АГРОХИМИЯ

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INFLUENCE OF SOWING RATES AND FERTILIZERS ON THE DYNAMICS OF THE CONTENT OF PHOSPHORUS AND POTASSIUM IN THE SOIL, DEPENDING ON THE DEVELOPMENT PHASES OF WINTER BARLEY ON LIGHT-CHESTNUT SOILS IN THE CONDITIONS OF BOGARA

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Abstract. The article summarizes the main agrochemical parameters in the light-chestnut soil of experimental field of Gobustan Regional Experimental Station situated in the territory of the cadastral district of Mountainous-Shirvan, on the southeast slope of the Greater Caucasus Mountains Range in Azerbaijan have been determined. The precipitation, which is the main limiting factor in rainfed regions,was quantified for the 2016-2019 vegetation years. The values of pH in the plowing layer (0-25 sm) was found to range between 8.1-8.4 (25-50 cm), and 8.7-8.8 (50-70 cm). So the plowing layer had weak and lower layers had strong alkaline properties. The soil contains carbonates. The fields of Gobustan RES (Maraza area) are of medium quality soils. Total humus ranged from 2.23 % to 2.29 % in the plowing layer and decreased in the lower layers. Total nitrogen at the depth of 0-25 cm was 0.165 %-0.179 %, which decreased in the lower layers. The analysis shows that the average amount (in 4 years) of easily hydrolyzed nitrogen at a depth of 0-25 cm varied between 45-74 mg per 1 kg soil, 25-31 mg at a depth of 25-50 cm and 13-17 mg at a depth of 50-70 cm. The total phosphorus content at 0–25 cm depth ranged from 0.18 % to 0.12 5 %, depending on the years of the study, and gradually decreased in the lower layers.The amount of active phosphorus was 30.4-33 mg/kg at a depth of 0-25 cm during 4 years, and amount of variable potassium was 269-292 mg/kg, which gradually decreased in the lower layers. Dynamics of phosphorus and potassium in soil was determined in relation to the growth stages, sowing and fertilizer rates of the "Jalilabad 19"barley variety.

Key words: climate, soil, fertilizer, plant, potassium, phosphorus, barley.

INTRODUCTİON

The tolerance of barley crops to diseases, nutritional quality of the grain, resistance to lodging, productivity and economic efficiency depend on the biological characteristics of variety, as well as the degree of potassium supply exchanged during the vegetation period.

The main issues to be considered in fertilizing of any crop are its growth and nutritional properties. The study of main nutritional elements (N, P, K) in the soil is of theoretical and practical importance. Knowing the above mentioned allows prediction of timing and method of fertilization [1]. Soil and climatic conditions, agrotechnical measures, fertilizer types, etc. have a major effect on the movement of mineral fertilizers in the soil [2]. As a result of N^{15}-labeling experiments under field conditions, it was found that 30-40 % of the applied fertilizers were consumed by plants, and 15-20 % of them were produced as a gas and thereby polluted the environment. Thus, the application of nitrogen fertilizers in accordance with the gradation is very important [3].

Certain chemical and physical processes occur in the soil when phosphorus fertilizers are applied and plants can consume only 10-30 % of them [4-6]

The main purpose of research on cereals is to increase productivity, economic efficiency, and attract the farmers to this area [7]. The normal nutritional supply of plants during the vegetation period depends on soil and climatic conditions, reserves of easily absorbable nutrients in the soil and rates and proportions of fertilizers [8-10]. According to V.I.Nikitishen [11], the amount of essential nutrients for the barley plant depends on the moisture content of the soil, the predecessor plant, the rates and proportions of fertilizers applied. When the plant is not properly supplied with potassium during the vegetation period, i.e.because of the potassium deficiency in the main developmental stages, *metabolic* processes are *disturbed*, the stem strength is decreased, the plant becomes prone to lodging, and productivity decreased [12]. A violation of agrotechnical rules for the use of mineral fertilizers, in other words, incorrect selection of fertilizers, their rates and proportions, timing and methods of their application reduces the productivity of agricultural plants, causes soil pollution, and decreases soil fertility. These factors cause disturbance of the ecological function of soils [13]. Some authors [14, 15] reported that without a proper supply of easily absorbable forms of essential nutrients (nitrogen, phosphorus and potassium) during the vegetation period, cereals do not produce good quality, economically efficient products.

