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EFFECT OF FOLIAR NANO NPK ON GROWTH, YIELD AND QUALITY OF WHEAT

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Abstract: A field experiment was conducted on Ain mara, Derna, Libya during the growing season of 2023/2024 to investigate the effect of Nano fertilizer NPK at different concentrations on vegetative growth, yield and chemical composition of wheat cv. "Giza 139". The experiment was laid out in Randomized Complete Block Design with three replications. Nano fertilizer NPK spraying with the liquid fertilizer 19-19-19, the liquid Nano NPK fertilizer was sprayed at early morning on the vegetative part till getting complete wetting and dropping of first drop from plants. The results showed increasing Nano NPK up to 100% increased all vegetative growth were studied i.e. plant height, dry matter accumulation/ plant, leaf area index, total chlorophyll and number of tillers/ m^2, also increased all yield and yield components i.e. spike length, number of spike/ m^2, 1000-grain weight, biological yield, grain yield and harvest index percentage, on the other hand, chemical composition of wheat increased with increasing Nano NPK up to 100% such nitrogen, phosphorus, potassium, protein and total carbohydrates percentages, followed by Nano NPK at 75%, as compared with the control treatment which recorded the lower all vegetative growth, yield and yield components and chemical composition of wheat. Conclusion: application of balanced fertilization of N, P and K recorded significantly higher NPK uptake. Nano-fertilizers are the most significant use of nanotechnology in agricultural crop production since they can feed plants gradually and under regulated conditions, unlike conventional fertilizers. When compared to chemical fertilizers, these Nano-fertilizers can be more effective in reducing soil pollution and other environmental problems.

Keywords: Wheat, Nano NPK, vegetative growth, yield, chemical composition

1. Introduction

As a member of the Poaceae family, wheat (*Triticum aestivum,* L.) is the most significant and commonly produced cereal crop worldwide (Choudhary et al., 2023). Originating in the Levant region (Feldman and Mordechai, 2007), wheat is a cereal crop that is currently grown all over the world. Carbohydrates are abundant in wheat (Shewry and Hey, 2015). With a protein level of roughly 13%, which is reasonably high compared to other main cereals but rather low in protein quality for delivering necessary amino acids, it is the world's most important source of vegetal protein in human meals. Whole grains are a good source of fiber and a variety of nutrients. Gluten, which makes up most of the wheat protein, can cause dermatitis herpetiformis, non-coeliac gluten sensitivity, coeliac disease, and gluten ataxia in a small percentage of the general population (Ludvigsson et al., 2013). Fertilizer application of nutrients is essential for preserving soil fertility and improving crop quality and productivity. Precise nitrogen management of horticultural crops is a major global concern because these crops mostly rely on chemical fertilizers (Zulfiqar et al., 2019). In addition to being costly for the producer, traditional fertilizers can pose a risk to human health and the environment. With 9 billion people expected to inhabit the earth by 2050, global agricultural production will need to rise by 70%. It is unable to accomplish this without using more fertilizer nutrients, such as NPK (Drescher et al. 2011). Inorganic fertilizers manufactured in optimal concentrations of macro and micronutrients are known as artificial fertilizers. An important nutrient that is necessary for plant growth is nitrogen (Hussein et al. 2019). This component is essential for the synthesis of proteins, cells, enzymes, and chemicals that support antioxidant defense. Numerous physiological activities in plants, including energy storage through photosynthesis, energy transfer and respiration, cell division and growth, and cell enlargement, depend on phosphorus (Malhotra et al., 2018).

