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# Response of some Wheat (*Triticum aestivum* L.) Growth Parameters to Nano Phosphate Fertilizer Compared to Superphosphate Fertilizer

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**Abstract:** An outdoor pots experiment was conducted at agricultural research station, University of Basrah, southern Iraq (30°34'4.80" N 47°44'56.40" E) during winter season of 2021-2022. The study was carried to reveal the effect of Nano phosphate fertilizer compared to superphosphate fertilizer on growth parameters of two wheat cultivars (*Triticum aestivum* L.). Superphosphate fertilizer was added at rates of 0, 30, 60 and 90 kg p ha$^{-1}$, while, Nano phosphate source was applied at 0, 3, and 6 kg P. ha$^{-1}$. Two wheat cultivars (Jad and Adina) were used. Both P sources were mixed with pot soils at planting time. Wheat plants were grown for 70 days period. Plant parameters: tillers numbers, plant high, leaves number, flag leaf area, dry weight, P concentration were obtained at harvest time. Phosphorus uptake was calculated at same time. Results of the study showed that there was no significant differences in all studied growth parameters between superphosphate and Nano phosphate sources, even though the rate of applied Nano phosphate source were much lower than that of superphosphate source. The results also indicated that, irrespective of the origin of phosphorus, higher rates of applied phosphorus led to an increase in all the growth parameters examined. When comparing the two phosphorus sources and their application rates, most growth parameters for the Adina cultivar exceeded those of the Jad cultivar at both phosphorus sources applied rates. Additionally, the results highlighted a significant interaction among treatments for all the investigated growth parameters.

**Keywords**: Growth parameters, Nano-phosphate, Superphosphate, Wheat cultivars.

## Introduction

Wheat (*Triticum aestivum* L.) is one of the world's most important crop plants, fallowing rice and maize in global world total food grain. Wheat is a source for fiber, protein, minerals, carbohydrates and vitamins (Elsahookie *et al.*, 2021). The average wheat production in Iraq was about 1.15 t.ha$^{-1}$ (IPADS, 2022). While, the average world production was about 3.51 t.ha$^{-1}$ (USDA, 2022). Phosphorus (P) is one of major essential elements for plant growth and it's involve in energy components (ATP and ADP), coenzymes (NADP, NADPH, NADH, FAD), phospholipid and phosphoprotein (Roberts & Johnston, 2015). Phosphorus applied to soil as chemical fertilizer react with calcium and magnesium carbonate in calcareous soils and with aluminum and iron hydroxides in acidic soil and subjected to fixation through adsorption and precipitation processes, which reduced P recovery for plant to 15-25% (Zhu *et al.*, 2018): Increasing of P uptake efficiency and use in agriculture is a necessity. Type of P-fertilizer and application methods are among factors affect P availability for plant (Urrutia *et al.*, 2013). Iqbal (2019) and Periakaruppan *et al.* (2023) reported that nano-technology proved it's place in agriculture and related industries showing promising pointed in modern intensive agriculture. Nano-fertilizer is Nano-method deliver nutrient to the plant and control their release into the soil, hence increase nutrient use efficiency (Davari *et al.*, 2017). Astaneh *et al.* (2021) indicated that some studies proved the beneficial effect of Nano-fertilizer on nutrient use efficiency, better yield and reduced soil pollution. Iqbal (2019) indicated that Nano-phosphate fertilizer reduced the recommended dose of traditional phosphorus to achieve optimum yield which reduced soil and water pollution as a result of high dose of mineral P fertilizers. Searching literatures showed little studies were carried to reveal the effect of Nano-P fertilization as compared with mineral P fertilization on growth of wheat (*Triticum aestivum* L.) in southern region of Iraq, hence the study was carried.