According to Z.R. Movsumov [16, 17], 30 % of Azerbaijani soils are weakly, 51 % medium and 18 % well supplied with potassium. Highly supplied soils occur very rarely.

According to the authors, an average of 2.9-3.2 kg of nitrogen, 0.9-1.1 kg of phosphorus and 2.8-3.0 kg of potassium are used to produce a centner of grain yield. The results of the study show that the demand for potassium in autumn cereals is less only compared with the demand for nitrogen.

The amount of easily absorbed forms of main nutrients in the soil depends on the moisture content, the rates and proportions of fertilizers, and application technology [18, 11].

The object and purpose of the study. The purpose of the study was to determine the effects of sowing and fertilizer rateson the accumulation of above-ground biomass, grain quality and productivity depending on growth stages of barley variety "Jalilabad 19". The experiments were performed in the light-chestnut soils of Gobustan Regional Experimental Station.

MATERİALS AND METHODS

The experiments were performed under 3 sowing rates: 120 kg/ha, 140 kg/ha, 160 kg/ha, and under 4 fertilizer rates: 1. Control (without fertilizer), 2. $N_{30}P_{30}K_{30}$, 3. $N_{45}P_{45}K_{45}$, 4. $N_{60}P_{45}K_{45}$. The area of each plot was 44-50 m^2 and the experiments were conducted in 4 replicates. Granular simple superphosphate [20.5 %], potassium sulfate [K_2SO_4- 46 %] and ammonium nitrate [NH_4NO_3-34%] were used. Disk harrow was used to apply the annual rate of phosphorus potassium fertilizers, 30 % of the annual rate of nitrogen fertilizers were applied before at sowing and 70 % - in the early spring.

The main agrochemical parameters were determined by soil sampling annually before sowing, at various depths in the non-fertilized field according to the standard method [19].

Soil analyses were performed as follows: pH of solutions was measured using pH meter; calcium carbonate ($CaCO_3$) – by the Scheibler calcimeter; total humus – by the Tyurin I.V. method; total nitrogen (N)- by the Kjeldahl method; easily hydrolyzed nitrogen – by the method of Tyurin and Kononova; active phosphorus (P_2O_5)- soluble in 1 % ammonium carbonate- by the method of Machigin; variable potassium (K_2O) – soluble in 1 % ammonium carbonate [$(NH_4)_2CO_3$] – using flame photometer [20].

RESULTS AND DİSCUSSİON

Gobustan Experimental Station is situated in the territory of the cadastral district of Mountainous-Shirvan, on the southeast slope of the Greater Caucasus Mountains Range. The climate of the area relates to moderately hot semi-desert type with dry winter and steppes (south) climate type and drought, moderately hot summer (north) type. According to G.Sh. Mammadov, the total area of the cadastral district of Mountainous-Shirvan is 412,290.66 hectares [21]. This is 4.8 % of the total country territory.

The total annual radiation is 122-132 kcal/cm^2, and the annual radiation balance is 38-40 kcal/cm^2. The average annual air temperature is 6-14°C, in the coldest month of the year (January) 2°C-4° C, and in the hottest month (July) 15-25°C. In summer, the absolute maximum temperature sometimes rises up to 20-40°C. In winter, the absolute minimum temperature sometimes falls below - 14-25°C. The average annual minimum temperature ranges from 10°C to 16°C. The average annual temperature of the soil surface is 12-14°C and ranges between 1°C and 29°C throughout the year. The first autumn frosts occur in the second decade of November, and the last spring frosts in the first decade of April. According to the author, the annual precipitation is up to 420 mm.

Currently, the amount of perennial precipitation is 412 mm. This shows that the decline in annual precipitation in recent years effects on perennial precipitation.

According to the results of the study performed in the Maraza area of Gobustan Regional Experimental Station, one of the major factors affecting the plant development, productivity and economic efficiency was the amount of precipitation.

