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Effect of adding perlite and nitrogen level on the growth and yield of wheat (*Triticm aestivum* L.)

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Abstract

This study was conducted at 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 N level on growth and yield of wheat (*Triticum eastvum* L.). A factorial field experiment, according to a Randomized Complete Block Design (RCBD) with three replicates. The experiment included two factors, the first one 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 N at five levels (0, 50, 100, 150 and 200) kg N ha^{-1} has the symbol N0, N1, N2, N3 and N4 respectively. 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 plant growth traits, including plant height, chlorophyll, biological yield, grain yield, N and P concentration in the plant. The effect of adding N fertilizer to the soil at a level of 200 kg N ha^{-1} in improving plant growth characteristics, including plant height, chlorophyll and K concentration in the plant, while there was no significant difference with the level of 150 kg N ha^{-1} for each of the N concentration in the plant and t The biological yield and grain yield.

Key words: Perlite, nitrogen, growth, yield, wheat (*Triticum aestivum* L.).

Introduction

Perlite is a material with small grains, about 1-5 mm in diameter, white in color, produced by heating silicon volcanic rocks up to 1000 m, which leads to an increase in the size of its grains from 4 to 20 times of its original size (Nelson, 2012). Agricultural perlite was characterized by its high ability to absorb water and retain fertilizer for a long time, thus, it is spaced between the stages of irrigation, in addition to its high ability to exchange positive ions, it has a neutral pH (6.5-7.5), thus, it works to preserve nutrients, including K and N nitrogen, in available- form for a long time without fixing it (Verdonck and Demeryer, 2004; Schmiewski, 2009).

Potassium is one of the most important

nutrients, its important role in many vital processes in plants, the earth's crust contains large amounts of potassium, but it is not enough for the plant's need because it is not available, exploiting or taking advantage of these restricted quantities, many natural or chemical materials have been used, to be added to plants or soil, lead to increase the availability of potassium or maintain it directly or indirectly, within sufficient levels for the plant, among these substances, which are called preservatives for moisture and nutrients, such as perlite mineral (Evans, 2004).

Nitrogen is an important nutrient for plants in agricultural ecosystems, plants take N from the soil through the roots in the form of ammonium NH_4^+ and nitrate NO_3^-, it is important for most of the vital processes in plants, its presence in the soil has an important and positive role in increasing the availability of many elements in the soil, including phosphorus (P) and potassium (K) (Qin et al., 2017).

The wheat crop, *Triticum aestivum* L., is one of the most important cereal crops in the world, and is a major source of human and animal nutrition. The wheat crop in Iraq suffers from a decrease in the agricultural yield unit, for reasons related to soil, irrigation water, crop variety and crop management methods, and the decline of nutrients in the growth stage of the crop due to reasons related to agricultural management, water scarcity, and lack of availability of nutrients (Shafak and Al-Dababi, 2008).

This research aims to study the effect of perlite mineral and N level on the availability and release of K in the growth and yield of wheat.

Material and methods

The experiment site:

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

Soil sample Collection:

Soil samples were taken from a depth of 0-30 cm and from different locations in the experimental field, the samples were mixed together to homogenize them, air dried, softened and passed through 2mm sieve, the chemical and physical analyses were carried out (Table 1).

Table (1) some chemical and physical properties of field soil.

	Parameters	Unit	Value
Chemical properties	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
	Silt		49.20
	Clay		32.71
	Texture	Clay loam	

Measurements required for some studied characteristics of the plant

1. Plant height (cm).

It was calculated as an average height of ten plants chosen randomly from the experimental unit and measured by measuring tape from the base of the plant touching the soil surface to the top of the spike without the awn.

2. Chlorophyll SPAD.

A measure of ten plants were randomly selected at the flowering stage, using a SPAD 520-meter device.

3. Biological yield (megagram 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).

4. Grain yield (megagram ha^{-1}).

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

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 the symbol 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 with three replicates, so that the total number of units was 45 experimental units.

Table (2) Chemical and physical properties of perlite mineral

Oxides	**Chemical symbol**	**Percent**
Silicon dioxide	SiO_2	72-75%
Potassium oxide	K_3O	2.8-4.3%
Water content	H_2O	3.2-4.5%
Properties	**Value**	**Unit**
Color	White	-
pH	7.5-6.5	-

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Experiment design and statistical analysis

This study was carried out a factorial experiment in 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 on the basis of analysis of variance for the studied traits according to the factorial trials method of RCBD using the statistical program (GENESTAT) and the comparison between the means of transactions was done using the Least Significant Difference (LSD) test at a probability level of 0.05.

