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Response of growth and productivity of wheat cultivars (*Triticum aestivum* L.) to Nano-N and urea fertilizer

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Abstract--The field experiment was carried out at the Agricultural Research Station of Basrah University, College of Agriculture in the north of Basrah governorate center during the winter season of 2020/2021 to study the response of growth and yield of three cultivars of wheat (IPA99, BANGIL, and JAAD) to nitrogen fertilization from urea exporters at four levels (0, 60, 120, 80) kg ha⁻¹, and Nanofertilizer at three levels (0, 15, 30) l ha⁻¹. The experiment was applied by randomized complete blocks design (R.C.B.D) by the method of global experiments with three replications. The study results showed that there was no significant difference in all growth components and the yield between two sources of nitrogen fertilizer (urea and Nano) used in the experiment. The cultivars differed significantly in the studied characteristics. JAAD cultivar outperformed the two cultivars, IPA99 and BANGIL, in recording the highest averages of plant dry weight and nitrogen absorbed for all stages of growth, weight of 1000 grains, and grain yield. The increase in nitrogen fertilization level for urea and Nano sources led to an increase in all studied traits. The level exceeded 180 kg N ha⁻¹ and the level 30 l ha⁻¹ than the rest of the levels, and for all stages of growth, they recorded the highest averages of dry weight of the plant, and the quantity absorbed nitrogen, average weight of 1000 grains and grain yield. The interaction treatment between JAAD cultivar with 180 kg N ha⁻¹ level of urea fertilizer and 30 l ha⁻¹ Nano level at the stage of full maturity excelled in recording the highest average dry weight of plant and nitrogen absorption. In contrast, the lowest average of dry weight and nitrogen absorbed was an interaction between BANGIL cultivar with control treatment at the tillering stage for urea and Nano fertilizer sources. As for the interaction treatment between

variety JAAD with 180 kg ha⁻¹ urea and the level of 30 l ha⁻¹ Nano, it gave the highest weight of 1000 grains and grain yield, while the lowest weight of 1000 grains and grain yield

was when an interaction between variety BANGIL with level zero for both Urea and Nano fertilizers.

Keywords--growth and productivity, *Triticum aestivum* L., nano and mineral nitrogen.

Introduction

Cereal crops are among the oldest crops known to man, as they are the main source of food (Al-Anbari, 2004), and the most important of these crops are wheat for its strategic role in achieving food security. The production reached 778.52 million tons globally (USDA, 2022). The level of Iraq's production at 6238 thousand tons (Directorate of Agricultural Statistics, 2020).

Nitrogen is one of the essential nutrients for plants, as it is an essential element for the formation of amino acids that make up plant proteins; in addition to that, it enters the synthesis of chlorophyll and other organic compounds in plants that contribute to increased plant growth and production (Liu et al., 2015).

Nitrogen added to the soil in the form of chemical or organic fertilizers is subjected to loss processes through washing, assimilation by soil microorganisms (immobilization) and ammonia volatilization (Volatilization), and in the form of gases by the process of reverse nitrification (Raut et al., 2014 which leads to Reducing the efficiency of using the added nitrogen fertilizer (Ichami et al., 2018). Sources indicate that the efficiency of nitrogen fertilizer ranges between 50-60% (Finck., 1992), so it is important to use modern technologies, including Nanofertilizers, to increase the efficiency of nitrogen fertilizers and reduce From the amount of nitrogen fertilizer added without affecting production and reducing the risks of environmental pollution on soil and water.

Nanotechnology is one of the sciences concerned with studying matter and its properties at the atomic and molecular levels. The use of Nanomaterials or Nanostructures as a fertilizer carrier (smart fertilizers or slow-release fertilizers) increases fertilizer use efficiency by releasing nutrients in a consistent and specific manner, thus reducing pollution. Environmental (Singh and Prasad, 2017). De Rosa et al. (2010) defined Nano-fertilizers as products made of materials that carry nutrients to the plant and are tightly wrapped inside capsules within Nanoparticles. This is done by placing the nutrient inside Nanomaterials such as Nanotubes or porous Nanomaterials or packaging with a layer of Protective film or its preparation in the form of particles or emulsions in Nano sizes.