As seen from the results, annual precipitation during the study period differs from perennial precipitation. Thus, the amount of perennial precipitation was 412 mm, whereas, during the years of conducting the study, the annual precipitation ranged from 360.3 mm to 542.9 mm. So the precipitation quantity was different even in these years. But the difference between precipitation amounts was somewhat less during the vegetation period of the plant. The highest precipitation in 2016-2017 (542.9 mm per year) was 383.2 mm during the vegetation period and 360.4 mm in 2015-2016. In general, the amount of precipitation in 2015-2019 was favorable for the development of barley variety "Jalilabad 19".

There was no significant difference in the minimum or maximum air temperature in the period of 2015-2019 when the experiments were conducted [figure 1]. Thus, 16°C was observed only in the first decade of January 2016. The minimum temperature was 9-11°C It was observed very rarely, for 1-2 days in January and did not have a negative impact on the development of barley variety "Jalilabad-19".

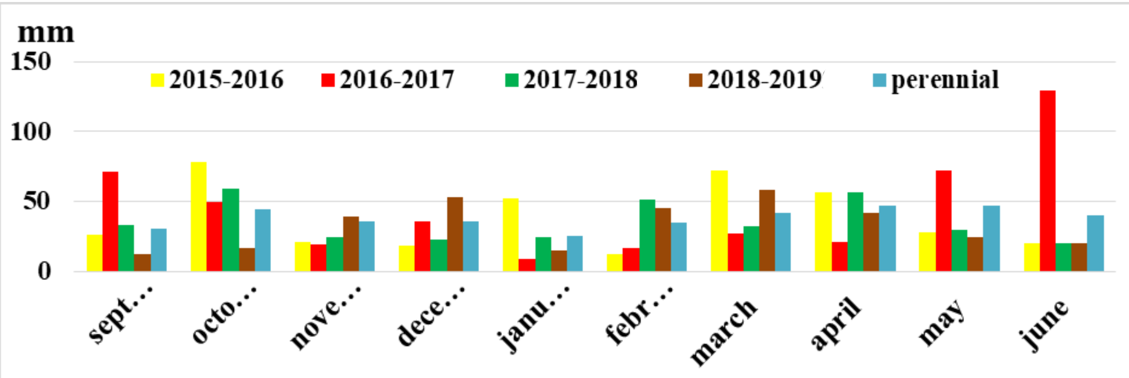

Figure 1 - Amount of precipitation during the 2015-2019 vegetation years

The main agrochemical parameters of light-chestnut soils were determined during the 2016-2019 years. The values of pH in the plowing layer (0-25 sm) was found to range between 8.1-8.4 (25-50 cm), and 8.7-8.8 (50-70 cm). So the plowing layer had weak and lower layers had strong alkaline properties. The soil contains carbonates. The fields of Gobustan RES (Maraza area) are of medium quality soils. Total humus ranged from 2.23 % to 2.29 % in the plowing layer and decreased in the lower layers. Total nitrogen at the depth of 0-25 cm was 0.165 %-0.179 %, which decreased in the lower layers. The total phosphorus content at 0–25 cm depth ranged from 0.18 % to 0.12 5 %, depending on the years of the study, and gradually decreased in the lower layers. The analysis shows that the average amount (in 4 years) of easily hydrolyzed nitrogen at a depth of 0-25 cm varied between 45-74 mg per 1 kg soil, 25-31 mg at a depth of 25 -50 cm and 13-17 mg at a depth of 50-70 cm. The amount of active phosphorus was 30.4-33 mg/kg at a depth of 0-25 cm during 4 years, and amount of variable potassium was 269-292 mg/kg, which gradually decreased in the lower layers.