## Materials & Methods

An outdoor pots experiment was conducted at Agricultural research station, University of Basrah, southern Iraq (30°34'4.80"N 47°44'56.40"E) during winter season of 2001-2022. Some physical and chemical properties of used soil were determined according to Page *et al.* (1982) and represented in table (1). Two sources of phosphorus fertilizer i.e. superphosphate and Nano-phosphate (cod-Nano-phosphorus 25%P), were applied at rate of 0, 30, 60 and 90 kgP.ha$^{-1}$ for superphosphate source and 0, 3, and 6 kg P.ha$^{-1}$ for Nano-phosphate source. Phosphor fertilizer for both source, nitrogen fertilizer (urea 46%N) at rate of 150 kg N.ha$^{-1}$ and potassium fertilizer ($K_2SO_4$) at rate of 100 kg K.ha$^{-1}$ were mixed with pots soils at planting time. Ten seeds of each of Adina and Jad wheat cultivars were sowing on 20 November 2020, then thinned to three plants.pot$^{-1}$ after emergence. Moisture level of soil in pots were maintained at field capacity throw growing period by weighting methods. Plants parameters: Tillers numbers, plant high, leaves number and flag leaf area were measured at 70 days after germination, then plants were harvested. Plants sample were dried at 70°C in air dry oven for 72 hours. Dry weight of plants were recorded. Dried plants samples were ground and digested according to Cresser & Parsons (1979).

**Table (1): some physical and chemical properties of experimental soil before sowing.**

| Traits | | Value | unite |
|---|---|---|---|
| **pH** | | 7.95 | - |
| **EC** | | 7.50 | dS.m$^{-1}$ |
| **OM** | | 2.10 | g.kgsoil$^{-1}$ |
| **CaCo3** | | 26.00 | |
| **Available Elements** | N | 19.60 | mg. kg$^{-1}$ |
| | P | 11.07 | |
| **dissolved cations** | $Ca^{+2}$ | 18.10 | mM. l$^{-1}$ |
| | $Mg^{+2}$ | 10.7 | |
| | $Na^{+}$ | 12.50 | |
| **dissolved anions** | $SO_4^{-2}$ | 15.10 | |
| | $HCO_3^{-}$ | 0.50 | |
| | $Cl^{-}$ | 38.70 | |
| **Soil texture** | sand | 260.45 | |
| | silt | 240.70 | Clay loam |
| | clay | 318.85 | |

Phosphorus concentration in plant tissues was determined calorimetrically (Page *et al.*, 1982). Phosphorus uptake was calculated as

$$\mathbf{p\ uptake = p\ concentration\ x\ dry\ weight}$$

Data were statistically analyzed by GenStat statistical software 12.0. Comparison between applied phosphorus sources was tested through T-test.

## Results

Table (2) showed the statistical analysis of experiment results of superphosphate source

(A) and Nano-phosphate source (B) of studied growth parameters. Table (3) showed T-test analysis for comparison between phosphorus sources on studied growth parameters.

**Tillers.plant$^{-1}$**

The results of fig. (1A and B) and statistical analysis (Table 2) showed that, regardless of sources application of phosphorus, average of tillers number increased from 2.65 at control treatment to 3.41 at 90 kg p.ha$^{-1}$ supplied as superphosphate and to 3.65 at 6 kg p.ha$^{-1}$ supplied as Nano-phosphate. Average tiller number (No.) of Jad cultivar was higher than that of Adina cultivar at both source of applied phosphorus. The average tillers No. were 3.30 and 3.02 at superphosphate source, 3.40, and 3.13 at Nano-phosphate source for Jad and Adina cultivars respectively. The interaction effect between p rate and cultivars (Fig.1) indicated that the highest tillers No. plants$^{-1}$ (3.53) was recorded at Jad cultivar fertilized with 90 kg P. ha$^{-1}$, while the lowest value (2.5) was recorded at Adina cultivar of control treatment. T-test values (Table 3) showed no significant differences between superphosphate and Nano- phosphate on tillers No. per plant$^{-1}$.

**Plant height (cm)**

Statistical analysis presented in table (2) shows significant effect of phosphorus rate, cultivars and their interaction on plant height for both sources of phosphorous. Nevertheless, T-test results (Table 3) shows no significant difference between superphosphate and Nano-phosphate on plant height. Data of fig. (1A and B) indicate that phosphorus application from both source increased average plant height from 39.78 cm at control treatment to 45.33 cm at 90 kg P. ha$^{-1}$ as superphosphate and to 41.13 cm at rate of 6 kg p.ha$^{-1}$ as Nano- phosphorus. Plant height of Adina cultivar was higher than of Jad cultivar at both phosphate source, with average value 44.71 and 40.52 cm, respectively at superphosphate, while that of Nano-phosphorus were 46.81 cm and 42.87 cm respectively. Highest value of plant height (47.20) were recorded at Adina cultivar supplied with 90 kg P ha$^{-1}$ as superphosphate and 6 kg P.ha$^{-1}$ as Nano- phosphate with value of 49.27 cm. The low value was recorded at control treatment of Jad and Adina cultivars with value of 36.93 cm and 42.63 cm, respectively.