Results and Discussion

Plant Height (cm):

Table (3) showed that the addition of perlite at different levels showed a significant effect on plant height compared to the treatment of no addition (control). The levels of addition B1 and B2 achieved averages of 94.06 and 99.93 cm, respectively, with an increase of 11.53 and 18.49%, respectively, compared to the control treatment which recorded the lowest average of 84.33 cm, B2 was significantly superior to the level B1. The reason is that minerals have the capacity to preserve moisture or provide water and elements, especially nitrogen, in a ready state in the root zone, which increases the availability of nutrients in the root zone throughout the vegetative growth period, which helped in the elongation of the stem (Borrel *et al*., 2000), these results encourage adding percentages of metal to the soil to improve its productivity, and the growth of grain crops in it for the purpose of production and fodder. The improvement of root growth with an increase in the proportion of metal added to the soil has contributed to increasing the vegetative growth of the plant and increasing its height.

Table (3) shows the significant effect of nitrogen fertilizer levels on plant height values compared with the control treatment, N4 level was significantly superior to all other levels, as it gave the highest average of 99.68 cm, with an increase of 18.83% over the non-addition (control) level, which reached an average of 83.88 cm, N2 level did not differ significantly with the N1 level, which gave an increase of 8.75 and 10.33% compared with the control treatment. The reason for the increase in the height of the plant may be due to the increase in N availability in the soil, and then the increase in its uptake by the roots of the plant, increasing the activity of vital processes, and since N is one of the fast-moving elements, it moves to new growth in plant, and increases cell division and elongation, and thus increases the height of the plant, it also works on the formation and regulation of gibberellin acid, which in turn makes the plant thicker and prevents it from lodging. These results are in agreement with the findings of Al-Murjani (2005); Abdullah *et al*.,(2011) and Singh *et al*., (2014).

Table (3) showed that the interaction between mineral levels and nitrogen fertilizer levels resulted in significant differences in plant height trait. B2N3 and B2N4 were superior to each other without significant differences in plant height only and gave averages of 105.66 and 107.66 cm, respectively, whereas, treatment B0N0 gave the lowest mean of 75.66 cm, while the rest of the treatments varied significantly among themselves. The reason was that the minerals (1:2) were distinguished in raising the availability of

NH_4^+ and K in the soil, which are the two essential elements (NK) in plant growth, thus, it increases plant height (Gairley *et al*., 2015), or that N is one of the fast-moving elements inside the plant, so it moves to the newly formed parts, such as the meristems responsible for growth, leads to an increase in cell division and elongation, and thus an increase in the height of the plant, and this is consistent with what was reached (Al-Badrany, 2010).

Table (3) Effect of perlite and nitrogen levels on the plant height (cm) of wheat.

B	**N**					**Mean**
	N0	**N1**	**N2**	**N3**	**N4**	
B0	75.66	83.33	86.00	87.66	89.00	84.33
B1	87.00	91.00	92.66	97.66	102.00	94.06
B2	89.00	99.33	99.00	105.66	107.66	99.93
Mean	83.88	91.22	92.55	97.00	99.68	
L.S.D$_{0.05}$	**N**		**B**		**N×B**	
	1.56		1.20		2.70	

Chlorophyll (SPAD):

Table (4) shows that there is an increase in plant chlorophyll with increasing levels of added perlite, addition levels B1 and B2 gave averages of 34.42 and 36.44 SPAD, respectively, with increases of 14.88 and 21.62%, compared with the level of control, which gave the lowest average of 25.36 SPAD, B2 level has significantly outperformed the rest of the other addition levels, as a result of the mineral's ability to keep nutrients ready for a long time, including nitrogen, which is important in the formation of chlorophyll for plants.

Table (4) shows that the addition of N fertilizer at different levels had a significant effect on the plant chlorophyll,

The levels N1, N2, N3, and N4 gave the highest averages of 28.88, 31.28, 40.76 and 42.66 SPAD, respectively, with an increase of 67.73 and 75.55%, respectively, for levels N3 and N4 over the level of control, which gave the lowest average of 24.30 SPAD. The increase is due to the fact that nitrogen is an important part of the formation of chlorophyll, so it is of great importance in the photosynthesis process, and these results are consistent with what was found (Mahmoud *et al*., 2005; Al-Mousawi, 2015).

Table (4) shows that the interaction between the levels of the mineral and the levels of nitrogen fertilizer led to a significant increase in this trait. The interaction treatment B2N3, which gave the highest mean of 49.76 SPAD, outperformed it with an increase of 96.21% over the control treatment (B0N0), which gave the lowest average of 25.36 SPAD, while the rest of the treatments have varied between them, rise and fall and this is due to the role of the mineral in preserving nutrients, including N in the soil, and thus affects the formation of chlorophyll in the plant.

