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Article

Effects of soil potassium availability and absorption, perlite, and nitrogen levels on wheat plant development and yield

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Abstract
This study was conducted in the Al Majd area in Al Muthanna Governorate (Away from the city center, about 5 km to the north) to study the effect of perlite and nitrogen levels on potassium availability and absorption in soil, growth and yield of the wheat plant, during the agricultural season 2022-2021—a factorial field experiment, according to a Randomized Complete Block Design (RCBD) with three replicates. The experiment included two factors. The first factor is the addition of perlite with three levels (0, 1.5 and 3)% symbolized by B0, B1 and B2, respectively, while the second factor is nitrogen at five levels (0, 50, 100, 150 and 200) kg N ha-1 has the symbol N0, N1, N2, N3 and N4 respectively. The land was divided into plots, including 45 experimental units in three blocks, the area of the experimental unit (2 × 2) m2. The experimental unit included 8 lines with a length of 2 m. The distance between one line and another was 20 cm, leaving a distance of 75 cm between one replicate and another. The seeds of wheat (Bohooth 22 cultivar) were sown on 11/11/2021. The results indicated the significant effect of adding perlite at a level of 3% by volume to the soil in increasing the ready potassium in the soil when adding the first and second batches of nitrogen and harvesting, the addition of perlite at a level of 3% by volume of the soil affected the growth characteristics of the plant, including the biological yield, grain yield, potassium concentration in the plant, and the absorbed amount of potassium in the plant, nitrogen fertilizer to the soil at a level of (150 and 200) kg N ha^{-1} had a significant effect on the increase of ready potassium in the soil in the first and second batch of adding fertilizer.

Keywords: Perlite, nitrogen, potassium availability and absorption, soil, growth, yield, wheat plant.

Introduction

Potassium is one of the most essential nutrients, involved in many vital plant processes since the earth's crust contains large amounts of potassium. However, more is needed for the plant's needs because it is not ready. For this purpose, many natural or chemical materials were used, which were added to the plant or soil and led to an increase in the availability of potassium or to maintain it directly or indirectly and within sufficient levels for the plant. Among these substances, preservatives for moisture and nutrients are perlite mineral[1].

Perlite is a material with small grains, about 1-5 mm in diameter, white in color, produced by heating silicon volcanic rocks to 1000 m, which leads to an increase in the size of its grains from 4 to 20 times its original size[2]. Agricultural perlite is characterized by its high ability to absorb water and retain fertilizer for a long time;

it separates the irrigation stages and has a high ability to exchange positive ions and a neutral pH (6.5 - 7.5). It works to maintain nutrients, including potassium, in a ready-made form for a long time without fixing it[3,4].

This research aims to study the effect of perlite mineral and nitrogen levels on the availability and release of potassium and its absorption in the soil and plant yield.

Materials and Methods

The experiment site:

A field experiment was conducted during the agricultural season 2022-2021 in the Al-Majd area in Al-Muthanna Governorate (about 5 km north of the city center) to determine the effect of perlite and nitrogen levels on potassium availability at the soil and the growth and yield of wheat (Triticum aestivum L.).

Soil Sample Collection:

Soil samples were taken from 0-30 cm depths and different locations in the experimental ground. The samples were mixed to homogenize them, air dried, softened and passed through a sieve with holes diameter of 2 mm. The chemical and physical analyses were carried out in Table 1.

Chemical properties	Parameters	Unit	Value
	pH	--	7.80
	EC	dS m^{-1}	5.70
	Organic matter	gm kg^{-1}	1.10
	CEC	centimol kg^{-1}	10.00
	Nitrogen availability	mg kg^{-1}	23.00
	Phosphorous availability		17.20
	Potassium availability		170.00
	Ca^{+2}	mmol. L^{-1}	25.52
	Na^{+1}		11.83
	Cl^{-1}		37.51
Physical properties	Sand	gm kg^{-1}	18.09
	Silty		49.20
	Clay		32.71
	Texture	Clay loam	

Table 1. Some chemical and physical properties of field soil.