**Leaves. plant$^{-1}$**

Statistical analysis presented in table (2) indicated no significant effect of both phosphorus rate, wheat cultivars and their interaction on leaves number at both sources of phosphorous. T-test value (Table 3) shows no significant effect for phosphates source on leaves number. Fig. (1A and B) indicated that leaves number ranged between 7.569 at control treatment and 7.367 at 90 kg P.ha$^{-1}$ applied as superphosphate and 8.250 at rate of 6 kg P.ha$^{-1}$ as Nano-phosphate. Leaves number of Adina cultivar was high than that of Jad cultivar with rate 7.610 and 7.050, respectively at superphosphate source. Leaves No. of Adina cultivar was 8.65 while that of Jad cultivar was 7.24 at Nano-phosphorus. Highest leaves number of Jad cultivar was obtained at 90 kg P. ha$^{-1}$ with value of 7.20, but the lowest value 7.09 obtained at control treatment in superphosphate source. Value of leaves number of Adina cultivar ranged between 9.00 when phosphorus applied at rate of 6 kg P. ha$^{-1}$ and 8.23 at control treatment in Nano-phosphorus source.

**Flag leaf area**

Results of the study showed a significant effect for phosphorus rates, wheat cultivars and their interaction on flag leaf area for both phosphate source (Table 2). T-test value (Table 3) showed no significant difference between

**Table (2): Analysis of variance represented by mean of square of studied growth parameters affected by superphosphate (A) and Nano-phosphate (B).**

| | S.O.V | d.f. | Tillers plant$^{-1}$ | plant height (cm) | Leaves plant$^{-1}$ | Flag leaf area (cm) | Dry weight (g) | P (g kg$^{-1}$) | P Uptake |
|---|---|---|---|---|---|---|---|---|---|
| A | R | 2 | 0.1817 | 230.0204 | 0.14000 | 0.3197 | 0.1482 | 0.20639 | 76.467 |
| | Cultivar | 1 | 0.4817 | 105.5371** | 0.57042** | 2.9892* | 14.3376** | 0.05348 | 90.375** |
| | P rate | 3 | 0.7344** | 37.6026** | 0.09708 | 15.1714** | 37.5679** | 0.83326** | 224.937** |
| | Cultivar x P rate | 3 | 0.0028* | 0.4526** | 0.00375 | 0.5632 | 0.7168* | 0.04353 | 0.189 |
| | Error | 14 | 0.1040 | 0.6650 | 0.02238 | 0.3738 | 0.4935 | 0.02857 | 7.180 |
| | Total | 23 | 1.5046 | 374.2777 | 0.83363 | 19.4173 | 53.264 | 1.16523 | 399.148 |
| B | R | 2 | 0.2617 | 0.1622 | 0.15167 | 0.26112 | 2.57 | 0.14517 | 25.838 |
| | Cultivar | 1 | 0.3200 | 196.6806** | 0.76056** | 7.28347** | 12.67** | 0.01974 | 0.651 |
| | P rate | 2 | 1.7450** | 269.1539** | 0.73167 | 52.31322** | 735.82** | 1.42727** | 394.881** |
| | Cultivar x P rate | 2 | 0.0017* | 56.5339** | 0.01056 | 0.78824** | 10.18** | 0.12020** | 12.984 |
| | Error | 10 | 0.1203 | 0.5049 | 0.05567 | 0.04820 | 2.57 | 0.01456 | 5.0450 |
| | Total | 17 | 2.187 | 522.8733 | 1.55846 | 60.43313 | 761.24 | 1.58177 | 439.399 |