The results of the study showed that the amount of active phosphorus in the soil varied considerably during the various years depending on the rate and proportions of fertilizers, and the plant development stages. In the control variant, during the booting stage, at 120 kg/ha sowing rate, at a depth of 0-25 cm, the amount of active phosphorus ranged from 25.9 mg to 30.7 mg per 1 kg of soil. Thus, in 2016, 2018 and 2019, the amount of active phosphorus per 1 kg of soil without fertilizer was 29.3; 30.7 and 28.7 mg, while in 2017 this value was 25.9 mg. The similar results were obtained during milk and full ripeness stages. Thus, in 2016, 2018 and 2019, during the milk ripeness stage, the amount of active phosphorus was 23.3; 23.9 and 22.7 mg/kg, while in 2017, this value was equal to 17.5 mg/kg. However, in the full ripeness stage, no significant differences were observed in various years of the study.

Similar results were also observed at 140 kg/ha and 60 kg/ha sowing rates. The significant differences in the parameters measured in different years are quite natural since the amount of active phosphorus in the soil depends on the humidity and temperature.In 2017, the amount of precipitation in the main plant development stages was lower than in 2016 and 2018. This has an effect on the amount of active phosphorus in the soil and plant productivity.

There were no significant differences in the plowing layer (25-50 cm) during the various years and depending on the plant developmental stages.

When mineral fertilizers (nitrogen, phosphorus, and potassium) were applied, the amount of active phosphorus (P_2O_5) at 120; 140 and 160 kg/ha sowing rates were higher than in the control variant, in the plowing layer (0-25 cm) of the soil. This increase was significantly different depending on the proportions of fertilizer rates and plant developmental stages. Thus, in 2016, 2018 and 2019, at the sowing rate of 120 kg/ha,during the booting stage, when $N_{45}P_{45}K_{45}$was applied, the amounts of activephosphorus (P_2O_5) at a depth of 0-25 cm were 41.6, 42.4 and 41.8 mg/kg. In 2017, this value was 36.5 mg/kg. During the milk ripeness stage, this value was found to be 31.4, 32.1, 33.9 mg/kg and 27.7 mg/kg, respectively.In the full ripeness stage, in various years of the study, the amount of active phosphorus in the plowing layer changed from 15.2 to 17.2 mg/kg. When the phosphorus-potassium ratio was stable and the nitrogen rate increased from 45 kg /ha to 60 kg /ha, the difference ranged from 1.2 to 1.5 mg/kg, depending on the plant developmental stages.

In the control variant of winter barley variety "Jalilabad-19", the amount of active phosphorus in the plowing layer decreased on average 2.01-2.08 times, depending on the sowing rates, from the booting stage to the end of the ripeness stage. Upon application of the $N_{30}P_{30}K_{30}$fertilizer,the amount of active phosphorus decreased 2.33,2.38, and 2.31 times at 120 kg/ha, 140 kg/ha, and 160 kg/ha sowing rates, respectively. When the $N_{45}P_{45}K_{45}$ fertilizer was applied, the amount of active phosphorus decreased 2.48, 2.61 and 2.58 times at 120 kg/ ha, 140 kg/ha, and 160 kg/ha sowing rates, respectively.

Correlations between sowing and mineral fertilizer rates and *proportions* on amount of phosphorus were also determined. Studies have shown that only at milk ripness stage, there is a reliable at the 0.01 level direct relationship between the fertilizer rate and amount of phosphorus, (r = 0.625**).

Also, between sowing rate and amount of nitrogen at all developmental stages reliable at the 0.01 level positive relationship have determined (table 1).

Table 1 - Pearson correlation coefficient for sowing and mineral fertilizer rates and *proportions* influence on amount of phosphorus in different developmental stages in unsupplied with moisture light mountain gray-brown (light chestnut) soils of Mountainous Shirvan (GRES)

Indices	Year	Sowing rate	Fertilizer rate	Booting	Milk ripeness	Full ripeness
Year	1	0.000	0.000	-0.112	-0.151	-0.258
Sowing rate		1	0.000	0.849**	0.670**	0.567**
Fertilizer rate			1	.302	0.625**	0.009
Booting				1	0.905**	0.773**
Milk ripeness					1	0.644 **
Full ripeness						1
**: Correlation is significant at the 0.01 level (2 tailed) *: Correlation is significant at the 0.05 level (2 tailed)						

According to the results, from the booting stage to milk ripeness, the amount of active phosphorus in the soil depending on the sowing rate decreased in the control variant 1.33-1.40 times. During the full ripeness stage, this value decreased 2.01-2.08, 2.31-2.38, 2.48-2.61 and 2.53-2.63 times, respectively, in the control variant and upon application of the $N_{30}P_{30}K_{30}$, $N_{45}P_{45}K_{45}$,and $N_{60}P_{45}K_{45}$ fertilizers.