Laboratory measurements of some chemical properties of soil:

Available potassium (K+):

It was extracted by ammonium acetate (1N NH4OAC) pH = 7, and the available potassium was estimated before planting and after adding the first and second batches of nitrogen and after harvesting using the Flame Photometer and according to the method mentioned in Richards[5] and the available Mg was estimated by smearing with Na2EDTA according to the method contained in Jackson[6].

Biological yield (mcg.ha^{-1}):

The weight of the harvested plants was estimated from the same two average lines to calculate the grain yield and was calculated for the experimental unit and then per hectare (mg ha-1).

Grain yield (mcg.ha^{-1}):

It was estimated from the grain yield of the group of plants harvested from the two middle lines. After isolating the straw from the seeds, the seeds were weighed and calculated for the experimental unit and then per hectare (mcg ha^{-1}).

Potassium concentration in the plant.

The plant sample was digested, and a weight of 0.2 g was taken from it and digested using concentrated sulfuric and pyrochloric acid in a ratio of (1:3) according to Haynes[7], then potassium was determined using a Flame Photometer.

The absorbed amount of potassium in the plant.

The total absorption of potassium in each of the weights and the concentration of the element in the plant part was calculated according to the equation indicated by Tisdale *et al*.[8] as follows:

Total absorption = concentration of the element in the plant part % x dry weight of the plant

Experiment factors

The first factor:

Perlite mineral was added at levels 0, 1.5 and 3% by volume to the soil and its symbol B0, B1 and B2, respectively

The second factor:

Nitrogen was added at levels 0, 50, 100, 150 and 200 kg N ha^{-1} and symbolized by N0, N1, N2, N3 and N4, respectively.

A factorial experiment was conducted according to the Randomized Complete Block Design (RCBD), which included 15 treatments and three replicates, so the total number of units was 45 experimental units.

Oxides	Chemical symbol	Percent
Silicon dioxide	SiO_2	72-75%
Aluminum oxide	AL_2O_3	11-14%
Potassium oxide	K_3O	2.8-4.3%
Water content	H_2O	3.2-4.5%
Properties	**Value**	**Unit**
Color	White	-
Density	100-80	Kg m^{-3}
Granule size	5-1	mm
pH	7.5-6.5	-

Table 2. Chemical and physical properties of perlite mineral.

Agricultural operations:

The field soil was plowed with the cultivator plow, 30 cm deep and smoothed by disc combs, settled and opened by main and subsidiary drivers, and divided into three sectors. One sector included 15 experimental units. The area of the experimental unit was 2×2 m2. The experimental unit included eight lines; the distance between one line and another was 20 cm, and a distance of 75 cm was left between one replicate and another. Nitrogen fertilizer at levels N0, N1, N2, N3 and N4 was added to fertilizer (0,50, 100,150, 200) kg N.ha^{-1} in the form of urea (N 46%) in two batches, the first one week after germination and the second after a month From the first edition.

Phosphate fertilizer was added at the level of 100 kg P2O5 ha^{-1} in the form of triple superphosphate fertilizer TSP (P 21%) in one batch before planting, and potassium fertilizer was added at the level of 100 kg K. ha-1 in the form of potassium sulfate fertilizer (K 41.5%)[9]. Perlite was added in volume by knowing the length and width of the experimental unit, the depth and density of the soil, making a box with known dimensions of length, width and height, and dimensions of length 40 cm, width 30 cm, and height 15 cm, the fund is added once for 1.5% transactions, and 2 funds are added for every 3% transaction, it was added with the soil a mixture that has chemical and physical properties (Table 2). All service operations were conducted equally for all experimental treatments in the study and whenever needed.

2.6. Experiment design and statistical analysis

The experiment was carried out using a two-factor factorial trial design of Randomized Complete Block Design (RCBD) with three replicates, and they were randomly distributed with 15 experimental units.