Nano-fertilizers play a key role in increasing the ability of crops to withstand different stress conditions, increasing the resistance of crops to diseases, maintaining the genetic characteristics required for other crops, and improving the active substances in plants. In addition, it contributes to the transfer of compounds to plant parts such as leaves, roots, fruits, or the rest of the plant parts and to metabolic processes by increasing the activity of photosynthesis processes by increasing the chlorophyll content in plant leaves (Lin et al., 2014).

The low production rate of wheat in Iraq compared to global production levels requires a search for ways to increase production, including introducing new varieties with high production and using modern techniques in fertilization such as Nano-fertilizer technology. This study aimed to study the effect of spraying Nanonitrozone fertilizer (nitrozone code 20% nitrogen) and its comparison with mineral nitrogen fertilization (urea) in growth and productivity characteristics of three cultivars (IPA99, BANGIL, and JAAD) of wheat crop under the conditions of the southern region of Iraq.

Materials and Methods

The field experiment was carried out at the Agricultural Research Station of College of Agriculture, Basrah University, located in Al-Haritha district, north of Basrah governorate, during the winter season 2020-2021. The composite sample was collected and dried aerobically and then sieved with a sieve with a diameter of 2 mm. Some chemical and physical properties of the soil were estimated according to what was mentioned in Black et al. (1965) and Page et al. (1982) (Table 1).

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

traits	value		unit
PH	7.6		—
E.C.	12.13		dSm ⁻¹
Available - N	12.46		mg Kg soil ⁻¹
Soil Separators	soil	70	g Kg soil ⁻¹
	silt	590	
	clay	340	
soil texture	Silty clay loam		

The study included the use of two sources of nitrogen fertilizer, including urea (46%N) added at levels 0, 60, 120, and 180 kg ha⁻¹ and in three batches (emergence,

tillering, and elongation) and Nano fertilizer at levels 0, 15 and 30 l ha⁻¹ was added to the vegetative part of the plant in the first, in the tillering stage. The second, at the elongation stage, the control treatment was sprayed with distilled water to treat the Nano fertilizer. Urea fertilizer was added at a 60 kg N ha⁻¹ for the Nano fertilization treatments at the seedling emergence stage.

The seeds of the cultivars (IPA99, BANGIL, and JAAD) were planted in experimental plots (3 x 3 m²) on 17.11.2020 at a seed average of 120 kg ha⁻¹. Each plot contained 15 planting lines with a distance of 20 cm between one line and another. The experimental units were separated by an area of 1 meter and were left. The distance between the replicates was 2 m. Phosphate fertilizer from a triple superphosphate source was added at a level of 100 kg p ha⁻¹ and potassium fertilizer from potassium sulfate fertilizer at 100 kg k ha⁻¹ before planting.

They were irrigated immediately after planting the seeds. All field operations were carried out from weeding and controlling the broad-leaved bush after emergence using the Cranstar pesticide. Plant samples were collected at the stages of midgrowth, stem elongation, spike, milky maturity, and full maturity. The samples were dried at a temperature of 70 °C until the weight was stable, then the dry weight was recorded, after which the plant samples were ground. The sample of each treatment weighing 0.2 g was taken and digested using a mixture of sulfuric acid (96%) and perchloric acid (4%) according to the method of Cresser and Persons (1979). al.(1982). The amount of nitrogen absorbed was calculated according to the Haynes equation (1980):

$$\text{N-uptake} = \text{Dry weight} \times \text{N-Concentration}$$

The total grain yield was calculated by harvesting 1 m² from each experimental unit and converted to Mg ha⁻¹. A sample of 1000 grains was randomly selected from the grain yield for each experimental unit and weighed with an electronic scale.

The experiment was carried out using factorial experiments according to the design of a completely randomized block (R.C.B.D) with three replications. The data was analyzed using SPSS 23 program, and the averages were compared with the L.S.D test. Then the results of the experiment transactions were compared between the two sources of fertilizer using the t-test.

The Results

Table (2) shows the analysis results of the variance of the coefficients for the studied traits, and Table (3) shows the T-test to compare the effect of the two types of fertilizers on the studied traits.

