Growth and Yield Response of Four Bread Wheat Varieties (*Triticum aestivum* L.) to Spraying with NPK nano Fertilizer

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ABSTRACT

A Field experiment was carried out during the season 2021-2022 in two locations, the first location was in Gleokhan within the borders of Mosul Center and the second was in administrative borders of Namrod district, which is 45 km from the center of Mosul, in order to know the effect of the NPK 20:20:20 fertilizer nano on growth and yield of four varieties of wheat. The experiment was carried out, which consisted of two factors, a randomized complete block design with three replications. The first factor was NPK nano fertilizer levels (1, 2, and 3 gm.L^{-1}), in addition to comparison treatment, which was the traditional farmer's method of fertilization (adding urea and dap fertilizer according to times and quantities recommended by the Iraqi of Ministry Agriculture). Second factor was four varieties of wheat (Bhoth 22, Abu Ghraib, Rashid and Jihan). The most important results of the study were as follows: Control treatment excelled in total chlorophyll content at Gleokhan site and number of spikes , weight of 1000 grains at Namrod site(28.41 Spad, 267.75 spikes.m^{-2}, and 44.91 g), respectively. (1 g) treatment excelled in number of tillers, number of spikes, spike length, grain yield, and weight of 1000 grains at Gleokhan site, leaf area and spike length in Namrod site, (178.17 tiller.m^{-2}, 100.08 spikes.m^{-2}, 8.58 cm , 128.83 g.m^{-2}, 35.20 g, 34.46 cm^2 and 10.85 cm) respectively. (3 g) was superior in plant height for both sites, number of days up to 50% flowering, and grain yield in Namrod site(54.42 cm, 80.77 cm, 135.83 days, and 332.17 g.m^{-2}), respectively. Bhoth 22 excelled in total chlorophyll content, weight of 1000 grains at Gleokhan site, number of tillers, number of days up to 50% flowering, number of spikes, and grain yield in Namrod site(27.29 Spad, 34.23 g, 302.75 tiller.m^{-2}, 134.92 days, 290.17 spike.m^{-2} and 405.42 g m^{-2}) respectively. Abu Ghraib achieved superiority in number of grains per spike at Namrod site (46.43 grains.spike^{-1}). Rashid excelled in number of tillers, number of spikes, and spike length at Gleokhan site, flag leaf area and spike length at Namrod site (169.08 tiller.m^{-2}, 104.58 spike.m^{-2}, 8.56 cm, 34.55 cm^2 and 12.98 cm) respectively. Jihan achieved superiority number of days up to 50% flowering and grain yield at Gleokhan site, with values of (131 days and 108.08 g.m^{-2}) respectively. Interaction of (1 g) with Jihan recorded the highest average grain yield at Gleokhan site, and (3 g) with Bhoth 22 had the highest average grain yield at Namrod site with values of (301 and 487.67 g.m^{-2}) respectively.

استجابة نمو وحاصل أربعة أصناف من حنطة الخبز
(*Triticum aestivum* L.) للرش بسماد NPK النانوي

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الخلاصة

نفذت تجربة حقلية خلال الموسم 2021-2022 في موقعين الموقع الاول منطقة جليوخان ضمن حدود مركز الموصل والثاني في الحدود الادارية لقضاء النمرود التي تبعد 45 كم عن مركز الموصل لمعرفة تأثير سماد النانو NPK 20:20:20 في نمو وحاصل أربعة أصناف من الحنطة. نفذت التجربة التي تكونت من عاملين بتصميم القطاعات الكاملة الكاملة وبثلاثة مكررات. العامل الأول كان مستويات سماد النانو NPK (1، 2، 3 غم.لتر⁻¹)، بالإضافة إلى معاملة المقارنة وهي طريقة التسميد التقليدية للمزارع (إضافة سماد اليوريا والداب حسب الأوقات والكميات الموصى بها من قبل وزارة الزراعة العراقية). أما العامل الثاني فهو أربعة أصناف من الحنطة (بحوث 22، أبو غريب، رشيد، جيهان). وكانت أهم نتائج الدراسة كما يلي: تفوقت معاملة المقارنة في صفة محتوى الكلوروفيل الكلي في موقع جليوخان ولصفتي عدد السنابل ووزن 1000 حبة في موقع النمرود (28.41 سباد، 267.75 سنبلة.م⁻²، و44.91 غم) على التوالي. تفوقت معاملة التسميد النانوي (1 غم) في صفات عدد الاشطاء وعدد السنابل وطول السنبلة وحاصل الحبوب ووزن 1000 حبة في موقع جليوخان ولصفتي المساحة الورقية وطول السنبلة في موقع النمرود (178.17 شطأ.م⁻²، 100.08 سنبلة. م⁻²، 8.58 سم، 128.83 غم⁻²، 35.20 غم، 34.46 سم² و 10.85 سم) على التوالي. تفوقت معاملة التسميد (3 غم) في صفة ارتفاع النبات لكلا الموقعين، وفي صفتي عدد الايام حتى 50% تزهير، وحاصل الحبوب في موقع النمرود (54.42 سم، 80.77 سم، 135.83 يوم، و332.17 غم.م⁻²) على التوالي. تفوق الصنف بحوث 22 في محتوى الكلوروفيل الكلي، وزن 1000 حبة في موقع جليوخان، ولصفات عدد الاشطاء، وعدد الايام حتى 50 % التزهير ، وعدد السنابل، وحاصل الحبوب في موقع النمرود (27.29 سباد، 34.23 غم، 302.75 شطأ.م⁻² ، 134.92 يومًا، 290.17 سنبلة.م⁻² و405.42 غم.م⁻²) على التوالي. وتفوق الصنف أبو غريب في عدد الحبوب للسنبلة الواحدة في موقع النمرود (46.43 حبة.سنبلة⁻¹). والصنف رشيد في عدد الاشطاء وعدد السنابل وطول السنبلة في موقع جليوخان ومساحة ورقة العلم وطول السنبلة في موقع النمرود (169.08 سنبلة.م⁻²، 104.58 سنبلة.م⁻²، 8.56 سم، 34.55 سم²، 12.98 سم).) على التوالي. في حين كان تفوق الصنف جيهان في عدد الايام حتى 50% تزهير وحاصل الحبوب في موقع جليوخان (131 يوم و108.08 غم.م⁻²) على التوالي. سجل التداخل بين معاملة التسميد (1 غم) والصنف جيهان أعلى متوسط لصفة حاصل الحبوب في موقع جليوخان، كما سجل تداخل معاملة التسميد (3 غم) والصنف بحوث 22 أعلى متوسط لحاصل الحبوب في موقع النمرود (301 و 487.67 غم.م⁻²) على التوالي.