Phosphorus plays a crucial role as a key structural element in various biochemical compounds like nucleic acids (DNA, RNA), coenzymes, nucleotides, sugar phosphate, and phospholipids. It promotes the growth of roots, fruit setting, blooming, and seed formation (Memon, 1996). Potassium is vital for photosynthesis, nitrogen metabolism, sugar translocation, enzyme activation, water relation, stomatal opening, and the growth of meristematic tissues (Hussein et al. 2008). Mostly, essential nutrients for plants are applied to both soil and plant foliage to achieve the highest economic yields. The soil application method is widely used and most effective for nutrients that are needed in larger quantities. However, in specific situations, foliar fertilization is more suitable. Nanotechnology can revolutionize the agriculture system, biomedicine, environmental engineering, safety and security, water resources and energy convention (Baruah and Dutta, 2009). Also, its role in raising the amelioration of plants against biotic and abiotic stresses (Hussein et al., 2019) and lowering coast of fertilizers application and diminishing the environment pollution (Fageria, 2009). Nano-fertilizers have become a pioneer approach in agriculture research nowadays (Abdel-Aziz et al., 2016). Nanotechnology holds great promise for sustainable agriculture practice, and it is expected to transform traditional farming practices into precision farming (Chhipa, 2017). Nano-fertilizers are the most significant use of nanotechnology in agricultural crop production since they can feed plants gradually and under regulated conditions, unlike conventional fertilizers. When compared to chemical fertilizers, these Nano-problems (Naderi et al., 2011). Such characteristics of nanoparticles can be attributed to their high surface area/volume ratio, high solubility, high mobility, and low toxicity (Sasson et al. 2007). The ability to apply Nano-fertilizers in smaller quantities than conventional fertilizers is one of their benefits. In the context of sustainable agriculture, Nano-fertilizers are one of the new emerging agri-technologies and becoming progressively important in modern agriculture as alternative to traditional chemical fertilizers in last decades as ecofriendly (El-Saadony et al., 2021), showing encouraging results in various crops.

Nanomaterials were materials that have at least one dimension of nanoscale, which was in the range 1 nm to less than 1 micrometer (μm) (Ali and Al-Juthery, 2019). Nanotechnology currently has a major role in crop production while maintaining environmental pollution, different nanomaterials provide a unique role in agriculture, such as nanoscale biosensors to detect moisture content, soil nutrient status, water management, nutrients and pesticides in crop fields, nanoparticles can be used as fertilizers and pesticide carriers (Qureshi et al., 2018). The uses of nanofertilizers are effective tools for nutrient management in agriculture and reduce the rate of chemical fertilizer use per unit area (Singh et al., 2017). During the last two decades, nanotechnology has produced a wide range of nanomaterials, mostly produced from synthetic materials or metal particles. Due to growing uncertainty about the negative effects of manufactured nanomaterials, there was interest in the development of natural nanoparticles, which can be utilized in medicine, agriculture, nutrition, engineering and other fields, depends on the production of waste and living organisms and biological treatment with nanotechnology, conversion of insoluble substances into biologically available forms (Griffin et al., 2017). Nano fertilizers are more effective and efficient than traditional fertilizers because of their positive effects on the quality nutrition of crops and the reduction of stresses in plants and the lack of added quantities and costs for their rapid uptake by the roots and their penetration into cells and transport and representation within the plant tissues (Singh et al., 2017; Ali and Al-Juthery, 2019).