* Significant at $P \leq 0.05$; ** Significant at $P \leq 0.01$

superphosphate and Nano-phosphate as phosphorus source on flag leaf area. Average flag leaf area range between 9.85 $cm^2$ at control treatment and 13.56 $cm^2$ at phosphorus rate of 90 kg $P.ha^{-1}$ when plants fertilized with superphosphate and to 15.93 $cm^2$ at phosphorus rate of 6 kg $P.ha^{-1}$ applied as Nano-phosphate (Fig. 1 A and B). As to cultivars, the flag leaf areas were 11.25 $cm^2$ and 11.5 $cm^2$ at superphosphate and 12.57$cm^2$ and 13.84 $cm^2$ at Nano-phosphate for Jad and Adina cultivars respectively. Highest flag leaf area12.75 $cm^2$ was obtained at superphosphate source at treatment of 90 kg $P.ha^{-1}$ and the lowest value was 9.63 cm at control treatment. However, for Nano fertilizer, the highest value was 14.57 $cm^2$ obtained at 6 kg P. $ha^{-1}$ and the lowest was 9.63 $cm^2$ at control treatment.

**Table (3): T-test values for comparison between phosphorus fertilizers sources on studied growth parameters**

| Growth Parameters | T-Value | Significance |
|---|---|---|
| Tiller No. | 0.64 | N.S |
| Plant high cm | 0.98 | N.S |
| Leaves $plant^{-1}$ | 2.10 | N.S |
| Flag leaf area ($cm^2$) | 2.34 | N.S |
| Dry weigh (g) | 1.83 | N.S |
| P g. $kg^{-1}$ | 0.07 | N.S |
| p-uptake (mg) | 0.04 | N.S |

### Dry weight

Fig (2) and ANOVA Table (Table 2) showed that application of phosphorus fertilizers from both source increased plant dry weight. Average dry weight was increased from 8.68 g at control treatment to 9.20, 9.71 and 11.12 g at 30, 60 and 90 kg $P.ha^{-1}$, respectively at superphosphate source. Showing similar trend, average dry weight increased from 8.68 g to 9.26 and 11.26 as P rate increased from 0 to 6 and 9 kg $P.ha^{-1}$ at Nano-phosphate source. Average dry weight of Adina was significantly higher than that of Jad with values 9.98 g and 9.45g, respectively for Nano fertilizer treatment. However, at superphosphate source average dry weight of Adina was 10.29 g as compared to 9.73 g for Jad cultivar. Highest dry weight at superphosphate source was recorded at 90 kg $P.ha^{-1}$ with value of 11.390 g, whereas, the lowest value 8.16 g was obtained at control treatment of Jad cultivar. At Nano-fertilizer source highest dry weight was 11.28 g recorded at 6 kg $P.ha^{-1}$ and Adina cultivar. T-test value (Table 3) shows no significant differences between dry weight of plant fertilized with superphosphate and Nano-fertilizer.

### P concentration

Fig. (2) and table (2) showed that P concentration (P conc.) in wheat plant increased with increasing applied phosphorus from both source used. Average P conc. were 1.91, 2.21, 2.5 and 2.77 g. $kg^{-1}$ for 0, 30, 60 and 90 kg $P.ha^{-1}$ when phosphorus applied as superphosphate. At Nano-fertilizer treatment average P conc. were 1.89, 2.22, and 2.87 $g.kg^{-1}$ as rate increased from 0 to 3, and 6 kg $p.ha^{-1}$. At both P source applied cultivars showed no significant effect on P conc., 2.4 $g.kg^{-1}$ for Adina cultivar and 2.31 g. $kg^{-1}$ for Jad cultivar at superphosphate source and 2.30 and 2.35 g. $kg^{-1}$ for Adina and Jad cultivars, respectively for Nano-source.