الكلمات المفتاحية: حنطة خبز ، سماد مركب ، NPK ، نانو ، اصناف

INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is a cereal crop belonging to the Poaceae family. It is one of the oldest crops cultivated and improved by humans thousands of years ago to the present day (Wolde *et al.,*, 2019). The crop ranks second in terms of global grain production after maize, and ranks first in terms of cultivated areas in the world, which reached in the season (2021-2022) is (222.19) million hectares, with a yield rate of (3.1) t.h⁻¹, with a productivity of (779.24) million tons. The countries of the European Union, China, India, Russia, United States of America, Canada and Australia are among the most producing countries for it (USDA ,2022).

The wheat crop was called king of cereals, because it has a good balance between proteins and carbohydrates, as it supplies the human body with approximately 25% of its need for protein and calories. and adequate amounts of essential amino acids (Costa *et al.,* 2013). Varieties are one of the important factors that have a direct impact on growth, productivity and quality traits, as well as their ability to adapt to various surrounding environmental conditions, as it was found in many recent scientific studies and researches that the overlap between environmental conditions, varieties and balanced management of

nutrients have a significant impact on increasing production and improving its quality. (Maes, 2016). Al-Fahdawi (2021) found when studied five varieties of wheat, was A significant difference between them, as the variety (Sham 6) excelled in yield traits and its components (number of grains per spike, total grain yield, and biological yield), while the variety outperformed (Bhoth 22) and recorded the highest mean for the characteristic of spike length, which was (12.85) cm. Al-Saadoun *et al.,*(2022) they found discrepancies between the varieties included in the study, which are sixteen Iraqi varieties and six Egyptian varieties introduced to all the studied traits, where the variety (Jamiza 7) excelled in the characteristic of flag leaf area.

Nanomaterials include materials whose particle diameters range between 1-100 nanometers (Liu and Lal, 2015). Nanomaterials are characterized by the fact that their surface area-to-volume ratio is greater than that of their volumetric materials due to the small size of their particles (Servin *et al.,* 2015) which leads to a difference in chemical, physical and mechanical properties. Nano fertilizers are considered an effective alternative to traditional fertilizers due to their ease of absorption and entry into cells, improving their vital functions and the efficiency of their effect due to their small size and the ability of nanoparticles to bind to protein carriers and penetrate the cell wall, thereby encouraging an increase in the transfer of nanomaterials between cells (Grover *et al.,* 2012). Among the recent studies on nano-fertilizers and in the experiment of Aziz and Nasser (2020) to know the effect of planting distances and spraying with integrated nano-fertilizer on growth and yield of bread wheat, it was noted that the treatment of nano-spraying fertilization with a concentration of 4.5 ml.l-1 had a significant superiority and recorded the highest averages compared with other concentrations (0, 2.5, 3.5, 4.5) ml.l^{-1} for traits of number of spikes (650.22 spikes.m^{-2}), grain yield (7.96 ton.h^{-1}), and weight of 1000 grains (44.87 g). Reza (2022) explained in her study to find out the genetic variation of genotypes of bread wheat under different concentrations of NPK nano- fertilizer, that the spray concentration (4) gm.l^{-1} was superior to rest of spray levels in traits of plant height (93.85 cm) and leaf area (27.47 cm^2), chlorophyll content (25.38 Spad), number of tillers (562.47 tiller.m^{-2}), spike length (10.57 cm), number of spikes (466.76 spike.m^{-2}), and grain yield (6045.43 kg.h^{-1}) The variety (Fayyad) which its interaction with spraying treatment (4) gm.l^{-1} was superior in terms of number of spikes (474 spikes.m^{-2}) and grain yield (7229 kg.h^{-1}). Therefore the purpose of this research is to study the effect of growth and yield traits of four bread wheat varieties for spraying with NPK nano fertilizer.

MATERIALS AND METHODS

A Field experiment was carried out in two locations within Nineveh Governorate. The first location inside the center of Mosul (Gleokhan) and second location (Balawat village) within the administrative boundaries of Namrod sub-district of Nineveh Governorate, which is 45 km from the center of Mosul district. Both locations are located below the Moderate rain areas, and supplementary irrigation (as needed). Three random soil samples were taken from different places for two experimental sites at a depth of (30 cm) before planting, and they were mixed with each other and mixed for the purpose of analyzing them and knowing

their contents of elements and physical traits. Soil samples were analyzed in the laboratories of the Nineveh Directorate of Agriculture, and the results shown in the table (Table 1).