Table (4) The effect of perlite and nitrogen levels on the chlorophyll content of wheat leaves (SPAD).						
B	**N**					**Mean**
	N0	**N1**	**N2**	**N3**	**N4**	
B0	25.36	27.33	28.20	33.76	35.13	29.96
B1	26.23	28.63	33.06	38.76	45.43	34.42
B2	21.30	30.70	32.60	49.76	47.86	36.44
Mean	24.30	28.88	31.28	40.76	42.66	
L.S.D$_{0.05}$	**N**		**B**		**N×B**	
	0.47		0.36		0.81	

Biological yield (megagram ha^{-1}).

Table (5) shows that there is an increase in the biological yield with the increase in the levels of added perlite, B1 and B2 gave averages of 16.74 and 19.21 megagram ha^{-1}., respectively, with an increase of 24.09 and 42.40%, respectively, than the no-addition treatment, which gave the lowest average of 13.49 mcg ha-1. B2 was significantly superior to the level B1 and this increase; it may be due to the positive role of the mineral in improving the fertile soil properties, especially the N and K elements. Table (4) had a significant effect on increasing plant height, and this is normal, accompanied by a high vegetative growth of leaves, stems and tillers, which is reflected in the increase in the biological yield of the plant (Abdul-Hassan, 2018; Asher *et al*., 2008).

Table (5) showed that the addition of N fertilizer at different levels had a significant effect on the biological yield, N1, N2, N3, and N4 gave averages of 15.68, 17.09, 17.85, and 18.65 megagram ha^{-1} respectively, with an increase of 37.62 and 43.79%, respectively, for levels N3 and N4 over the level of control treatment, which gave the lowest average of 12.97 megagram ha^{-1}., N4 level did not differ significantly with 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, produce straws and improve the performance of vital processes within the plant, thus, most of the nitrogen absorbed from the roots is exploited to increase the size of the vegetative part and grains, and these results are consistent with what was found (Al-Waeli, 2002; Al-Murjani, 2005; Faraj and Jadoua, 2015).

Table (5) indicates that the interaction between the levels of the mineral and the levels of nitrogen fertilizer has led to a significant increase in this trait, the interaction treatment B2N4 outperformed and gave the highest value of 21.88 megagram ha^{-1}. with an increase of 90.75% over the no addition treatment (control) B0N0 which gave an average of 11.47 megagram ha^{-1}., while the rest of the transactions varied significantly between them, between rise and fall, this increase is due to the fact that the mineral reduces the loss of urea by washing to retain it in the vacuoles of the mineral and release it slowly, thus providing the ready nitrogen to the plant continuously, led to an increase in the biological yield of the cultivated crops (Latifah *et al*., 2011), adding minerals with chemical fertilizers gave a high production in the plant, also, when treating the soil with metal, a high yield of wheat is obtained, for its adsorption of macronutrients, including N, P and K, which have a significant impact on the growth and productivity of the crop (Wiedenfeld, 2003).

Table (5) Effect of perlite and nitrogen levels on the biological yield of wheat plant (megagram ha^{-1}).

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	

Grain yield (megagram ha^{-1}).

Table (6) shows the significant effect of adding perlite levels on grain yield, B1 and B2 gave averages of 6.71 and 7.22 mcg ha-1, respectively, with an increase of 40.67 and 51.36%, respectively, compared to the level of no addition (control), which reached the lowest average of 4.77 mcg ha-1, B2 was significantly superior to the level B1. The reason is that the role of the mineral in increasing the grain yield, the mineral provides nutrients to the plant better, including nitrogen ready in the soil, which is reflected in the increase in its concentration in the plant, therefore, it is represented in grain proteins that increase plant productivity, and this is consistent with what was found (Faraj and Jadoua, 2015 and Zheng et al., 2018).

Table (6) shows the significant effect of adding nitrogen levels on grain yield, N1, N2, N3, and N4 gave averages of 6.00, 6.11, 7.09 and 7.10 megagramha^{-1}., respectively, with an increase of 37.66 and 37.86%, respectively, for levels N3 and N4 over the level of no addition (control), which gave the lowest yield of 5.15 mcg ha-1, N4 level did not differ significantly with the N3 level, but they differed significantly on the other levels, and the N2 level did not differ significantly with the N1 level, but they differed significantly with the comparison treatment (control). The reason may be due to the increase in nitrogen content in the plant, and the increase in its availability and absorption leads to an increase in vital processes. It is one of the components of enzymes, proteins and chlorophyll, it was involved in all processes, enzymatic reactions and photosynthesis and works to increase the fertilization of the branches bearing the ears, in addition to an increase in the number of grains in the spike and the weight of one grain, and these results are consistent with (Al-Waeli, 2002; Faraj and Jajoua, 2015).