Table (2)
Analyze of variance of experiment treatments (A) urea

S.O .V	df	Dry weight		N - Uptake	
		M.S	L.S.D	M.S	L.S.D

Varieties(V)	4	7.242	0.0508	8437.89	1.628
N-Rate(N)	0	26.541	0.0587	42937.77	1.880
Growth stages(S)	1	212.930	0.0656	86618.45	2.102
V*N	7	0.0766	0.1016	426.20	3.256
V*S	8	0.4064	0.1136	341.18	3.640
N*S	44	2.679	0.1312	3961.47	4.203
V*N*S	41	0.0503	0.2272	75.82	7.280
Error	448	0.0197		20.27	
S.O. V	df	Weight of 1000 grain		Grain yield	
		M.S.	L.S.D	M.S.	L.S.D
Varieties(V)	2	116.423	0.410	16536728.	94.73
N-Rate(N)	3	45.187	0.474	7682073.	109.39
V*N	6	3.025	0.821	188555.	189.47
Error	22	0.235		12520.	

(B)Nano

S.O. V	df	Dry weight		N - Uptake	
		M.S	L.S.D	M.S	L.S.D
Varieties(V)	4	7.04712	0.0577	8197.06	2.077
n- Rate(n)	4	31.11347	0.0577	42970.59	2.077
Growth stages(S)	1	159.30291	0.0744	66892.11	2.682
V*n	1	0.26094	0.0999	601.34	3.598
V*S	8	0.41396	0.1289	414.05	4.645
n*S	8	3.24331	0.1289	4158.29	4.645
V*N*S	47	0.05621	0.2233	71.53	8.046
Error	88	0.01894		24.59	
S.O. V	df	Weight of 1000 grain		Grain yield	

		M.S.	L.S.D	M.S.	L.S.D
Varieties(V)	2	472.1478	0.622	13739791.	82.91
n- Rate(n)	2	22.4106	0.622	5381909.	82.91
V*n	4	1.1460	N.S	38183.	143.60
Error	16	0.3876		6883.	

Table (3)

T-test to compare the two types of fertilizers (urea and Nano)

S.O.V	t values	significantly
Dry weight	0.103	N.S
N-uptake	0.262	N.S
Weight 1000 grain	0.717	N.S
Grain yield	0.307	N.S

Dry weight (Mg ha⁻¹)

The statistical analysis results are shown in Tables 2 (A and B).

There is a significant effect of both sources of nitrogen fertilizer (urea and Nano), cultivars, and growth stages and their double and triple interactions on the dry weight of wheat plants. The results of t-test table (3) indicate no significant difference between the two sources of nitrogen fertilizer, urea, and Nano, in the dry weight of wheat plants.

Figures 1 (A and b) shows that the addition of nitrogen fertilizer to both sources of fertilizer (urea and Nano) led to an increase in the dry weight of the plant and for all growth stages. The average dry weight was 162 Mg ha⁻¹ when the control treatment and 3.95 Mg ha⁻¹ when adding level 180 kg N ha⁻¹ of urea fertilizer and 2.17 Mg ha⁻¹ when the control treatment and 3.81 Mg ha⁻¹ when spraying plants with 30 l ha⁻¹ of Nano-fertilizer.

(A)

(B)

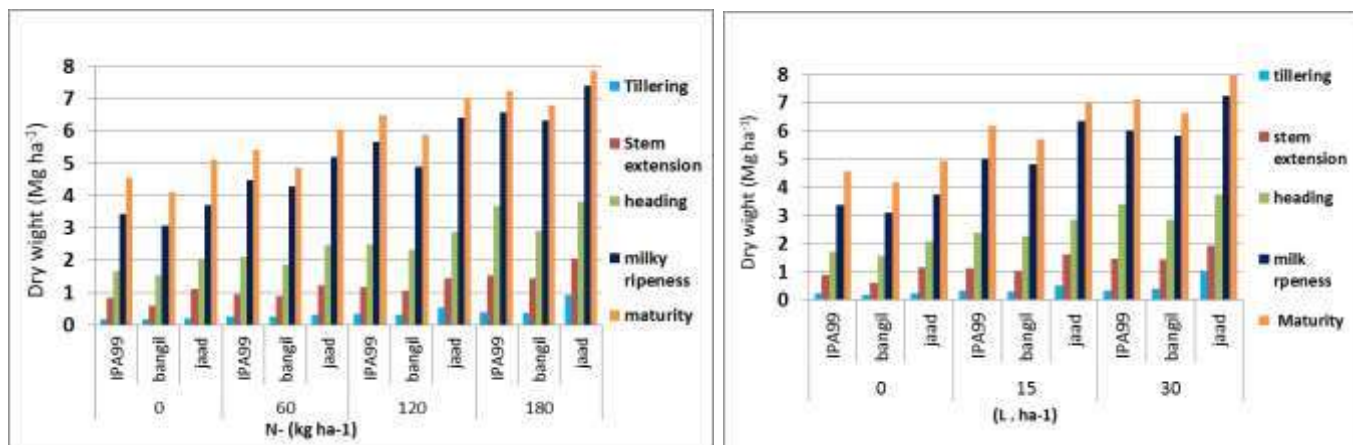


Fig.(1) Effect of Cultivars and Nitrogen rates on dry plant weights of wheat plant at different growth stages. A-Urea