Table (1) Results analysis of soil samples for two experiment sites

Traits	Gleokhan site	Namrod site
Electrical conductivity (ds.m-1)	0,90	1,08
PH	7,1	7,5
Organic matter %	1,03	1,72
Nitrogen ppm	1,16	1,23
phosphors ppm	9,06	13,08
Potassium ppm	5,54	9,14
Sand %	43,93	42,68
Silty %	33,38	33,38
Clay %	22,70	23,95
Texture	sandy	sandy

Nineveh Agriculture Directorate laboratories

The land prepared for cultivation was prepared by plowing the land using a disc plow, then smoothed by using a plow, after which the land was divided into experimental units with an area of (2 m^2) for each unit, then each experimental unit was divided into five lines for sowing, the distance between one line and other was (20 cm), leaving first and last 10 cm from each experimental unit to achieve symmetry, in addition to leaving a 50 cm walk after one experimental unit and another, with (75 cm) between blocks. Cultivation took place on 12/2/2021 in the first site (Gleokhan) and 12/8/2021 in the second site (Namrod). With the adoption of the seeding rate (300 grains.m^{-2}) live it was adopted on the basis of the germination test and according to what was stated by (Alrijabo and Hassan, 2011), in the stage of vegetative growth and after the appearance of the weeds, the two experimental fields were controlled using the herbicide Atlantis in order to eliminate the narrow and broad weeds.

As for the factors of the study, it consisted of three levels of NPK nano- fertilizer (1, 2 and 3 gm.l^{-1}) that were added in two stages, the first stage at the basal tillers according to the Zadoks scale (Z.2-1) and the second before the boating on the scale of Zadoks (Z.4-0) (Zadoks, 1974), using a knapsack sprinkler with a capacity of (16 liters) and spraying was in the early morning, fourth addition level represented by the control treatment (the traditional method of the farmer by fertilization), which is the addition of urea and dap fertilizers in quantities and times Recommended by the Iraqi Ministry of Agriculture (Urea fertilizer (40 kg.donum) was added in two stages, half of the amount at planting and the second at the tillering, with dap fertilizer was added in full recommendation (25 kg.donum) when planting). The second factor was four varieties of wheat, which are (Bhoth 22, Abu Ghraib, Rashid and Jihan). At harvest, an area of (1 m^2) was harvested from each experimental unit.

A Factorial field experiment was carried out with two factors according to the randomized complete block design (R.C.B.D) with three replications, where the levels of the

first factor (levels of nano-fertilizer) and the second (wheat varieties) were randomly distributed, thus the number of experimental units is (48 experimental units) in each site.

Traits studied
Traits of vegetative growth
1- Plant height (cm): The lengths of 10 plants were calculated randomly from the base of plant at the soil surface to the end of the spike (without the top), then the average height of one plant for each experimental unit was calculated.
2- Number of tillers (m²): The total number of tillers.m^{-2} was calculated within each experimental unit.
3- Leaf area (cm²): It was calculated from an average of ten plants from each experimental unit, by using the following formula:
Flag leaf area (cm²) = leaf length x maximum leaf width x 0.95 (Thomas, 1975).
4- Total Chlorophyll Content Index (SPAD): This trait of the flag leaf was measured by the Chlorophyll Content meter, its trademark Optics-sciences, and its index CCI (Chlorophyll Content) unit according to (Al-Obaidi ,2021).
5- Number of days until 50% flowering (day)
The number of days from sowing to 50% flowering was calculated.
Traits of the yield and its components
6- Number of spikes (spike.m^{-2})
The number of spikes.m^{-2} for each experimental unit was calculated randomly.
7- Spike length (cm): The lengths of 10 spikes were calculated randomly from each experimental unit, as the measurement was taken from the base of the spike to the top of spike, then the average lengths were calculated.
8- Number of grains per spike (grain.spike^{-1}): Calculated from the average number of grains for 10 spikes taken randomly from each experimental unit.
9- Grain yield (g.m^{-2}): The thrashing was done for all spikes that were harvested of the field, then the grains were cleaned and weighed.
10- The weight of 1000 grains (g): 1000 grains from each experimental unit were counted at random and then weighed using a sensitive scale.

The trial data for both sites were analyzed using the Statistical Analysis System (SAS 9.0) program (Antar and Al-Waka'a, 2017) and the coefficients' averages were compared using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION
Table (2) shows the effect of NPK nano fertilizer, varieties and the interaction between them on the vegetative growth traits of Gleokhan site, in terms of plant height (cm) and the effect of nano fertilizer levels. It is noted that the highest height of the plant was (54.42 cm) in treatment (3 g) without significant difference from the (1 g) coefficient recorded an average of (54.37 cm), while the comparison treatment recorded the lowest plant height reached (48.91 cm), which did not differ significantly from the (2 g). This result is consistent with what (Burhan ,2018) found, which showed that the use of fertilizer Nano-NPK led to a significant increase in plant height, and the reason may be the increase in the

efficiency of the transport of synthetic compounds that contribute to an increase in the diameter of the stem and the number of transport vessels (Grover *et al.,* 2012). As for effect of varieties on this trait, it was observed that were no significant differences between four varieties. As for the interaction between fertilizer and varieties, the treatment of (1 g) and Jihan variety recorded the highest average for the trait reached (62.13 cm) compared to the comparison treatment with two varieties Abu Ghraib and Rashid, who recorded the lowest averages of the trait which were (46.1 and 46.37 cm) respectively.

The number of tillers (tiller.m^{-2}) and in the effect of fertilizer levels, it was found that the highest number of tillers was in (1 g) which reached (178.17 tiller), while the lowest number of tiller reached (126.25 tiller) was recorded by (3 g). The reason for the superiority of (1 g) may be due to the use of nano-fertilizer which is characterized by its rapid penetration into the plant cell which contributed to the processes of division of meristematic tissue cells, which in turn led to an increase in the growth rate of the root and vegetative system (Al-Obaidi, 2021). These results are consistent with (Abdel-Aziz *et al.,* 2016 and Burhan, 2018).