The most significant area of agriculture, nano fertilizer, has drawn the interest of ecologists and soil scientists because of its potential to boost productivity, enhance soil fertility, lower pollution, and foster an environment that is conducive to microorganisms (Ahmed et al., 2012) and has been contrasted with conventional chemical fertilizers (Rajonee and Colleagues, 2017). The goal of nano-fertilizers is to increase nutrient use efficiency by taking advantage of the special qualities of nanoparticles (FAO/WHO, 2010). It has been observed that nano-fertilizers release nutrients gradually and continuously over a period of more than thirty days. This could help to increase nutrient use efficiency without having any negative side effects. As a result of the nano-fertilizers' long-term, slow delivery system (Rahale, 2010). The world needs a new "Green revolution" in agriculture to increase crop production for food security and biofuel because conventional breeding methods have not kept up with the growth in global population. Nano fertilizers are essential to reducing the use of inorganic fertilizers (Thapa and Bhusal, 2020). Nano fertilizers are essential to reduce the use of inorganic fertilizers and reduce their negative effects on the environment. Nano-fertilizers are more reactive and can penetrate the epidermis allowing for gradual release, targeted distribution, and thus reducing nutrients surplus, enhancing nutrient use efficiency, and the function of NPs in alleviating the negative effects of abiotic stress and heavy metal toxicity (El-Saadony et al., 2021). According to earlier research, applying NPK nanofertilizer topically increased all growth variables measured during the fully vegetative and reproductive growth stages in a statistically significant way (Abdel-Aziz et al., 2016). Nano-fertilizers generally improve nutrient penetration and uptake (Nair et al. 2010) as well as the amount of dry matter (Ditta and Arshad, 2015). Furthermore, it has been demonstrated that NFs shield plants from various biotic and abiotic stresses when they increase carbon uptake (Manjunatha et al., 2016), plants can withstand prolonged periods of water stress by keeping their stomata closed, which improves crop yield and food quality as well as soil fertility (Qureshi et al., 2018).

The substantial increase in studied macronutrient availability brought about by manuring may be attributed to the production of N, P, and K through the decomposition of organic materials, the fixation of atmospheric N, and the subsequent impact on soil fertility. Additionally, these materials may improve the sand soil's capacity for cation exchange, which would decrease nutrient leaching losses. These findings concur with those of Taha (2007), Ali (2007), and El-Ghamry et al. (2005). It has been demonstrated that using organic manure is crucial in this regard. According to Khalil and Aly (2004), adding organic manure to wheat plants greatly enhanced the plants' uptake of N, P, and K. Furthermore, organic manure fertilization increased the uptake of nutrients, according to Mekail et al. (2006). However, soil manuring had a significant impact on the nutrients that were available in the soil (Ali, 2007; Taha, 2007). Since very few soils are able to supply sufficient quantities of all the nutrients, inorganic fertilizers are thought to be an important source of nutrients in soil. Numerous researchers claimed that raising N, P, and K levels had a major impact on wheat plants' uptake of these nutrients (Galal, 2007). The objective of this work was to study the effect of foliar Nano NPK on vegetative growth, yield characters and grain chemical constituents of wheat.

2. Materials and Method

A field experiment was conducted on Ain mara, Derna, Libya during the growing season of 2023/2024 to investigate the effect of Nano fertilizer NPK at different concentrations on vegetative growth, yield and chemical composition of wheat cv. “Giza 139”. The experiment consists of 6 treatments (control, 20, 40, 60, 80 and 100 Nano NPK), arranged in Randomized Complete Block Design with three replications. Farmyard manure (FYM) was applied to soil at 10 t ha^{-1}during preparing the soil for agriculture. Nano fertilizer NPK spraying with the liquid fertilizer 19-19-19, the liquid nano NPK fertilizer was sprayed at early morning on the vegetative part until getting complete wetting and dropping of first drop from plants.

2.1 Studied attributes

2.1.1 Vegetative growth

i. **Plant height (cm):** The height wheat was measured from the soil surface to the tip of a spike from 10 randomly tagged plants in the net plot area at physiological maturity.
ii. **Dry matter accumulation (g/ plant).**
iii. **Leaf area index (cm^2):** it was estimated by using portable leaf area meter (AM350) for ten leaves and the mean was calculated.
iv. **Total chlorophyll (SPAD)**: With the use of the Minolta SPAD Chlorophyll Meter (Minolta Camera Co., Osaka, Japan), the amount of greenery present in a plant was assessed. The digital

SPAD value produced by the SPAD-502 chlorophyll meter is proportional to the quantity of chlorophyll present in the leaf and is determined by measuring the absorbance of chlorophyll in the red and near-infrared bands (Minolta, 1989).

v. **Number of tillers (m^2):** The number tillers were counted from square box of (1x1) m^2 selected randomly per net plot at physiological maturity and converted to m^2.