Fig. (1) Effect of Cultivars and Nitrogen rates on dry plant weights of wheat plant at different growth stages. A-Urea, B-Nano

The results show in Figures 1 (A and B) the superiority of JAAD cultivar over IPA99 and BANGIL cultivars for all growth stages and both sources of urea and Nano fertilizers in the dry weight of the plant. The average dry weight was (3.38, 2.97, and 2.69) Mg ha⁻¹ at level 180 kg N ha⁻¹ of urea and (3.48, 2.93, and 2.72) Mg ha⁻¹ for 30-l ha⁻¹ spray treatment of urea of Nano-fertilizers of JAAD, IPA99 and BANGIL cultivars respectively.

The effect of the interaction between cultivars, growth stages, and fertilizer levels was significant on dry weight for all study parameters. The highest dry weight was recorded for JAAD cultivar, and the addition of level 180 kg N ha⁻¹ urea and 30 l ha⁻¹ Nano at a stage of full maturity reached (7.86 and 7.99) Mg ha⁻¹ for two fertilizer sources, respectively. The lowest dry weight of the plant was recorded when the interaction between the cultivar BANGIL and the control treatment for two fertilizers in the tillering stage was (0.163 and 0.177) Mg ha⁻¹ for the two sources of urea and Nano fertilizers, respectively.

The amount of nitrogen absorbed by the plant (kg ha⁻¹)

The statistical analysis results in Table 2 (A and B) showed a significant effect of both fertilizer sources, cultivars, nitrogen fertilizer levels, growth stages, and their double and triple interactions on the amount of nitrogen absorbed by the plant. The results of the t-test table (3) indicate that there is no significant difference between two sources of urea nitrogen fertilizer and Nano.

The addition of nitrogen fertilizer from urea and Nano sources (Figures 2 A and B) led to an increase in nitrogen absorbed for all growth stages. The average absorbed amount was 36.66 kg ha⁻¹ during the control treatment, and 107.29 kg N ha⁻¹ when adding 180 kg N ha⁻¹ of urea fertilizer reached 37.06 kg ha⁻¹ during control treatment 98.67 kg ha⁻¹ when spraying plants with a level of 30 l ha⁻¹ Nano-fertilizer.

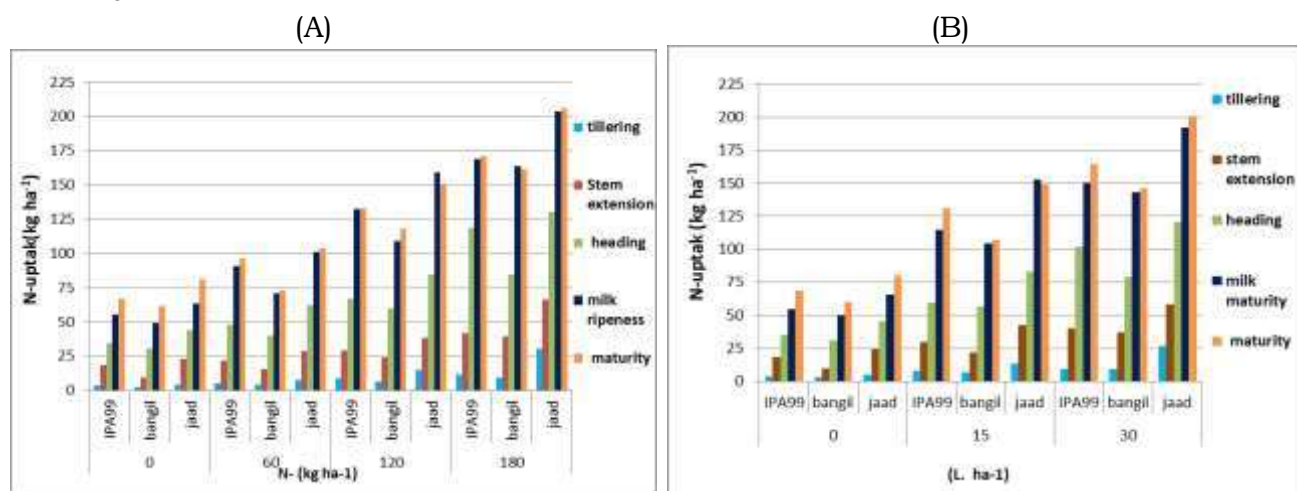


Fig. (4) Effect of Cultivars and Nitrogen rate on N- uptake in wheat plant at different growth