The effect of varieties, Rashid variety excelled and recorded the highest average for the trait (169.08 tiller), and outperformed the rest of the three varieties, which did not differ significantly among themselves, with the Abu Ghraib variety recording the lowest average for the trait (142.17 tiller), perhaps the reason for the superiority of Rashid variety to the genetic nature of the variety because that the number of tillers is one of the traits that are mainly governed by genetic genes, this result agrees with (Zenhom *et al.,* 2018 and Al-Jabri, 2020), who showed that the difference in varieties in number of tillers due to the genetic nature of the variety. As for the interaction of two factors, (1 g) with Rashid was superior and the highest average was recorded for this trait which amounted (224 tiller), while the lowest value of the trait was recorded by (3 g) with Rashid (112.33 tiller).

Leaf area (cm^2), it is noted that no significant differences were recorded between the fertilizer levels as well as between the varieties for this trait. And for interaction between two factors, (2 g) treatment with Jihan recorded highest mean for this trait (25.41 cm^2) without a significant difference for all interactions except for (2 g) with Abu Ghraib, which achieved the lowest mean for the trait (16.47 cm^2).

In total chlorophyll content (SPAD) and for effect of fertilizer levels, it was found that the highest mean for the trait amounted to (28.41 SPAD), was in comparison treatment, without significant difference of (1 g), while the treatment of (2 g) recorded the lowest value for the trait (23.65 SPAD). Perhaps the reason for the superiority both of comparison treatment and (2 g) treatment is due to the provision of the necessary elements needed by the plant such as nitrogen, phosphorus and potassium, because comparison treatment used two types of fertilizers (the traditional urea and dap) as the availability of the phosphorous element had a vital role in the plant and a key to physiological processes such as the process of photosynthesis, respiration, energy storage, plant cell division and increase in size (Marschner, 2011). As for the availability of nitrogen, it had a role in increasing the length of the leaf and duration of its greenness stay. Spray treatment also provided major elements through fertilizer. The nanoparticles, which in turn led to an increase in the chlorophyll content in the science paper, and this result is consistent with what found (Al-Fahdawi, 2019). The nuclei have the ability to penetrate plant cells and sustain their survival, which

provides the meristematic tissues with the requirements of building and division, and thus activating the building metabolism in the whole plant, including photosynthesis and its requirements for chlorophyll pigment, and this was confirmed by (Al-Mutairi, 2012 and Siddiqui *et al.,* 2014) that the addition of nano fertilizer to the plant is reflected In improving vital activities and increasing the speed of enzymatic activities of photosynthesis.

Table (2): Effect of nano-fertilizer levels and Varieties and interaction between them for vegetative growth traits for Gleokhan site

levels fertilization g.l^{-1}	Varieties	plant height(cm)	number of tillers (tiller.m^{-2})	leaf area (cm^2)	total chlorophyll content (Spad)	days to 50% flowering (day)
Control	Bhoth 22	49.03 c d	131.67 d e	21.89 a b	34.6 a	133 a
	Abu Ghraib	46.1 d	155 b - e	22.29 a b	24.55 b c d	133 a
	Rashid	54.13 b c	180b c	20.63 a b	23.13 c d	134 a
	Jihan	46.37 d	133.33 c d e	20.74 a b	31.35 a b	131 a
1	Bhoth 22	50.3 b c d	172.67 b c d	22.28 a b	23.47 b c d	133 a
	Abu Ghraib	52.9 b c d	122 e	23.05 a b	29.6 a b c	132 a
	Rashid	52.13 b c d	224 a	17.22 a b	24.4 b c d	134 a
	Jihan	62.13 a	194 a b	23.15 a b	25.2 b c d	131 a
2	Bhoth 22	51.4 b c d	149.67 b - e	22.83 a b	25.07 b c d	133 a
	Abu Ghraib	54.23 b c	148.67 b - e	16.47b	24.93 b c d	132 a
	Rashid	49.7 c d	160 b - e	22.09 a b	19.8 d	134 a
	Jihan	47.87 c d	119 e	25.41 a	24.8 b c d	131 a
3	Bhoth 22	54.17 b c	115 e	25.3 a	26.03 b c d	133 a
	Abu Ghraib	53.6 b c d	143 c d e	22.14 a b	23.87 b c d	132 a
	Rashid	57.8 a b	112.33 e	25.37 a	24.55 b c d	134 a
	Jihan	52.1 b c d	134.67 c d e	22.88 a b	24.27 b c d	131 a
means of levels fertilization	Bhoth 22	48.91 b	150 b	21.39 a	28.41 a	132.75 a
	Abu Ghraib	54.37 a	178.17 a	21.43 a	25.67 a b	132.50 a
	Rashid	50.80 b	114.33 b c	21.70 a	23.65 b	132 a
	Jihan	54.42 a	126.25 c	23.92 a	24.68 b	132.50 a
means of Varieties	Bhoth 22	51.23 a	142.25 b	23.08 a	27.29 a	133 a b
	Abu Ghraib	51.71 a	142.17 b	20.99 a	25.74 a b	132.25 b c
	Rashid	53.44 a	169.08 a	21.33 a	22.97 b	134 a
	Jihan	52.12 a	145.25 b	23.05 a	26.40 a b	131 c

Means followed by the same letter are not significantly at the probability level 5%

As for the effect of varieties, Bhoth 22 recorded the highest mean for trait, (27.29 SPAD), without a significant difference from the rest of varieties, except for the Rashid variety, which recorded the lowest mean (22.97 SPAD). The interaction between comparison treatment and Bhoth 22 variety achieved highest averages for the trait (34.6 SPAD) without a significant difference from between the comparison treatment and Jihan variety, the interaction between (1 g) with Abu Ghraib variety, while the lowest averages for the trait were recorded in (2 g) with Rashid, (19.8 SPAD).