Statistical analysis of all results was carried out based on analysis of variance for the studied traits according to the factorial trials method of Randomized Complete Block Design (RCBD) using the statistical program (GENESTAT). The comparison between the means of transactions was done using the Least Significant Difference (LSD) test at a probability level 0.05.

Results

Potassium available in the soil (mg K kg^{-1} soil):

Potassium available in the soil when adding the first batch of nitrogen:

Table 3 shows the significant effect of adding perlite levels on the values of available potassium in the soil after adding the first batch of nitrogen fertilizer. B1 and B2 gave averages of 230.33 and 244 mg K kg-1 soil, respectively, achieving an increase of 26.60 and 34.11%, respectively, compared to the no addition treatment (comparative) B0, which gave the lowest average of 181.93 mg K kg-1 soil.

Table 3 shows the significant effect of adding nitrogen levels on the values of available potassium in the soil when adding the first batch of nitrogen fertilizer. The N3 level did not differ significantly from the N4 level, achieving the highest value of available potassium in the soil, which amounted to 254.22 and 257.66 mg K kg^{-1} soil, respectively. Soil in a row, while the lowest value was reached at the level of no addition (comparison), which amounted to 162.55 mg K kg^{-1} soil. The reason may be due to the effect of ammoniacal fertilizers on the availability of potassium from the soil, as the increase in the availability of potassium by adding urea was attributed to the effect of the ammonium ion resulting from the decomposition of this fertilizer and its replacement with potassium, and the latter was released from the exchanged layer to the available layer in the soil and this is consistent with what was reached[11].

The interaction between the levels of the mineral and the levels of nitrogen significantly increased the amount of potassium in the soil. The B2N4 treatment achieved the highest amount of ready potassium in the soil, which amounted to 293.33 mg K kg^{-1} soil, with an increase of 7.93% compared to the treatment of no addition (comparison), which gave the lowest average. It reached 155.33 mg K kg-1 soil. In contrast, the rest of the treatments only differed significantly between them, and this may be due to the fixation of ammonium by specific areas in the perlite network because it is linked to perlite with the most excellent density of all cations, which leads to the liberation of potassium from these areas and thus increases its readiness in the soil. The results are in agreement with the Markoska [12].

B	N					Mean
	N0	N1	N2	N3	N4	
B0	155.33	170.00	182.33	202.33	209.66	181.93
B1	167.66	207.33	226.00	280.66	270.00	230.33
B2	174.66	211.33	261.00	279.66	293.33	244.00
Mean	162.55	196.22	223.11	254.22	257.66	
L.S.D$_{0.05}$	**N**		**B**		**N×B**	
	8.07		6.37		11.31	

Table 3. The effect of perlite and nitrogen levels on pH soil when adding the first batch of nitrogen.

Available potassium in the soil when adding the second batch of nitrogen:

The results of Table 4 indicated that adding perlite levels significantly affected the values of available potassium in the soil after adding the second batch of nitrogen fertilizer. Increasing the levels of perlite led to an increase in the values of available potassium in the soil with averages of 241.96 and 272.82 mg K kg^{-1} soil for the levels of addition B1 and B2, respectively, achieving an increase of 31.00 and 47.70% over the non-addition treatment (comparison) B0, which gave the lowest average amount of potassium available in the soil 184.7 mg K kg^{-1} soil.

The addition of nitrogen levels was significant in the values of available potassium in the soil. N3 did not differ significantly from level N4, achieving the highest amount of potassium available in the soil, amounting to 261.16 and 266.08 mg K kg^{-1} soil, respectively. Both of them were significantly superior to the levels N1 and N2. The available potassium in them was 224.36 and 241.88 mg K kg^{-1} soil, respectively, while the lowest amount was when the no addition treatment (comparison), which amounted to 169.16 mg K kg^{-1} soil. The reason may be due to the displacement of the potassium ion from the exchange complex and the layers of clay minerals in the high concentrations of ammonium resulting from the added urea due to the convergence of their sizes. It is also due to the oxidation of ammonium by the nitrification process, and the formation of nitrates, which reduces the degree of reaction and thus increases the solubility of some compounds and minerals containing potassium, which was reflected in its readiness in the soil, and this is consistent with Khairo[14]; BarTal[15]; Al-Yassari[16].