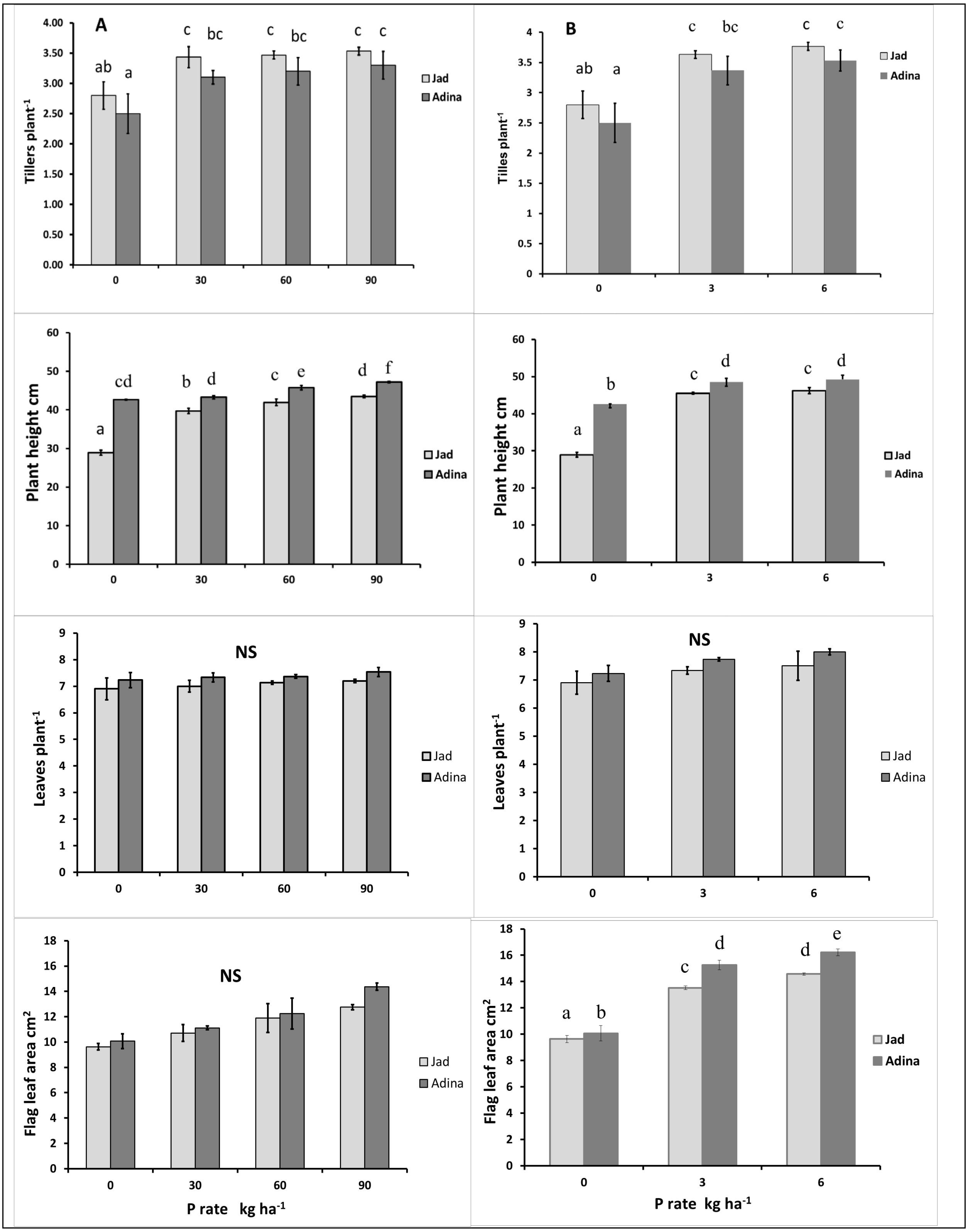


Fig. (1): **Effect of Superphosphate (A) and Nano-phosphate (B) on some growth properties of two Wheat cultivars. Measurements were performed 70 days after treatment. Bars and error bars are means and confidence intervals at 0.05 probability level (n=10). Lowercase letters indicate significant differences for the interaction effect of cultivars and phosphate fertilizer, following lest significant differences test at P≤0.05. NS refer to not significant differences between treatments.**