The trait number of days up to 50% flowering (day). It is noted that there were no significant differences between the fertilizer levels, in addition to the interaction between the

fertilizer levels with varieties. As for the effect of varieties, it is noted that the Jihan excelled by recording a significant decrease and needed the least number of days to reach the stage of 50% flowering reached (131 days), while Rashid needed the longest period to reach the same stage with an average of (134 days) recording a un superiority for trait without a significant difference from Bhoth 22, perhaps the reason for the superiority of Jihan in this trait to flowering due to its difference in the amount of its response to temperature and the length of the photoperiod, and to the difference in the duration of the time periods of the stages of vegetative and reproductive growth, starting from the stage of germination to full maturity This in turn is caused by the fact that the trait is under the influence of the genetics of the variety. This conclusion agreed with (Wahid, 2017, Al-Saidan, 2019 and Al-Ghanmi, 2021) who indicated that the difference in number of days up to 50% flowering is due to the difference in the genotypes of the varieties.

Table (3) which shows the effect of NPK nano fertilizer, varieties and the interaction between them on the vegetative growth traits of the Namrod site, in the plant height (cm), it was found in effect of fertilizer levels that the highest average of trait was in the treatment (3 g) without a significant difference from comparison treatment and (1 g), while the (2 g) recorded the lowest values of the trait with averages of (80.77, 80.48, 80.11 and 73.13 cm), respectively.

As for the effect of varieties, Rashid recorded the highest mean which reached (81.85 cm), without a significant difference from two varieties Abu Ghraib and Jihan, which recorded averages of (81.23 and 78.57 cm), while the lowest mean for the trait was (72.84 cm), and it was in Bhoth 22. In the interaction of two factors, (1 g) with Rashid recorded the highest average (88.5 cm) without significant difference from most of interactions, while (2 g) with Bhoth 22 recorded the lowest mean (66.05 cm).

Number of tillers (tiller.m^{-2}), it is noted in the effect of fertilizer levels that the highest mean for the trait was (270.08 tiller), without a significant difference from rest of the fertilizer treatments, except for (1 g) which recorded the lowest mean (217.92 tiller). In the effect of varieties, Bhoth 22 recorded an average of (302.75 tiller) achieving a significant superiority over the rest of varieties that did not differ significantly among them, while Jihan recording the lowest average (222.67 tiller). The interaction between two factors, (3 g) with Bhoth 22 achieved the highest mean for the trait (385.33 tiller) compared to the (1 g) with Jihan which recorded the lowest mean (176.33 tiller).

Table (3): Effect of nano-fertilizer levels and Varieties and interaction between them for vegetative growth traits for Namrod site

levels fertilization g.l^{-1}	Varieties	plant height(cm)	number of tillers (tiller.m^{-2})	leaf area (cm^2)	total chlorophyll content (Spad)	days to 50% flowering (day)
Control	**Bhoth 22**	76.6 c d	323.33 b	31.51 b c d	23.45 d	135 e f
	Abu Ghraib	82.7 a - d	221 d e	28.5 d	24.37 c d	136 c d
	Rashid	86.9 a b	231.33 c d e	32.04 b c d	32.65 a	137 a b
	Jihan	75.7 d	251.33 c d	35.95 b	31.13 a b	136 c d
1	**Bhoth 22**	68.13 e	216.67 d e	33.72 b c d	33.47 a	135 e f
	Abu Ghraib	83.33 a - d	252.33 c d	29.69 c d	26.43 c d	136 c d
	Rashid	88.5 a	226.33 c d e	41.75 a	25.57 c d	137 a b
	Jihan	80.47 a - d	176.33 e	32.66 b c d	28.23 b c	136 c d
2	**Bhoth 22**	66.05 e	285.67 b c	34.36 b c	31.35 a b	135.33 d e
	Abu Ghraib	80.67 a - d	250.67 c d	29.21 c d	32.9 a	136.33 b c
	Rashid	67.8 e	222.67 d e	34.55 b c	28.4 b c	137.33 a
	Jihan	78 c d	274 b c d	28.5 d	26 c d	136.33 b c
3	**Bhoth 22**	80.57 a - d	385.33 a	31.12 b c d	26.3 c d	134.33 f
	Abu Ghraib	78.2 c d	233 c d e	31.03 b c d	22.77 d	136 c d
	Rashid	84.2 a b c	273 b c d	29.85 c d	26.8 c d	137 a b
	Jihan	80.1 b c d	189 e	30.31 b c d	24.73 c d	136 c d
means of levels fertilization	**Bhoth 22**	80.48 a	256.75 a	32 b	27.90 a	136 a b
	Abu Ghraib	80.11 a	217.92 b	34.46 a	28.43 a	136 a b
	Rashid	73.13 b	258.25 a	31.66 b	29.66 a	136.33 a
	Jihan	80.77 a	270.08 a	30.58 b	25.15 b	135.83 b
means of Varieties	**Bhoth 22**	72.84 b	302.75 a	32.68 a b	28.64 a	134.92 c
	Abu Ghraib	81.23 a	239.25 b	29.61 c	26.62 a	136.08 b
	Rashid	81.85 a	238.33 b	34.55 a	28.35 a	137.08 a
	Jihan	78.57 a	222.67 b	31.86 b c	27.53 a	136.08 b

Means followed by the same letter are not significantly at the probability level 5%

The leaf area (cm^2) in effect of fertilizer levels, it was found that the highest mean for this trait (34.46 cm^2) achieved by (1 g) and it was significantly superior to the rest of the treatments, in which no significant differences were recorded with the (3 g) which recorded the lowest mean (30.58 cm^2). The reason for superiority of (1 g) may be to stimulate the nano fertilizer to increase the area of flag leaf and its role in the vegetative seedling to the late stages of the crop's life, so that it contributes to increasing the area of the flag leaf as well as the possibility of its direct penetration into the plant cells, this conclusion agrees with (Al-Obaidi, 2021). In effect of varieties, Rashid recorded the highest mean (34.55 cm^2), without any difference Significant for Bhoth 22, which recorded an average of (32.68 cm^2), while the lowest average recorded by Abu Ghraib (29.61 cm^2).