The interaction between the levels of the mineral and the levels of nitrogen had a significant effect in increasing the amount of potassium in the soil, and B2N3 treatment achieved the highest amount of potassium in the soil, which amounted to 310.66 mg K kg^{-1} soil, with an increased rate of 53.54%. In contrast, it did not achieve a significant difference with the treatments B1N4 and B2N4, in which the amount of potassium was 291.00 and 295.33 mg K kg^{-1} soil, respectively, while the lowest value was when the treatment of no addition (comparative) B0N0, which amounted to 146.16 mg K kg^{-1} soil, while the rest of the treatments differed significantly in the amount of potassium available, perhaps the reason is that mixing perlite with chemical fertilizers added to the structure of perlite mineral, which contains large cavities that retain nutrients, including ammonium, and thus increases the chemical and fertility properties of the soil[17].

B	N					Mean
	N0	N1	N2	N3	N4	
B0	146.16	184.33	195.33	202.33	212.33	184.7
B1	182.66	223.33	242.33	270.50	291.00	241.96
B2	195.66	265.43	288.00	310.66	295.33	272.82
Mean	169.16	224.36	241.88	261.16	266.08	

L.S.D0.05	N	B	N×B
	6.05	5.59	9.56

Table 4. Effect of perlite and nitrogen levels on prepared potassium (mg N kg^{-1} soil) after adding the second batch of nitrogen.

Available Potassium in soil (mg kg^{-1} soil) after harvest:

Table 5 shows the significant effect of adding perlite levels on the values of available potassium in the soil after harvesting. The B2 level outperformed the rest of the B1 level, with an average of 258.63 mg K kg-1 soil, with an increase of 60.24% compared to the level of no addition (comparative) B0, which amounted to 161.40 mg K kg^{-1} soil.

The addition of nitrogen fertilizer at different levels showed a significant increase in the values of ready potassium in the soil after harvest compared to the level of no addition (the comparison), where the levels of N1, N2, N3, and N4 achieved averages of 226.93, 240.91, 246.50 and 253.22 mg K kg^{-1} soil, respectively, with increases of 51.20, 60.52, 64.24 and 68.72%, respectively, over the comparison level, which recorded the lowest average of 150.08 mg K kg^{-1} soil, N4 has significantly outperformed all other levels of addition. A decrease in the values of ready potassium is noted after the harvest compared to the stage of adding the second batch of nitrogen because the process of wheat cultivation and its growth, the accompanying absorption and fixation of quantities of potassium in an unprepared form, all of which leads to a decrease in its values, and this is consistent with what was reached by Khairo[14]; Al-Yassari[16]; Johnston and Milford[18].

The interaction between metal levels and nitrogen levels led to a significant increase in this trait, where the interaction of the B2N4 treatment outperformed all other treatments except for the B2N3 treatment, where it did not significantly outperform it. With an increase of 78.58 and 81.81%, respectively, compared to the control treatment, which gave the lowest average of 138.73 mg K kg-1 soil.

B	N					Mean
	N0	N1	N2	N3	N4	
B0	138.73	150.40	163.06	172.00	182.83	161.40
B1	151.20	257.06	278.00	281.16	285.33	250.55
B2	160.33	273.33	281.66	286.33	291.50	258.63
Mean	150.08	226.93	240.91	246.50	253.22	
L.S.D0.05	N		B		N×B	
	3.724		2.335		5.986	

Table 5. Effect of perlite and nitrogen levels on post-harvest potassium of wheat (mg K kg^{-1} soil).

Biological yield (microgram ha^{-1}):

Table 6 shows increased biological yield with increased levels of added perlite. The levels B1 and B2 gave averages of 16.74 and 19.21 mcg ha^{-1}, with an increase of 24.09 and 42.40%, respectively, to the no-addition treatment (comparison), which gave the lowest average of 13.49 mcg ha^{-1}. It is noted from the table that the B2 level was significantly superior to the B1 level.