Table (6) showed that the interaction between the levels of the mineral and the nitrogen fertilizer led to a significant increase in the grain yield. The B2N3 treatment was superior to the comparison treatment (no addition), but it did not differ significantly with the B2N4 interaction treatment, these two treatments gave the highest averages of 9.01 and 8.88 mcg ha-1, respectively, with an increase of 109.53 and 106%, respectively, over the no-addition treatment (control), which gave the lowest average of 4.30 megagram ha^{-1}. The reason may be due to the quantities of fertilizers added before and during plant growth from nitrogen and potassium fertilizers, which increased the grain yield, which the mineral had a clear effect on retaining it (N and K) for a period that accompanies the length of the growing season. The results agree with (Hussain, 2019).

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

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	
$L.S.D_{0.05}$	N		B		N×B	
	0.24		0.18		0.42	

Nitrogen concentration in plants (%):

Table (7) indicated the effect of adding perlite levels on the nitrogen concentration in the plant (%), the addition of levels of perlite led to a significant increase between the levels of the experiment. The addition levels B1 and B2 achieved averages of 2.13 and 2.34%, respectively, over the control level, which achieved the lowest average of 1.46%, and the percentage increase was 45.89 and 60.27%, respectively, over the comparison treatment. The reason may be due to the ability of perlite to provide nutrients, including N, which increases the absorption of N and thus is reflected in the concentration of N in the plant (Markoska *et al*., 2019).

Table (7) shows that the addition of N fertilizer at different levels had a significant effect on the N concentration in the plant. N3 level did not differ significantly with the N4 level, achieving the highest amount of N concentration in the plant, which amounted to 2.32 and 2.27%, respectively, and both of them were significantly superior to the levels N1 and N2, whose N concentration in the plant reached 1.94 and 2.09%, respectively, while the lowest value was at the control level, which amounted to 1.24%. The reason may be due to the increase in the availability and concentration of N in the soil and in the root zone and its homogeneous distribution with the increase of the addition, which raises the efficiency of the roots to represent the largest amount of N and thus increase its concentration in the plant and this is consistent with what was reached (Blockshow *et al*., 2002; Al-Murjani, 2005 and Farhan, 2005).

Table (7) shows the interaction between the levels of the mineral and the levels of nitrogen that there is a significant increase in the concentration of N in the plant between the interaction factors, the interaction treatment B2N4 was significantly superior with an average of 2.95% than the comparison treatment B0N0 with the lowest average of 1.22% and an increase of 141.80% over the comparison treatment, which did not differ significantly from the treatment B1N0, which amounted to 1.25%, while the rest of the transactions have varied between them significantly between rise and fall, perhaps the reason is due to the ability of perlite mineral to maintain the high amount of nitrogen in its ready form for a long time in the soil, which is reflected in its absorption by the plant and increasing its concentration.

Table (7) Effect of perlite and nitrogen levels on N concentration in wheat (%).

B	**N**					**Mean**
	N0	**N1**	**N2**	**N3**	**N4**	
B0	1.22	1.36	1.40	1.49	1.76	1.46
B1	1.25	2.28	2.33	2.74	2.09	2.13
B2	1.27	2.20	2.55	2.74	2.95	2.34
Mean	1.24	1.94	2.09	2.32	2.27	
L.S.D$_{0.05}$	**N**		**B**		**N×B**	
	0.060		0.046		0.10	

Potassium concentration in the plant (%):

Table (8) shows that the addition of perlite levels had a significant effect on the K concentration values in the plant after harvesting, the increase in the levels of perlite 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% over the control B0, which gave the lowest K concentration in the plant 1.60%. The reason may be due to the ability of perlite to provide available nutrients, including K, in the plant (Ippolito *et al*., 2011).

Table (8) showed the significant effect of adding N levels on the K concentration values in the plant after harvest, N4 achieved significant differences with an average of 2.31% and an increase rate of 80.46% compared to the level of comparison, which amounted to an average of 1.28%. The reason for the increase may be due to the role of N in building several compounds within the vegetable system that require its formation and participation in metabolic processes and growth regulators such as cytokine and the formation of proteins, which works to stimulate and absorb K and thus increase its concentration in the plant and this was consistent with what was reached (Barraclough and Haynes, 1996; Al-Waeli, 2002).

Table (8) shows that the interaction between the levels of the mineral and the levels of nitrogen fertilizer had a significant effect on increasing the amount of potassium concentration in the plant, the interaction B2N3 treatment had the highest amount of potassium absorbed in the plant, which gave an average of 2.70%, while it reached the lowest value when treating B0N0, which amounted to 1.25%, as for the rest of the transactions, they differed significantly, it may be due to the fact that when the mineral is mixed with chemical fertilizers, the mineral has a high ability to retain water and elements for a long time, including potassium in its ready form in the soil, thus, it reduces its loss and increases its absorption by the roots and increases its concentration in the plant, and this is consistent with the result of Schmilewski (2009).

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

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.D$_{0.05}$	**N**		**B**		**N×B**	
	0.01		0.01		0.02	

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