In interaction between two factors, (1 g) with Rashid achieved the highest average (41.75 cm^2) while control treatment with Abu Ghraib, and (2 g) with Jihan recorded lowest mean (28.5 cm^2) for both interactions.

Total chlorophyll content (Spad) it was found no significant differences were observed between varieties. As For effect of fertilizer levels, (2 g) treatment recorded the highest average of the trait with a value of (29.66 SPAD) without significant difference from

the rest of the treatments except for (3 g) which recorded the lowest levels (25.15 SPAD). In the interactions, (1 g) with Bhoth 22 achieved highest mean without a significant difference from control treatment with Rashid, and (2 g) with Abu Ghraib, (33.47, 32.65, and 32.9 SPAD) respectively, while the lowest levels of the trait were recorded by control treatment with Bhoth 22, and (3 g) with Abu Ghraib, (23.45 and 22.77 SPAD) respectively.

Trait of number of days up to 50% flowering (day) and for effect of fertilizer levels, it was observed that the treatment (2 g) recorded the highest number of days achieving undesirable superiority without significant difference from control treatment and (1 g) treatment, while (3 g) treatment recorded the lowest number of days for flowering achieving a desirable decrease it has the trait with averages of (136.33, 136, 136 and 135.83 days) in the aforementioned order. As for the effect of varieties, Bhoth 22 achieved significant, desirable decline and needed the least number of days to reach the stage of 50% flowering, with an average (134.92 days), compared to Rashid, which needed (137.08 days) to reach the same stage recording an undesirable superiority for this trait. In interaction between two factors, it is noted that (2 g) with Rashid had the highest average of the trait, recording an undesirable height with an average (137.33 days) and without a significant difference from control treatment with (1, 3 g) treatments, as they interaction with Rashid, with an average of (137 day) for the three aforementioned interactions, while (3 g) with Bhoth 22 needed the least number of days recording a desirable decrease with an average (134.33 days).

Table (4) data of the trait number of spikes (spike.m^{-2}) in effect of fertilizer levels, it was found that the highest average for the trait was recorded by (1 g) treatment (100.08 spike), while (3 g) treatment recorded the lowest levels without a significant difference for control and (2 g) with averages of (81.17, 84.92 and 82.75 spike) respectively, the reason for the superiority of (1 g) may be due to the treatment's superiority in number of tillers (Table 2) in addition to the effect of NPK nano particles in contributing to the activation of the system transportation in the phloem tissue, which helps in transporting processed foodstuffs from their sources to the estuaries, which reflected positively on the trait of number of spikes, the conclusion agrees with what found (Burhan, 2018 and Al-obeidi, 2021). In effect of varieties, it was found that the highest average recorded by Rashid (104.58 spike) and significantly superior to the rest of the varieties, while Abu Ghraib recorded the lowest levels of the trait (71.33 spike). The reason for the superiority of Rashid in this trait may be due to the genetic nature of the variety addition It indicates its superiority in the number of tillers (Table 2) as an increase in the number of tillers will lead to an increase in the number of spikes. This conclusion is consistent with (Baqer, 2018 and Al-Ghanmi, 2021). As for interaction between factors, it was found that the highest value of the trait was recorded by (1 g) treatment with Rashid (132.67 spike) compared to the (1 g) treatment with Abu Ghraib which recorded the lowest mean (46.67 spike).

The trait of spike length and the effect of fertilizer levels, (1 g) recorded the highest average of the trait (8.58 cm) and a significant difference from rest of the fertilizer levels, while the control treatment and (2 g) recorded the lowest levels (6.73 and 6.58 cm), respectively. The superiority of (1 g) treatment in spike length may be a result of the effect of the nano fertilizer as the increase in the length of the spike is associated with an increase in cell elongation and growth as a result of the availability of nitrogen. These results are consistent with what was found by(Abdel-Aziz *et al.,* 2016) when spraying wheat plants with

the treatment 10% of Recommendation of nanoparticle NPK as they obtained the highest spike length. In the effect of varieties, Rashid achieved the highest spike length (8.56 cm) and a significant difference from the rest of the varieties, while Bhoth 22 recorded the lowest average (6.75 cm). The reason for the superiority of Rashid may be due to the genetic composition of the variety because this trait is more related to the genetic factor, this result is consistent with what was confirmed by (Abu Al-Nader ,2019) that the significant difference between wheat varieties is due to their genetic difference. In the interaction between factors, (1 g) with Rashid achieved the highest mean for the trait reached (10.8 cm).) and significantly outperformed the rest of the interactions, while the lowest mean of the trait it was recorded (3 g) with Bhoth 22 (6.03 cm).

Number of grains per spike (grain.spike^{-1}) and for the effect of fertilizer levels, it is noted that no significant differences were recorded between fertilizer levels, as well as between varieties included in the study. As for the interaction between fertilizer levels and varieties, it was found that the highest average of the trait was recorded by (2 g) with Jihan (27.33 grain) and without a significant difference from most of the interactions, while control treatment with Jihan recorded the lowest average trait (20.07 grains).

Grain yield (gm.m^{-2}), it is noted in the effect of fertilizer levels that the highest average of the trait was recorded by (1 g) which reached (128.83 g) with a significant difference from the rest of the fertilizer levels, while (2 g) recorded the lowest values (41.83 g). Perhaps the reason for the superiority of (1 g) treatment is due to the superiority of the treatment in terms of number of spikes and spike length, which may be due to the positive role of nano-fertilizer in facilitating nutrients and making them more available to the plant, which helped in increasing the components of the yield, which led to an increase in grain yield. This result is in line with what he reached (Al-Zaboun, 2013, Al-Saedan, 2019, and Al-Shammari, 2021). In the effect of varieties, Jihan achieved the highest mean for the trait (108.08 g) and a significant difference from the rest of the varieties, while the lowest average for the trait was (53.33 g) recorded by Abu Ghraib. In the interaction between two factors, it is noted that the highest value of the trait amounted (301 g) and was recorded (1 g) with Jihan, while the lowest average was (33.33 g) and recorded by (2 g) with Bhoth 22.