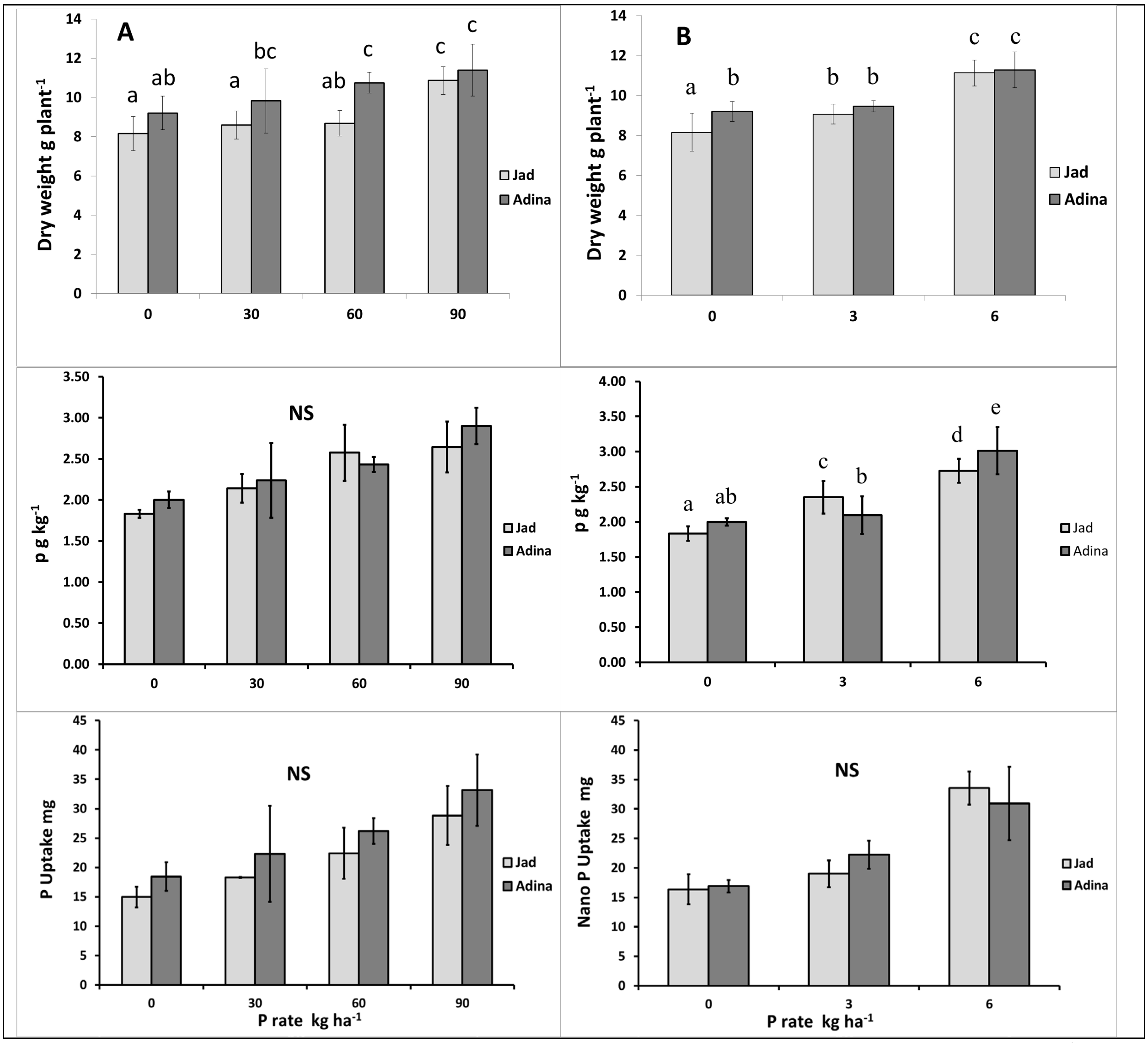


**Fig. (2): Effect of superphosphate (A) and Nano-phosphate (B) on dry weight g plant$^{-1}$, P conc. and P uptake, of two Wheat cultivars. Measurements were performed 70 days after treatment. Bars and error bars are means and confidence intervals at 0.05 probability level (n=10). Lowercase letters indicate significant differences for the interaction effect of cultivars and phosphate fertilizer, following lest significant differences test at P≤0.05. NS refer to not significant differences between treatments.**

As of interaction, between P rate and cultivars at superphosphate source highest P concentration was obtained at phosphorus rate 90 kg ha$^{-1}$ and Adina cultivar (2.91 g.kg$^{-1}$), while lowest value was at control treatment of Jad cultivar (1.88 g.kg$^{-1}$). However, at Nano-phosphate source, the highest phosphorus conc. (3.01 g.kg$^{-1}$) and lowest value (1.38 g.kg$^{-1}$) were recorded at Adina applied with 6 kg p.ha$^{-1}$ and control of Jad cultivar, respectively.