The addition of nitrogen fertilizer at different levels significantly affected the biological yield. The levels of N1, N2, N3 and N4 gave averages of 15.68, 17.09, 17.85 and 18.65 mcg ha^{-1}, with an increase of 37.62 and 43.79%, respectively, for the levels N3 and N4 compared to the non-addition (comparative) level, which gave the lowest average of 12.97 mcg ha^{-1}. It is noted that the N4 level did not differ significantly from the N3 level, but it was significantly superior to the rest of the other levels. The reason is that the addition of nitrogen fertilizer leads to an increase in the plant's ability to grow and produce straws and improve the performance of vital processes within the plant, thus exploiting most of the nitrogen absorbed from the roots to increase the size of the vegetative group and grains, these results were in agreement with what was found by Al-Waeli[21]; Al-Murjani[22]; Faraj and Jajoua[23].

The interaction between the mineral levels and nitrogen fertilizer levels led to a significant increase in this trait. The interaction treatment B2N4 outperformed and gave the highest value of 21.88 mcg ha^{-1} with an increase of 90.75% compared to the treatment of no addition (comparison) B0N0 which gave an average of 11.47 mg ha^{-1}, while the rest of the treatments varied significantly between them between rise and fall. This increase is because the mineral reduces the loss of urea by washing to retain it in the mineral gaps and release it slowly, which provides the available nitrogen for the plant continuously, and this led to an increase in the vital yield of the cultivated crops[24]. Adding minerals with chemical fertilizers gave a high production in the plant, just as when treating the soil with minerals leads to a high yield of wheat plant due to the adsorption of major nutrients, including nitrogen, phosphorous and potassium, which have a significant impact on the growth and productivity of the crop[25].

B	N					Mean
	N0	N1	N2	N3	N4	
B0	11.47	12.40	13.83	14.48	15.25	13.49
B1	12.87	15.81	17.89	18.32	18.83	16.74
B2	14.57	18.85	19.56	20.74	21.88	19.21
Mean	12.97	15.68	17.09	17.85	18.65	
L.S.D$_{0.05}$	**N**		**B**		**N×B**	
	0.11		0.08		0.19	

Table 6. Effect of perlite and nitrogen levels on the biological yield of wheat (mcg ha^{-1}).

Grain yield (mcg ha^{-1}):

Table 7 shows the significant effect of adding perlite levels on grain yield, as B1 and B2 levels gave averages of 6.71 and 7.22 mcg ha^{-1}, with an increase of 40.67 and 51.36%, respectively, compared to the non-addition level (comparison). Which reached the lowest average of 4.77 mcg ha-1, and it is noted that the B2 level was significantly superior to the B1 level.

Table 7 shows the significant effect of adding nitrogen levels on grain yield. The levels of N1, N2, N3, and N4 gave averages of 6.00, 6.11, 7.09 and 7.10 mcg ha^{-1}, with an increase of 37.66 and 37.86%, respectively, for the two levels of N3. Furthermore, N4 from the level of no addition (comparison) gave the lowest yield of 5.15 mcg ha^{-1}, and it is noted that the N4 level did not differ significantly from the N3 level. However, they differed significantly at the other levels, and the N2 level did not differ significantly from the N1 level. However, they differed significantly. With the comparison treatment (no addition), the reason may be due to the increase in the nitrogen content in the plant (table 14), and its increased availability and absorption lead to an increase in vital processes. The number of grains per spike and the weight of one grain agree with Al-Waeli[21], Faraj and Jadoua[23].

The interaction between the mineral and nitrogen fertilizer levels led to a significant increase in grain yield, and the B2N3 treatment outperformed the control treatment (no addition). However, it did not differ significantly from the B2N4 interaction treatment, as these two treatments gave the highest averages, reaching

9.01 and 8.88 mcg ha- 1Respectively, with an increase of 109.53 and 106%, respectively, compared to the treatment of no addition (comparative), which gave the lowest average of 4.30 mcg ha^{-1}. The reason may be the quantities of fertilizers added before and during plant growth from nitrogen and potassium fertilizers, increasing grain yield. The mineral has an apparent effect on retaining it (nitrogen and potassium) for a period that accompanies the length of the growing season. The results are consistent with Hussain[27].