Weight of 1000 grains (g), the effect of fertilizer levels. It is noted that the highest mean for the trait amounted (35.20 g) and was recorded by (1 g) with a significant difference from the rest of the fertilizer levels that did not differ significantly between them, while (3 g) recorded the lowest rate amounted (31.24 g), and the reason for the superiority of the (1 g) may be due to the role of nano-fertilizer particles in entering into metabolic reactions efficiently and effectively which resulted in achieving the necessary requirements of phosphorus which directly contributed to the increase in grain weight, This result is consistent with what he reached (Al-Shammari, 2021). Effect of varieties, Bhoth 22 recorded the highest mean for the trait (34.23 g), which did not differ from two varieties Abu Ghraib and Rashid, but differed from Jihan, which recorded the lowest mean (31.20 g). It is noted in the effect of interaction between two factors that the highest average for the trait was (40.01 g) recorded by (1 g) with Bhoth 22, which was significantly superior to the rest of the interactions, while the lowest average was (29.4 g) which was recorded by (3 g) with Rashid.

Table (4): Effect of nano-fertilizer levels and Varieties and interaction between them for yield and its components traits for Gleokhan site

levels fertilization g.l^{-1}	Varieties	plant height(cm)	number of tillers (tiller.m^{-2})	leaf area (cm^2)	total chlorophyll content (Spad)	days to 50% flowering (day)
Control	Bhoth 22	84.67 c - g	6.3 g h	21.6 b	65 c d	31.5 b c d
	Abu Ghraib	86.33 c - f	7.03 e f g	22.8 a b	71.67 c d	34.65 b c d
	Rashid	110 a - d	7 e f g	23.6 a b	66.67 c d	32.32 b c d
	Jihan	58.67 f g h	6.57 g h	20.07 b	40 f	29.98 b c d
1	Bhoth 22	121 a b	8 c	24.2 a b	79 c	40.01 a
	Abu Ghraib	46.67 h	7.57 c - f	24.93 a b	36.67 f	32.07 b c d
	Rashid	132.67 a	10.8 a	21.13 b	98.67 b	33.95 b c d
	Jihan	100 b - e	7.93 c d	20.13 b	301 a	34.75 b c
2	Bhoth 22	55 g h	6.67 g h	21.13 b	33.33 f	34.2 b c d
	Abu Ghraib	75 e - h	6.83 f g h	21.73 b	47.33 e f	31.27 b c d
	Rashid	88.33 c - f	6.5 g h	21.13 b	41.67 f	35.1 b
	Jihan	112.67 a b c	6.33 g h	27.33 a	45 e f	29.5 c d
3	Bhoth 22	82.33 d - g	6.03 h	21.87 a b	74.33 c	31.2 b c d
	Abu Ghraib	77.33 e f g	7.83 c d e	22.53 a b	57.67 d e	33.8 b c d
	Rashid	87.33 c - f	9.93 b	23.27 a b	67.67 c d	29.4 d
	Jihan	77.67 e f g	7.1 d - g	24.4 a b	46.33 e f	30.55 b c d
means of levels fertilization	Bhoth 22	84.92 b	6.73 c	22.02 a	60.83 b	32.11 b
	Abu Ghraib	100.08 a	8.58 a	22.60 a	128.83 a	35.20 a
	Rashid	82.75 b	6.58 c	22.83 a	41.83 c	32.52 b
	Jihan	81.17 b	7.73 b	23.02 a	61.50 b	31.24 b
means of Varieties	Bhoth 22	85.75 b	6.75 c	22.20 a	62.92 b	34.23 a
	Abu Ghraib	71.33 c	7.32 b	23 a	53.33 c	32.95 a b
	Rashid	104.58 a	8.56 a	22.28 a	68.67 b	32.69 a b
	Jihan	87.25 b	6.98 b c	22.98 a	108.08 a	31.20 b

Means followed by the same letter are not significantly at the probability level 5%

Table (5) show number of spikes (spike.m^{-2}), for effect of fertilizer levels it was found that the highest mean was recorded in control treatment without significant difference between (2 ,3 g), while the lowest was in (1 g) (267.75, 242.58, 259.17 and 198.67 spike) respectively, in effect of varieties Bhoth 22 scored highest mean reached (290.17 spike) and was significantly superior to the rest of the varieties, while Jihan recorded the lowest mean (205.25 spike). In interactions, (3 g) with Bhoth 22 recorded highest levels of the trait (376.33 spike) and a significant difference from the rest of the interactions, while (1 g) with Jihan recorded the lowest mean (155 spike).

Spike length (cm), the effect of fertilizer levels. It is noted that the highest mean was recorded by the (1 g) without significant difference from control treatment and (2 g), while (3 g) recorded the lowest levels of the trait (10.85, 10.02, 9.95 and 9.68 cm) respectively. In effect of varieties, Rashid achieved the highest average for the trait reached (12.98 cm) with a significant difference from the rest of the varieties that did not differ significantly among themselves, while Bhoth 22 recorded the lowest levels (8.8 cm). The reason for the superiority of Rashid, as previously mentioned may be due to the genetic nature of the variety

(Abu Al-Nader, 2019). In interaction of fertilizer levels with varieties, (1 g) with Rashid had the highest average for the trait reached (16.2 cm) and was significantly superior to the rest of the interactions, while (2 g) with Bhoth 22 had the lowest mean (7.9 cm).

Number of grains per spike (grain.spike^{-1}), no significant differences were recorded between fertilizer levels in this trait. As for effect of varieties, Abu Ghraib excelled by achieving the highest average for the trait (46.43 grain), and was significantly superior to the rest of the varieties, while Bhoth 22 and Jihan recorded the lowest averages (36.79 and 37.43 grain), respectively. In interactions, (2 g) with Abu Ghraib achieved the highest mean reached (53.2 grain) without a significant difference between control treatment and (3 g) with Abu Ghraib, while (3 g) with Bhoth 22 recorded the lowest average (30.87 grain).