**P-uptake**

Increasing P rate significantly increased P-uptake at both source of phosphorus (Fig 1, Table 2). At superphosphate source, average phosphorus content of plant increased from16.70 at control treatment to 31.00 mg.

plant$^{-1}$ at 90 kg p.ha$^{-1}$ treatment. Application of 30 and 60 kg p ha$^{-1}$ produced P content value of 20.32 and 24.30 mg. plant$^{-1}$ respectively. However, at Nano-phosphorus, source P-content were 16.45, 20.57 and 32.18 mg. plant$^{-1}$ for 0, 3 and 6 kg P.ha$^{-1}$ respectively. Data of fig. (2) show that average of P content of Adina cultivar was higher than of Jad with values 25.02 and 21.14 mg.plant$^{-1}$ respectively at superphosphate source. Nevertheless, Nano-phosphor source showed not significant effect on P content with values 22.21 and 32.42 mg, respectively. Highest P content of plants grown under superphosphate source (33.15 mg) was recorded with Adina cultivar fertilized with 90 kg P. ha$^{-1}$ and lowest value (14.16 mg) was recorded with control treatment of Jad cultivar. At Nano-phosphorus source, highest and lowest values were 33.99 mg at Adina cultivar supplied with 6 kg P. ha$^{-1}$ and 14.96 mg at control treatment of Jad cultivar.

## Discussion

The present study was conducted to reveal the effect of phosphate Nano-fertilizer compare to superphosphate fertilizer on growth parameter of two cultivars of wheat plant (Adina and Jad) during vegetative growth period. The results of T-test value (Table 3) showed no significant differences between Nano-phosphate and superphosphate fertilizer in plant height, flag leaf area, dry weight and P content rate and uptake (Fig. 1A and B; Fig. 2A and B) in spite that, the rate of superphosphate were 0, 30, 60 and 90 kg.P ha$^{-1}$, while, that of Nano-phosphate source were 0, 3 and 6 kg P.ha$^{-1}$. The results are in accord with that of Al-Shammari & Al-Ansari (2021) ad Al-Murshidy *et al.* (2022) for wheat plants, Liu & Lal (2014) for soybean, Zhang *et al.* (2011) for vegetables, Zebarth *et al.* (2009) for crops, Manikandan & Subramanian (2016) for maize and Benzon *et al.* (2015) for rice. Moreover, Xiao *et al.* (2008) indicated that slow release fertilizer coated with nanoparticle increased the productivity of wheat, maize cropping system. Abdel-Aziz *et al.* (2018) reported that treated wheat plants grown in different texture soils with chitosan NPK Nano-particles, increased polysaccharides content, but decreased total soluble squares and protein in wheat grain, Nano-fertilizer increase photosynthesis, seedling growth, carbohydrate, protein synthesis and nitrogen metabolism in plants (Zulfiqar *et al.*, 2019). According to literatures Nano-fertilizer have higher nutrient use efficiency that conventional mineral fertilizes could be due to: I-Considerably less losses in the form of leaching, volatilization and smaller surface area, which increases nutrient root surface interaction and gradual release of nutrients in contrast to rapid and spontaneous release of nutrient from chemical fertilizers (Iqbal, 2019). II- Plant root are significantly porous to Nanomaterials compare to conventional fertilizer (Fleischer *et al.*, 1999). III- Promote germination, radicle and plumule growth and development (Liu *et al.*, 2008). IV- high nutrient absorption, increased photosynthesis, high surface area of leaves (Meng *et al.*, 2021). In addition, Rawat *et al.* (2021) stated that Nano-phosphorus may increase reactive oxygen species (ROS) in plants, which activate the defense pathways to combat the oxidative stress. The results of our study also showed that increasing P rate applied from both sources increased all studied growth parameter (Fig. 1 A and B; Fig. 2 A and B). The role P in increasing growth of all plants is evident and well documented in literatures. Phosphorous is a structural component of energy source molecules (ATP and ADP), acetic acid, phytic acids, phosphides and participate in photosynthetic activity (Rico *et al.*, 2011). On other hand, Assuero *et al.* (2004) reported that