B	N					Mean
	N0	N1	N2	N3	N4	
B0	4.30	4.82	4.81	4.94	5.01	4.77
B1	5.28	6.63	6.93	7.34	7.41	6.71
B2	5.87	6.55	6.61	9.01	8.88	7.22
Mean	5.15	6.00	6.11	7.09	7.10	
L.S.D0.05	N		B		N×B	
	0.24		0.18		0.42	

Table 7. Effect of perlite and nitrogen levels on wheat grain yield (mcg ha^{-1}).

Potassium concentration in the plant (%):

Table 8 shows that the addition of perlite levels had a significant effect on the potassium concentration values in the plant after harvest. The increase in perlite levels led to an increase in the potassium concentration values in the plant with averages of 1.97 and 2.14% for the levels of addition B1 and B2, respectively, achieving an increase of 23.12 And 33.75% of the non-addition level (comparative) B0, which gave the lowest potassium concentration in the plant 1.60%.

Table 8 shows the significant effect of adding nitrogen levels on the values of potassium concentration in the plant after harvest. It is noted from the table that the N4 level achieved significant differences with an average of 2.31% and an increase of 80.46% compared to the (comparative) addition level, which averaged 1.28%. Perhaps The reason for the increase is due to the role of nitrogen in building several compounds within the vegetable system that require its formation and participation in metabolism and growth regulators such as cytokinin and the formation of proteins that stimulate and absorb potassium and thus increase its concentration in the plant, and this is consistent with what was reached[21, 29].

The interaction between the levels of the mineral and the levels of nitrogen fertilizer significantly increased the amount of potassium concentration in the plant, as the interaction B2N3 treatment outperformed the highest amount of potassium absorbed in the plant, which gave an average of 2.70%. At the same time, it reached the lowest value when treating B0N0, which amounted to 1.25%. As for the rest of the treatments, they varied morally, and this may be because when mixing the mineral with chemical fertilizers, the mineral has a high ability to retain water and elements for an extended period, including potassium in its ready form in the soil, and thus reduces its loss and increases its absorption by the roots and increases its concentration in the soil. This is consistent with what was found by Schmilewski[4].

B	N					Mean
	N0	N1	N2	N3	N4	
B0	1.25	1.36	1.36	2.08	1.93	1.60
B1	1.30	2.00	2.07	1.99	2.52	1.97
B2	1.31	1.82	2.37	2.70	2.49	2.14

Mean	1.28	1.72	1.93	2.25	2.31	
L.S.D0.05	**N**		**B**		**N×B**	
	0.011		0.01		0.02	

Table 8. Effect of perlite and nitrogen levels on potassium concentration in wheat (%).

Potassium absorbed in the plant (kg k ha^{-1}):

Table 9 indicates the significant effect of adding different levels of perlite. The increase in perlite levels led to an increase in potassium absorption in the plant with averages of 33.8 and 41.9 kg k ha^{-1} for the levels of addition B1 and B2, respectively, achieving an increase of 55.04 and 92.20%. The reason for the positive role of the mineral in preserving nutrients and consequently increasing its concentration in the plant and consequently increasing the amounts of final total absorption calculated based on the concentration and dry weight of the plant, respectively, for the treatment of no addition (comparison) which achieved a minimum average of 21.8 kg K ha^{-1}.

Table 9 shows the moral effect of adding nitrogen levels on the values of potassium absorbed in the plant. It was noticed from the table that the level of N4 outperformed all other levels of addition, as it achieved an average of 43.7 kg K ha^{-1}. In contrast, the non-addition treatment achieved N0 less An average of 16.6 kg K ha^{-1}, and this is consistent with the results of Yang and Skogley[30], that the ammonium ions in the soil solution play a significant role in increasing the speed of potassium liberation and thus increasing its uptake by the plant.

