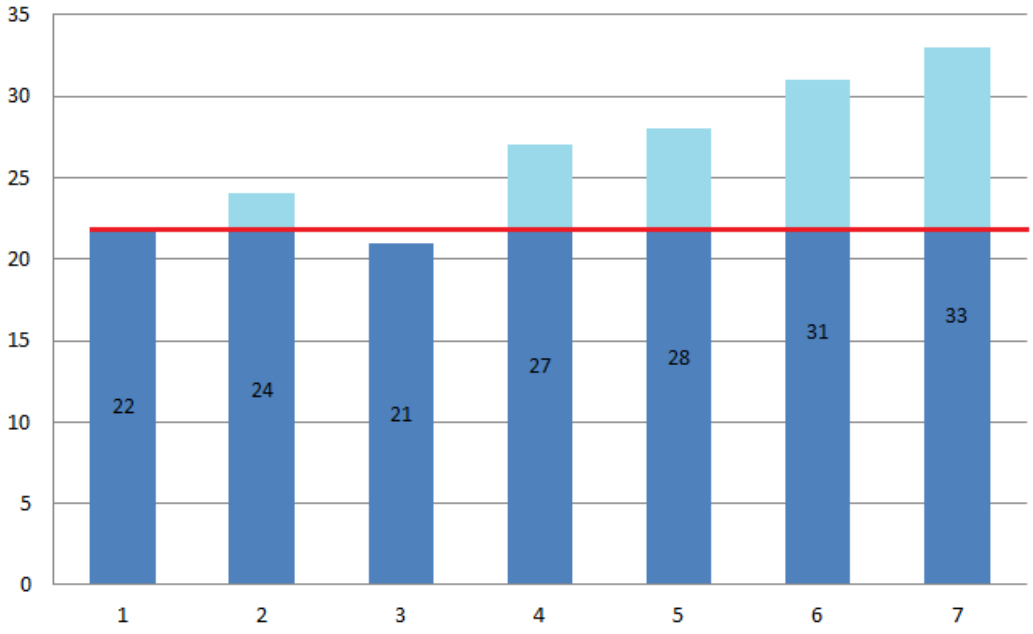

Fig. Yield of winter wheat depending on fertilization periods (average in 2018-2020)

We were also interested in studying the effect of application periods of ammonia saltpeter on the yield of winter wheat.

According to the three-year average data, the best grain yield variants were 6 and 7 where phosphorus-potassium fertilizers were applied to the soil before sowing and the equivalent amounts of nitrogen were applied as a nutrient in the spring (Fig).

Conclusion

The yield of crops mainly depends on the general pressure of the environment in the conditions of arid agriculture in the foothill zone of Artsakh Republic.

Numerous studies have shown that if plants grow in the early stages of ontogenesis under low environmental pressure, they develop mesophytic properties. Such plants are more vulnerable to unfavorable external conditions. With the application of agro-technical measures in the period of low environmental pressure the development of xerophytic features in plants contributes to the increase of their resistance to unfavorable external conditions and the yield.

Our research has shown that fertilizers are not only a source of mineral nutrition, but also regulators of water regime, winter and drought resistance of the plants.

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Շուշիի տեխնոլոգիական համալսարան

Արցախի Հանրապետության նախալեռնային գոտու հետանտառային շագանակագույն, խճաքարային, կարբոնատացված միջին հզորության հողային պայմաններում, որտեղ օդի տարեկան միջին ջերմաստիճանը 11^{o}C է, մթնոլորտային տեղումների բազմամյա միջինը՝ 490-550մմ, հողում հումուսի պարունակությունը՝ 3,5-4%, ուսումնասիրվել է պարարտացման ժամկետների ազդեցությունը աշնանացան ցորենի երաշտադիմացկունությունը պայմանավորող այնպիսի անատոմիա-մորֆոլոգիական առանձնահատկությունների վրա, որոնց ձևավորումը ուղղակիորեն կախված է օնտոգենեզի շրջանում բույսերի սննդառության և ջրապահովվածության կոնկրետ պայմաններից:

Փորձարարահետազոտական ճանապարհով բացահայտվել է ցանքից առաջ հող մտցված ֆոսֆորա-կալիումական պարարտանյութերի դրական ազդեցությունը ցորենի բույսերի մոտ ցրտադիմացկունություն ու երաշտադիմացկունություն ապահովող քսերոֆիտ հատկանիշների զարգացման վրա և հակառակը՝ ցանքից առաջ ազոտական պարարտանյութերի ինչպես առանձին, այնպես էլ ֆոսֆորակալիումականի հետ համատեղ կիրառման ազդեցությունը մեզոֆիտ հատկանիշների ձևավորման վրա, ինչը իր հերթին նվազեցնում է բույսերի դիմացկունությունը արտաքին անբարենպաստ պայմանների նկատմամբ և պայմանավորում է աշնանացան ցորենի ցածր բերքատվություն: Միաժամանակ պարզվել է, որ Ֆոսֆորա-կալիումական պարարտանյութերը ցանքից առաջ, իսկ ազոտականը սնուցման ձևով գարնանը հող մտցնելիս՝ ստեղծվում է հանքային սննդառության հավասարակշռված հարաբերակցություն, ապահովվում է քսերոֆիտ հատկանիշների զարգացում և մթնոլորտային գործոնների բարձր լարվածության դեպքում ստացվում է բարձր բերք:

Բանալի բառեր. Պարարտացման ժամկետ, տերևի, ցողունի, արմատի անատոմիական առանձնահատկոջություններ, քսերոֆիտ հատկանիշներ, երաշտադիմացկունություն, բերքատվություն:

ВЛИЯНИЕ СРОКОВ ВНЕСЕНИЯ УДОБРЕНИЙ НА НЕКОТОРЫЕ АНАТОМО-МОРФОЛОГИЧЕСКИЕ ОСОБЕННОСТИ И УРОЖАЙНОСТЬ ОЗИМОЙ ПШЕНИЦЫ

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В условиях предгорной зоны Республики Арцах на коричневых щебнистых, карбонатных почвах средней мощности, где среднегодовая температура воздуха составляет 11ºС, среднее многолетнее количество осадков - 490-550 мм, содержание гумуса в почве - 3,5-4%, изучено влияние сроков внесения удобрений на такие анатомо-морфологические особенности озимой пшеницы, обусловливающие ее засухоустойчивость, формирование которых напрямую зависит от конкретных условий питания и водоснабжения растений в период онтогенеза.

Экспертно-исследовательским путем выявлено положительное влияние фосфорно-калийных удобрений, внесенных в почву перед посевом, на развитие ксерофитных признаков, обеспечивающих морозостойкость и засухоустойчивость зерновых растений, и наоборот - влияние применения азотных удобрений перед посевом, как по отдельности, так и в сочетании с фосфорно-калийными, на формирование мезофитных признаков, что, в свою очередь, снижает устойчивость растений к неблагоприятным внешним условиям и приводит к снижению урожайности озимой пшеницы. В то же время выяснилось, что при внесении в почву фосфорно-калийных удобрений перед посевом, а азотных, в виде подкормки - весной, образуется сбалансированное соотношение минерального питания, обеспечивается развитие ксерофитных свойств и при интенсивном воздействии атмосферных факторов урожайность повышается.

Ключевые слова: сроки внесения удобрений, анатомические особенности листьев, стебля, корня, ксерофитные признаки, засухоустойчивость, урожайность.

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