This is quite reasonable, because in the control variant at the end of the spring tillering and in booting stage, amount of nutritions meet the demand of plants while they are not sufficient during the further developmental phases.

The amount of variable (well-absorbed) potassium in the plowing layer (0-25 cm) and under the plowing layer (25 -50 cm) was determined in various years, at various sowing and fertilizer rates, during the main developmental stages of variety "Jalilabad 19"[figure 2]. According to the results of the analysis, amounts of potassium in the plowing layer (0-25 cm) changed depending on the developmental stages of the plant, fertilizer rates and were different in various years.

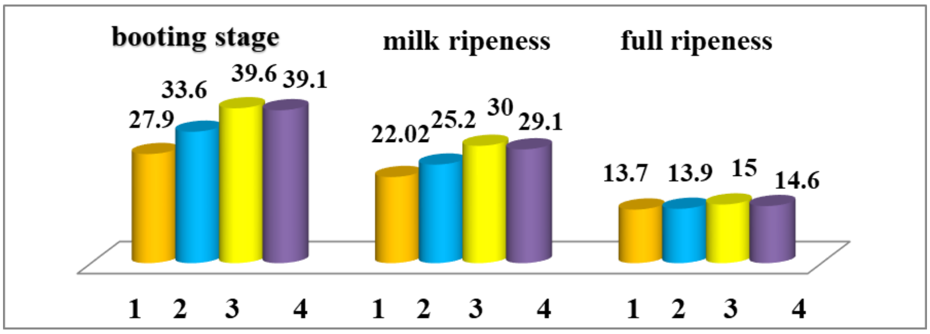

Figure 2 - Dynamics of phosphorus in the soil at 140 kg/ha sowing rate, depending on developmental stages of barley variety "Jalilabad 19" and fertilizer rates
1. Control (without fertilizer). 2. $N_{30}P_{30}K_{30}$. 3. $N_{45}P_{45}K_{45}$. 4. $N_{60}P_{45}K_{45}$.

Thus, in the control variant, at the sowing rate of 120 kg/ha, in the booting, milk and full ripeness stages, amount of variable potassium was found to be 358-375 mg/kg, 278-295 mg/kg and 256-267 mg/kg, respectively. Similar results were obtained at the sowing rates of 140 and 160 kg/ha.At 140 kg/ha sowing rate, in the plowing layer (0-25 cm), amount of variable potassium was equal to 360-370 mg/kg, 280-318 mg/kg and 249-266 mg/kg in the booting, milk , and full ripeness stages,respectively.

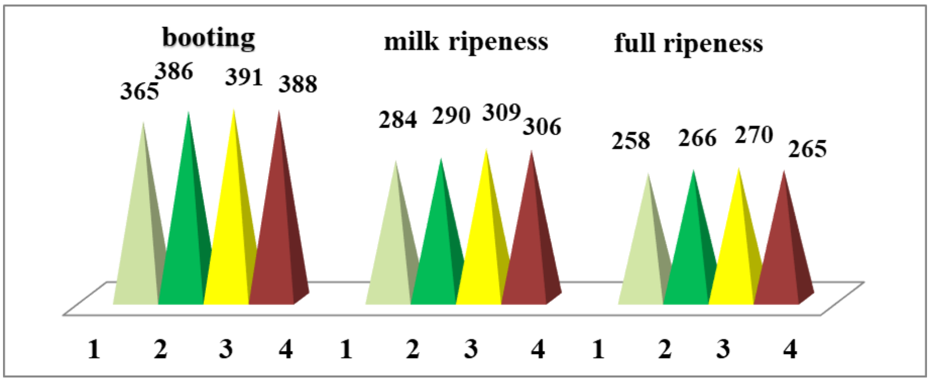

Figure 3 - Dynamics of variable potassium in the soil at 140 kg/ha sowing rate, depending on the rates and ratios of fertilizers and developmental stages of the plant
1. Control (without fertilizer). 2. $N_{30}P_{30}K_{30}$.3. $N_{45}P_{45}K_{45}$. 4. $N_{60}P_{45}K_{45}$.