Fig. (4) Effect of Cultivars and Nitrogen rate on N- uptake in wheat plant at different growth stages. A- Urea, B-Nano

It is noted in Figures 2 (A and B) the superiority of JAAD cultivar over IPA99 and BANGIL cultivars in the average amount of nitrogen absorbed into plant for all growth stages and both urea and Nano fertilizer sources. It reached (80.99, 66.34, and 56.82) kg ha⁻¹ when urea fertilizer and (84.08, 66.07, and 57.67) kg ha⁻¹ at Nano-fertilizer for JAAD, IPA99, and BANGIL cultivars, respectively.

Figures 2 (A and B) indicate the superiority of the interaction treatment between cultivar JAAD and level 180 kg N ha⁻¹ and 30 l ha⁻¹ at the full maturity stage in recording the highest amount of nitrogen absorbed amounted to (206.20 and 200.51) kg ha⁻¹, respectively. But the lowest amount of nitrogen absorbed during the interaction treatment between BANGIL cultivar and the control treatment at the tillering stage was (2.60 and 2.98) kg ha⁻¹ for the two sources of urea and Nano, respectively.

Weight 1000 grains (g)

The analysis of variance in Table 2 (A and B) indicate a significant effect of cultivars and nitrogen fertilization levels for both fertilizer sources and the interaction between them in the weight of 1000 grains. The results of the t-test table (3) showed no significant difference between the two sources of urea and Nano fertilizer, as can be seen in Figures 3 (A and B).

Figures 3 (A and b) show that the increase in the level of nitrogen fertilization for both sources of fertilizer led to an increase in the weight of 1000 grains for the wheat crop and all varieties, as the average weight of 1000 grains increased from 33.85 g when compared to 39.19 g for the level of 180 kg N ha⁻¹ of urea fertilizer and from 33.65 g when the control treatment was 36.80 g for a level of 30 l ha⁻¹ of Nano-fertilizer.

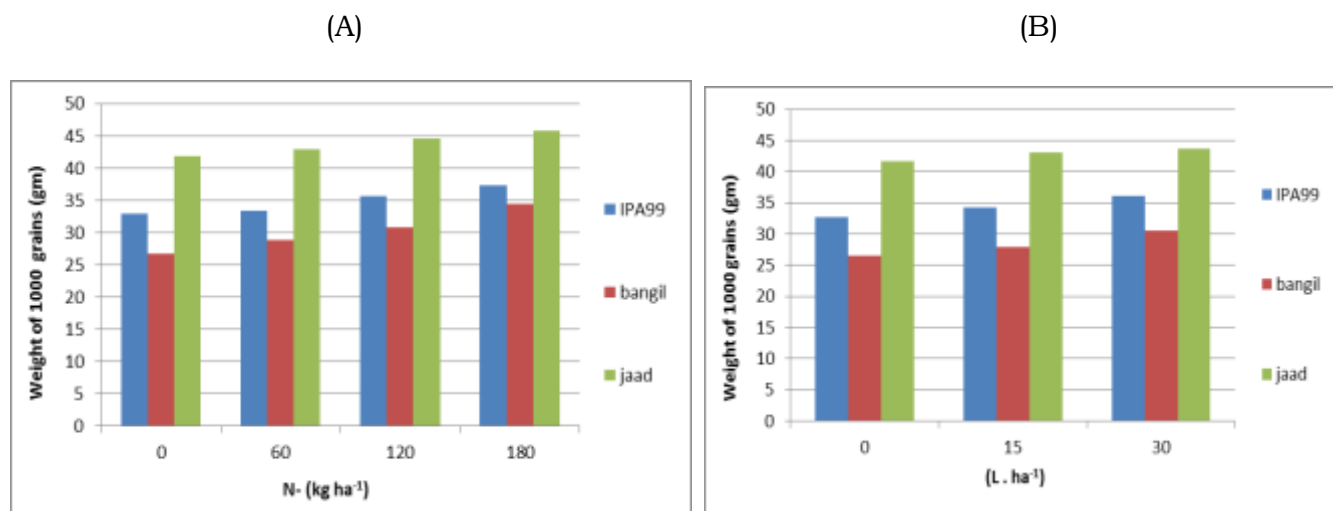


Fig (3) Effect of Cultivars and Nitrogen rate on weight of 1000 grain of wheat A- Urea, B- Nano