Grain yield (g.m^{-2}) in terms of effect of fertilizer levels, it was found that the highest rate for the trait was (332.17 g) without significant difference for the control treatment and (1g), while the lowest rate was (284 g) and was recorded by (2 g). In effect of varieties, it is noted that the highest rate for the trait was recorded by Bhoth 22 (405.42 g) and a significant difference from the rest of the varieties, while the lowest average recorded by Jihan (250 g). The reason for the superiority of Bhoth 22 in yield may be due to its superiority in number of spikes, which ultimately led to an increase in yield, this conclusion is consistent with (Al-Obaidi, 2021), which indicated that the increase in the components of the yield leads to an increase in the yield. As for the effect of interaction between two factors, (3 g) with Bhoth 22 recorded highest averages without a significant difference from control treatment with Bhoth 22, while (2 g) with Jihan recorded lowest level of the trait (487.67, 471 and 212 g) in the aforementioned order.

Weight of 1000 grains (g), and for effect of varieties, no significant differences were recorded between them. As for the effect of fertilizer levels, it was found that the highest rates of the trait were recorded by control treatment, without a significant difference from (1 and 2 g) treatments, with a significant difference from (3 g) which recorded the lowest rates of the trait (44.91, 43.95, 43.33, and 42.65 g), respectively. In interactions, control treatment with Rashid recorded highest levels without significant superiority over control treatment with Abu Ghraib and Jihan, (3 g) with Bhoth 22 (48.03, 45.08, 47.37, and 44.93 g) respectively, while (3 g) with Abu Ghraib was recorded lowest average for the trait, (40.77 g).

Table (5): Effect of nano-fertilizer levels and Varieties and interaction between them   for yield and its components traits for Namrod site

levels fertilization g.l^{-1}	Varieties	plant height(cm)	number of tillers (tiller.m^{-2})	leaf area (cm^2)	total chlorophyll content (Spad)	days to 50% flowering (day)
Control	Bhoth 22	303 b	9.13 c d	40.9 d e	471 a	42.72 c d
	Abu Ghraib	311 b	9.9 c d	49.5 a b c	312 b - e	45.08 a b c
	Rashid	219 d e	11.9 b	31.5 f	274.33 d - g	48.03 a
	Jihan	238 c d e	9.13 c d	40.7 d e	255 e f g	47.37 a b
1	Bhoth 22	205 d e f	9 c d	41.33 d e	311.33 b - e	43.1 c d
	Abu Ghraib	227.33 c d e	9.13 c d	32.33 f	370 b c	42.53 c d
	Rashid	207.33 d e f	16.2 a	43.7 c d	303.33 b - f	42.8 c d
	Jihan	155 f	9.07 c d	41.9 d e	294 c - g	43.55 c d
2	Bhoth 22	276.33 b c	7.9 d	34.07 f	351.67 b c d	41.73 c d
	Abu Ghraib	236 c d e	9.73 c d	53.2 a	316 b - e	44.22 b c d
	Rashid	211.33 d e	12.7 b	41.1 d e	256.33 e f g	43.8 c d
	Jihan	246.67 c d	9.47 c d	31.5 f	212 g	42.15 c d
3	Bhoth 22	376.33 a	9.17 c d	30.87 f	487.67 a	44.93 a b c
	Abu Ghraib	217.33 d e	9.07 c d	50.7 a b	218.67 f g	40.77 d
	Rashid	261.67 b c d	11.13 b c	45.3 b c d	383.33 b	42.75 c d
	Jihan	181.33 e f	9.33 c d	35.6 e f	239 e f g	42.72 c d
means of levels fertilization	Bhoth 22	267.75 a	10.02 a b	40.65 a	328.08 a	44.91 a
	Abu Ghraib	198.67 b	10.85 a	39.82 a	319.67 a b	43.95 a b
	Rashid	242.58 a	9.95 a b	39.97 a	284 b	43.33 a b
	Jihan	259.17 a	9.68 b	40.62 a	332.17 a	42.65 b
means of Varieties	Bhoth 22	290.17 a	8.8 b	36.79 c	405.42 a	44.22 a
	Abu Ghraib	247.92 b	9.46 b	46.43 a	304.17 b	43.12 a
	Rashid	224.83 b c	12.98 a	40.4 b	304.33 b	43.15 a
	Jihan	205.25 c	9.25 b	37.43 c	250 c	44.35 a

Means followed by the same letter are not significantly at the probability level 5%

CONCLUSIONS

As a result of superiority (1 g) in number of tillers, number of spikes, spike length, grain yield, and weight of 1000 grains at the Gleokhan site, it is preferable to adopt the above concentration under the conditions of the region, while adhering to the dates that were used in the study (tillering and boating stage) as the use of half of the recommended amount provides a yield for the farmer. As for (3 g) which exceeded in plant height, number of days up to 50% flowering and grain yield in the Nimrud site, therefore it is recommended to use the above concentration in the conditions of the region, while adhering to the dates that were sprayed in the study (tillering and boating stage). The superiority of Jihan variety in number

of days up to 50% flowering and grain yield is noted at the Gleokhan site, and Bhoth 22 in number of tillers , number of days up to 50% flowering and grain yield at the Namrod site. Based on the results obtained, it is preferable to adopt the cultivation of Jihan variety in the first site and Bhoth 22 in the second site as a result of the superiority of the level of fertilizer and variety in each site. Depending on the results obtained, it is recommended to adopt the spray concentration of (1 g) with Jihan in first site s(Gleokhan), and (3 g) with Bhoth 22 in second site (Namrod).

CONFLICT OF INTEREST
The authors declare no conflicts of interest associated with this manuscript.

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