The amount of variable potassiumin the soil also varied slightly depending on the sowingrate. The difference in the booting stage was within the limits of experimental error, and in 2017, in the milk ripenessstage, the difference was 10-12 mg/kg. When the sowing rate increased from 120 kg/ha to 140 and 160 kg/ha, amount of variablepotassium (K_2O) in the soil decreased by 10-12 mg/kg.

The fertilizer rates also affect the amount of variablepotassium depending on the years of the study and plant developmental stages. Thus, upon application of $N_{45}P_{45}K_{45}$, at the sowing rate of 140 kg/ha amount of variable potassium was found to be 386-397 mg/kg, 303-315 mg/kg and 260-275 mg/kg during the booting, milk and full ripeness stages, respectively [figure 3].

This is closely related to the amount of precipitation observed during the various stages of plant development. Similar values were also obtained at the sowing rates of 120 kg/ha and 160 kg/ha.

Table 2-Pearson correlation coefficient for sowing and mineral fertilizer rates and *proportions* influence on amount of potassium (K_2O) in different developmental stages in unsupplied with moisture light mountain gray-brown (light chestnut) soils of Mountainous Shirvan (GRES)

Indices	year	Sowing rate	Fertilizer norm	Booting	Milk ripeness	Full ripeness
year	1	0.000	0.000	-0.240	-0.268	0.219
Sowing rate		1	0.000	-0.034	-0.265	-0.092
Fertilizer norm			1	0.775**	0.743**	0.624**
Booting				1	0.832**	0.742**
Milk ripeness					1	0.701 **
Full ripeness						1
**: Correlation is significant at the 0.01 level (2 tailed) *: Correlation is significant at the 0.05 level (2 tailed)						

Correlations between sowing and mineral fertilizer rates and *proportions* on amount of potassium were also determined. Studies have shown that at all stage, there is a reliable at the 0.01 level direct relationship between the fertilizer rate and amount of potassium (table 2).

CONCLUSION

Thus, results of the experiments performed in light-chestnut soils of the rainfed regions of Mountainous Shirvan showed that in the control variant, during the booting, milk and full ripeness stages, the amount of variable potassium on average for 4 years (2016-2019) was equal to 359-365 mg/kg, 282-288 mg/kg and 258-261 mg/kg, respectively.

Based on results of the study, amount of variable potassium decreased when the sowing rate increased from 120 kg/ha to 160 kg/ha (except for the full ripeness stages). The difference in the booting and full ripeness stages was 5 mg/kg and 6mg/kg, respectively.

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ТҮЙІН

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ТӘЛІМІ ЕГІСТІК ЖАҒДАЙЫНДА АШЫҚ-ҚОҢЫР ТОПЫРАҚТАРДА КҮЗДІК АРПАНЫҢ ДАМУ ФАЗАЛАРЫНА БАЙЛАНЫСТЫ, СЕБУ МЕН ТЫҢАЙТҚЫШ НОРМАЛАРЫНЫҢ ТОПЫРАҚТАҒЫ ФОСФОР МЕН КАЛИЙ МӨШЕРІНІҢ ДИНАМИКАСЫНА ӘСЕРІ