The results in Figures 3 (A and B) indicate the superiority of JAAD cultivar over BANGIL and IPA99 cultivars by giving the highest average weight of 1000 grains for both fertilizer sources; it reached (43.79, 30.25, and 34.84) g when urea fertilizer and (42.76, 28.33 and 34.42) g for the treatment of Nano fertilizer sequentially.

The results show in Figures 3 (A and B) that the interaction treatment between JAAD cultivar with nitrogen fertilization level of 180 kg N ha⁻¹ in treatment of urea fertilizer and level of 30 l ha⁻¹ when the Nano-fertilizer recorded the highest average weight of 1000 grains of 45.73 and 43.62 g, respectively. The lowest average recorded by interaction treatment between BANGIL and the control treatment for urea and Nano fertilizer sources was 26.76 and 26.52 g, respectively.

Grain yield (Mg ha⁻¹)

The statistical analysis results in Table 2 (A and B) show a significant effect of the varieties and levels of nitrogen fertilization for both sources of fertilizer (urea and Nano) and the interaction between them in the grain yield. It is noted from Figures 4 (A and B) that increase in the level of nitrogen fertilization for both sources of urea and Nano fertilizers led to an increase in grain yield for all cultivars grown in the experiment. Grain yield increased from 3.51 Mg ha⁻¹ when the control treatment to 5.61 Mg ha⁻¹ at the level of 180 kg N ha⁻¹ for urea fertilizer and from 3.11 Mg ha⁻¹ when the control treatment to 5.06 Mg ha⁻¹ when treating plants with 30 l ha⁻¹ Nano fertilizer.

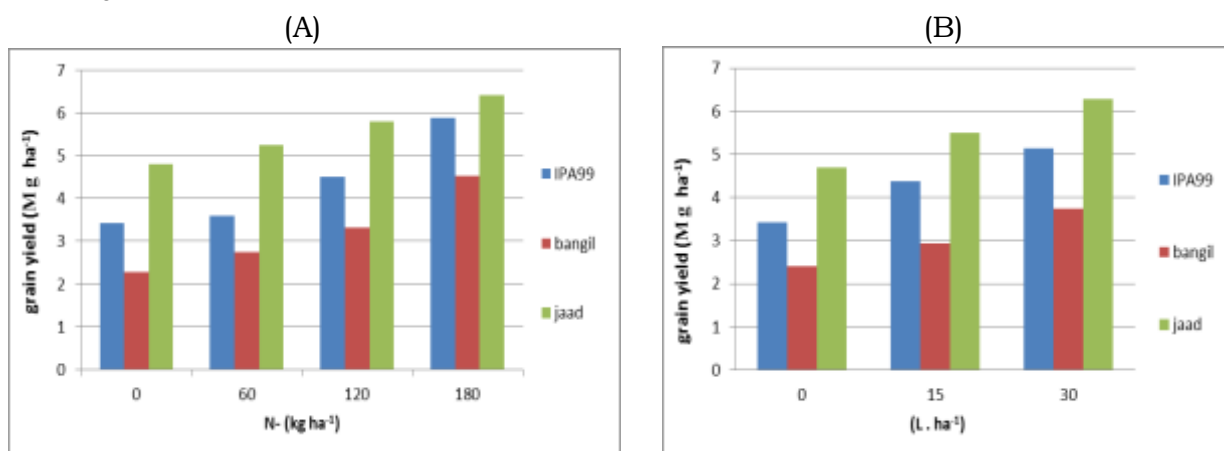


Fig.(4)Effect of Cultivars and Nitrogen Rate on

Fig (4) Effect of Cultivars and Nitrogen Rate on wheat grain yield (Mg ha⁻¹). A- Urea, B- Nano

The results in Figures 4 (A and B) indicate that JAAD cultivar outperformed cultivars IPA99 and BANGIL in giving the highest grain yield average for both fertilizer sources; yield reached (5.56, 4.35, and 3.22) Mg ha⁻¹ when treated with urea fertilizer (5.49 and 4). .32 and 3.03) Mg ha⁻¹ when treating the Nanofertilizers of JAAD, IPA99, and BANGIL cultivars sequentially.