P deficiency decreases cell division rate and cell expansion but does not affect cell morphogenesis. Moreover, Chiera *et al.* (2002) indicated that P deficiency in soybean seedling decreased rate of leaves initiation. The results indicated that regardless of P sources applied most, but not all studied growth parameters of Adina cultivar were higher than counted parts of Jad cultivar at all applied phosphorus rate. Differences in growth parameter between Adina and Jad cultivars observed in the study could be due to genetic differences in nutrients absorption other metabolism in plants. Results of Zhu *et al.* (2008) showed a variation among genotype of lima been in response to Nano particles application. Showing similar trend, Nair *et al.* (2010) indicated that effect of Nano particles on growth and metabolism in plants, nutrient uptake and use efficiency vary among genotypes. The results also showed significant differences for interaction between P rate and cultivars under study for both sources of phosphorus i.e. superphosphate and Nano-phosphate.

## Conclusion

It could be conclude from current study that, there is a possibility of reducing amount of phosphorus applied as superphosphate to wheat plant to less than 25% of recommended rate, by using Nano phosphate as source of P without affecting growth parameters.

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## Contributions of authors

**M.A.A.;** Managing the experiment of pots and laboratory works, collected and analyzed data and reviewed the manuscript.

**A.S.A.;** suggested the proposal of the article, supervised teamwork, wrote the manuscript.

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## Conflicts of interest

The authors declare that they have no conflict of interests.

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# أستجابة بعض صفات نمو نبات الحنطة *Triticumm aestivum* L. لسماد الفوسفات النانوي بالمقارنة مع سماد السوبر فوسفات

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**المستخلص** : اجريت تجربة حقلية باستخدام السنادين في محطة البحوث والتجارب الزراعية التابعة لكلية الزراعة، جامعة البصرة، جنوب العراق N "30°34'4.80 E "47°44'56.40. هدفت التجربة الى دراسة تاثير سماد النانوفوسفات بالمقارنة مع تاثير سماد السوبر فوسفات الثلاثي في بعض صفات النمو لصنفين من الحنطة *Triticum aestivum* L. . تمت اضافة سماد النانوفوسفات بالمستوى 0 و 3 و 6 كغم.هكتار$^{-1}$، بينما تم اضافة سماد السوبرفوسفات الثلاثي بالمستويات 0 و 30 و 60 و90 كغم هكتار$^{-1}$. تم زراعة صنفين من الحنطة (جاد وادنة). خلط كلا مصدري السماد الفوسفات مع تربة السنادين عند الزراعة. بعد مرور 70 يوما من الزراعة تم قياس عدد التفرعات بالنبات وارتفاع النبات وعدد الاوراق ومساحة ورقة العلم وحاصل المادة الجافة للنبات وتركيز الفوسفات في النبات عند الحصاد. وكذلك تم قياس الفوسفات الممتص في نفس الوقت. بينت نتائج الدراسة عدم وجود فرق معنوي بين تاثير كلا مصدري السماد في جميع الصفات المدروسة على الرغم من كون مستويات سماد النانوفوسفات جدا قليلة بالمقارنة مع مستويات سماد السوبر فوسفات الثلاثي. بينت النتائج كذلك ان زيادة مستويات الفوسفات لكلا مصدري السماد ادت الى زيادة صفات النمو لصنفي الحنطة. اختلف الصنفين (ادنة وجاد) معنويا فيما بينهما وقد سجل الصنف ادنة تفوقا معنويا على الصنف جاد في اغلب الصفات المدروسة تحت تاثير مصدري السماد الفوسفاتي. واشارت النتائج الى وجود تداخل معنوي بين المعاملات لاغلب الصفات المدروسة.

**االكلمات المفتاحية**: صفات النمو، سماد النانوفوسفات، سماد السوبرفوسفات الثلاثي، صنفي الحنطة.