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Мақалада Әзірбайжандағы Үлкен Кавказ жотасының оңтүстік-шығыс беткейі аумағындағы Таулы-Ширван кадастрлық ауданында орналасқан, Гобустан облыстық тәжірибе станциясындағы тәжірибе танабы ашық-қоңыр топырағының негізгі агрохимиялық көрсеткіштері келтірілген. Тәлімі егістік жағдайында *шектеуші факторлардың* бірі жауын-шашын болып табылады. 2016-2019 жылдары жүргізілген температуралық факторларға байланысты үлгілердің вегетациялық кезеңінің ұзақтығы мен арпаның сапасы анықталды, тыңайтқыштың енгізілетін оңтайлы мөлшерлері анықталды. Жыртылу қабатындағы (0-25 см) pH мәні 8,1-8,4 (25-50 см) пен 8,7-8,8 (50-70 см) дейінгі аралықта болды. Топырақ ортасының реакциясы әлсіз-сілтіден жоғары сілтілікке дейін өзгереді. Топырақ карбонатты. Зерттелетін танаптың топырағы (Гобустан АЭЖ (Мараза ауданы)) жылжымалы фосформен *әлсіз* және орташа *қамтамасыз* етілген. Жыртылу қабатындағы қарашіріктің жалпы мөлшері 2,23 % - дан 2,29 % - ға дейін, тереңдеген сайын төмендейді. 0-25 см тереңдікте жалпы азот 0,165 % -0,179 % құрады, ал тереңдеген сайын екі еседен астамға азайды. Жеңіл ыдырайтын азоттың мөлшері 13-74 мг/кг топырақ шегінде болды. 0-25 см тереңдіктегі фосфордың жалпы мөлшері зерттеу жылына байланысты 0,18 %–дан 0,12-5 % - ға дейін болды және топырақтың төменгі қабаттарында біртіндеп төмендеді. Белсенді фосфордың мөлшері 30,4-33 мг/кг топырақ шегінде болды. Алмаспалы калийдің топырақтағы мөлшері 269-292 мг/кг құрады, ол біртіндеп тереңдеген сайын төмендеді. "Жалилабад 19" арпа сұрпы егілген егістіктердегі топырақтағы фосфор мен калий мөлшерінің динамикасы, егістің өсуіне және тыңайтқыш нормаларына байланысты анықталды.

Түйінді сөздер: климат, топырақ, тыңайтқыш, өсімдік, калий, фосфор, арпа.

РЕЗЮМЕ

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ВЛИЯНИЕ НОРМ ПОСЕВА И УДОБРЕНИЙ НА ДИНАМИКУ СОДЕРЖАНИЯ ФОСФОРА И КАЛИЯ В ПОЧВЕ, В ЗАВИСИМОСТИ ОТ ФАЗ РАЗВИТИЯ ОЗИМОГО ЯЧМЕНЯ НА СВЕТЛО-КАШТАНОВЫХ ПОЧВАХ В УСЛОВИЯХ БОГАРЫ

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В статье приведены основные агрохимические показатели светло-каштановой почвы опытного поля Гобустанской областной опытной станции, расположенной на территории кадастрового района Горно-Ширван, юго-восточного склона Большого Кавказского хребта в Азербайджане. Одним из лимитирующих факторов в условиях богары являются осадки Определена продолжительность вегетационного периода образцов и качество ячменя в зависимости от температурных факторов проведенных в 2016-2019 гг, установлены оптимальные дозы внесения удобрений. Значения pH в пахотном слое (0-25 см) находились в пределе от 8,1-8,4 (25-50 см) до 8,7-8,8 (50-70 см). Реакция среды почвы варьирует от слабощелочной до сильнощелочной. Почва карбонатная. Почвы исследуемого поля (Гобустанский РЭС (район Мараза)) слабо- и средне обеспечены подвижным фосфором. Общее содержание гумуса в пахотном слое колеблется от 2,23 % до 2,29 %, снижаясь с глубиной. Общий азот на глубине 0-25 см составил 0,165 % -0,179 %, а с глубиной уменьшился более чем в два раза. Содержание легкогидролизуемого азота находилось в пределах 13-74 мг/кг почвы. Общее содержание фосфора на глубине 0–25 см составило от 0,18 % до 0,12–5 % в зависимости от года исследования и постепенно снижалось в нижних слоях почвы. Количество активного фосфора находилось в пределах от 30,4-33 мг/кг почвы. Количество обменного калия составило от 269-292 мг/кг почвы, которое постепенно снижалось с глубиной. Определена динамика содержания фосфора и калия в почве на полях с сортом ячмень «Джалилабад 19», в зависимости от роста посева и норм удобрений.

Ключевые слова: климат, почва, удобрение, растение, калий, фосфор, ячмень.