The results also show in Figures 4 (A and B) that the interaction treatment between JAAD cultivar and the nitrogen fertilization level of 180 kg N ha⁻¹ in the treatment of urea fertilizer and the level of 30 l ha⁻¹ when treating the Nanofertilizer recorded the highest grain yield rate of 6.41 and 6.29 Mg ha⁻¹ respectively. The lowest average yield was when the interaction between BANGIL cultivar and the comparison treatment for urea and Nano fertilizer sources was 2.29 and 2.40 Mg ha⁻¹, respectively.

Discussions

The results of the study showed that there were no significant differences in dry weight (Fig. 1), amount of nitrogen absorbed (Fig. 2), weight of 1000 grains (Fig. 3), and grain yield of wheat crop (Fig. 4) between the two sources of urea nitrogen fertilizer and Nano fertilizer. Although the added amount of Nano-fertilizer is approximately 25% of amount of urea fertilizer added. The Nano fertilizer composition possesses a number of desirable properties such as high solubility, stability, controlled release with effective concentration, low toxicity, and ease of nutrient delivery, as Nanoparticles have great potential to deliver nutrients to specific and targeted sites in living systems. The use of Nanomaterials as carriers or wrappers for traditional fertilizers increases the ability to control the decomposition process. It increases the plant's ability to absorb nutrients as a result of its easy entry into cells, in addition to its contribution to improving the activity of the photosynthesis process by increasing the content of plant leaves from chlorophyll and increasing the ability of crops to withstand Various stress conditions and disease resistance, thus reducing environmental risks as a result of

the use of traditional fertilizers (Rai et al., 2015). The results of Hussein et al. (2019) and Astaneh et al. (2021) showed the superiority of Nano-fertilization in increasing dry weight, amount of nitrogen absorption, weight of 1000 grains, and grain yield of wheat crop over those of urea fertilizer treatment.

The results indicated that increased levels of nitrogen fertilization added from both sources of urea and Nano fertilizers led to an increase in dry weight (Fig. 1), amount of nitrogen absorbed (Fig. 2), weight of 1000 grains (Fig. 3), and grain yield (Fig. 4). This result is consistent with Hussein et al. (2019) and Abdelsalam et al. (2019) and Al-Shammary and Huthily (2019). Nitrogen fertilization affects dry weight of plants through its impact on different growth characteristics, including plant height, tillering formation, and leaf area. Nitrogen is one of the important components in forming the porphyrin ring that is part of the chlorophyll molecule that is formed. By absorbing light energy and converting it into carbohydrate compounds that are synthesized and accumulated within the plant tissue during the photosynthesis process, which is reflected in the increase in dry weight of plant, and availability of mineral and Nano nitrogen plays a key role in encouraging the growth of vegetative and root system and making it more efficient in absorbing water and nutrients. A more significant benefit from the exploitation of light energy and improving the plant's ability to increase the efficiency of vegetative parts by photosynthesis and then an increase in the absorbed elements, including nitrogen (Meng et al. 2013).

The results showed superiority of JAAD cultivar over IPA99 and BANGIL cultivars in dry weight of wheat plants, amount of nitrogen absorbed for all growth stages, weight of 1000 grains, and the grain yield (Figures 1, 2, 3, and 4) for both urea and Nano fertilizer sources. This is consistent with what the researchers found by Hussein et al. (2019) and Astaneh et al. (2021) and Falih et al (2015) indicated a significant difference in growth characteristics and yield in different wheat cultivars. The difference between cultivars is due to the genetic susceptibility of different cultivars in terms of nitrogen use efficiency and their ability to absorb nutrients which depends on the nature of the root system and available leaf area (Meng et al. 2013).

Conclusions

There were no significant differences in growth and production characteristics of wheat plants fertilized with 120 kg N ha⁻¹ of urea fertilizer or sprayed with 30 l ha⁻¹ of Nano-nitrogen fertilizer for all cultivars grown in the experiment, which indicates the possibility of reducing amount of nitrogen fertilizer added to wheat plants to 0.25 from the required amount of urea fertilizer.

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