The interaction between the levels of the mineral and the levels of nitrogen significantly affected the amount of potassium absorbed in the plant, as we note from the table that the interaction treatment B2N3 and B2N4 had the highest amount of potassium absorbed in the plant, which amounted to 55.9 and 54.4 kg K ha^{-1}, respectively. At the same time, the lowest value was reached When the treatment of B0N0 amounted to 14.3 kg K ha^{-1}. In contrast, the rest of the treatments varied significantly between rising and falling. Perhaps the presence of ammonium works to reduce the adsorbed and fixed amount of potassium in the clay minerals in the soil because ammonium can enter between the layers of minerals to dissolve potassium is replaced due to the convergence of its radii, and this increases its absorption by the plant, and this is consistent with what was reached by Yang and Skogley[30].

B	**N**					**Mean**
	N0	**N1**	**N2**	**N3**	**N4**	
B0	14.3	16.8	18.8	30.1	29.4	21.8
B1	16.7	31.6	37.03	36.4	47.4	33.8
B2	19.08	34.3	46.3	55.9	54.4	41.9
Mean	16.6	27.5	34.04	40.8	43.7	16.6
L.S.D0.05	**N**		**B**		**N×B**	
	1.20		0.85		3.80	

Table 9. Effect of perlite and nitrogen levels on potassium absorbed in wheat (kg K ha^{-1}).

Discussion

The results show the significant effect of adding perlite levels on the values of available potassium in the soil after adding the first batch of nitrogen fertilizer. The reason may be attributed to the composition of the mineral from the factors affecting the process of liberating potassium, and one of the most critical aspects of the shape of the mineral composition is the availability of gaps at the surfaces and edges areas. These gaps affect the cation exchange capacity of the metal by allowing and accelerating the cations of the soil solution to the internal sites of the metal, which increases the rate of potassium displacement from these gaps and thus increases its readiness in the soil and this is consistent with what was reached[10], or the reason may be due to the effect of the low soil reaction due to the effect of adding perlite, which causes dissolution and decomposition of minerals and the release of potassium ion. The results also indicated that adding perlite levels significantly affected the values of available potassium in the soil after adding the second batch of nitrogen fertilizer. This is because the exchangeable cations in perlite, potassium and calcium are trapped inside cavities in the perlite structure. These cations can be replaced by ammonium and other metal cations depending on the pH value and its concentration. This is agreed with the results of Mazeikiene[13]. However, the results show the significant effect of adding perlite levels on the values of available potassium in the soil after harvesting. The reason may be that the cations within the interchangeable perlite, potassium and calcium, are trapped within cavities in the perlite structure. These cations can be replaced by ammonium and other metal cations depending on the pH value and its concentration. This is agreed with the results of Mazeikiene[13].

Conclusions

Whereas the results show that there is an increase in the biological yield with the increase in the levels of added perlite, this increase may be due to the positive role of the mineral in improving the fertile soil properties, especially the nitrogen and potassium elements, as it had a significant effect in increasing the height of the plant This is normal, accompanied by high vegetative growth of leaves, stems and ears, which is reflected in an increase in the biological yield, for the plant[19, 20]. Also, the results show the significant effect of adding perlite levels on grain yield. The reason is due to the role of the mineral in increasing the grain yield, as the mineral provides nutrients to the plant better, including the ready nitrogen in the soil, which is reflected in the increase in its concentration In the plant and, consequently, it is represented in grain proteins that increase the productivity of the plant, and this is consistent with what was found with Faraj and [23]; [26]. Furthermore, the results show that adding perlite levels significantly affected the potassium concentration values in the plant after harvest. The reason may be due to the ability of perlite to provide ready-made nutrients, including potassium, in the plant[28]. Finally, the results indicate the significant effect of adding different levels of perlite, and the increase in perlite levels led to an increase in potassium absorption in the plant.

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