2.1.2 Yield and yield components

i. Spike length (cm)
ii. Number of spike/ m^2
iii. 1000-grains weight (g): weight 1000 grains were counted and weighed. It was expressed in (g).
iv. Biological yield (t/ ha^{-1}): It was calculated from the weight of harvested plants (grain + straw) from an area of one square meter of each experimental unit and converted to t ha^{-1}
v. Grain yield (t/ha^{-1}): It was estimated from the square meter area of each experimental unit of grain yield for the harvested plants after separating the straw from the seeds, after which the grain was weighed and the weight was converted into t ha^{-1}.
vi. Harvest index (%): The harvest index was calculated according to the equation (Donald and Hamblin, 1976).
vii. Harvest index (%) = (grain yield/ biological yield) x 100

2.1.3 Chemical composition

i. **N (%):** Total nitrogen was determined in the grains extract using the micro-Kjeldahl according to the method of Allen et al. (1986).
ii. **P (%):** The methods adopted for extraction of phosphorus were essentially those described by Barker and Mapson (1964).
iii. **K (%):** Potassium content was measured according to the method described by Motsara and Roy (2008).
iv. **Protein (%):** It was calculated after estimating the nitrogen concentration in the grains using the Microkeldal apparatus and extracted according to the (Thachuk et al., 1977). The percentage of protein in grains = N × 6.25.
v. **Carbohydrates (%):** Carbohydrates in grains were estimated in the Graduate Studies Laboratory, Department of Field Crops, according to the standard method (AOAC, 2008), and to dissolve the sample, sulfuric acid was used, then phenol and concentrated sulfuric acid were added. In the spectrometer, the sample was read at a wavelength of 490 nm, and then the concentration was read from the standard curve.

2.2 Statistical analysis

The collected data on different soil properties and crop yield were analyzed statistically by MS Excel in addition to statistical package M Stat C. Treatments were compared using Fisher's least significant difference test (LSD) matching of significance at ($P < 0.05$) as reported by Gomez and Gomesz (1984).

3. Results and analysis

3.1 Vegetative growth

Results presented in Table (1) and Figure (1) showed that positive effect of foliar application of nano NPK at different concentrations on vegetative growth of wheat cv. "Giza 139". However, increasing concentration of nanoNPK up to 100% increased all vegetative growth were studied i.e. plant height (102.20 cm), dry matter accumulation (19.08 g/ plant), leaf area index (6.9 cm^2), total chlorophyll (48.98 SPAD) and number of tillers (383.04 m^2), followed by 80% nanoNPK which recorded plant height (92.98 cm), dry matter accumulation (24.71 g/ plant), leaf area index (6.7 cm^2), total chlorophyll (48.43

SPAD) and number of tillers (366.67 m^2), as compared to control treatment which recorded the lower values of plant height (68.12cm), dry matter accumulation (12.57 g/ plant), leaf area index (4.65 cm^2), total chlorophyll (41.39 SPAD) and number of tillers (294.79 m^2), respectively. According to Jahan et al. (2009), nitrogen plays a crucial role in the biochemical and physiological processes of plants, which significantly enhanced plant growth and production. As a result, the increase in vegetative growth may be attributed to nitrogen's role and availability in the ready form in the form of NO_3 and NH4. All of this would contribute to the formation of larger and more numerous cells, which would in turn increase the plant's overall growth and serve as a sign of increased vegetative growth (Mckenzie, 2001). In addition, the nano-fertilizers are smaller than the diameter of the stomata and cell wall holes, resulting in efficient absorption and permeability into the plant tissues. The high specific surface area and energy of the nanoparticles further support the previously stated characteristics (Jassim, 2018).

The recommendation for fertilizer also affects the plant's uptake of critical nutrients, such as nitrogen, which is necessary for the formation of amino acids and proteins, cell division, and elongation; potassium, which is necessary for the synthesis of vital growth enzymes; and phosphorous, which is necessary for the synthesis of energy compounds, which increases the formation of roots and vegetative growth, all of which have a positive impact on yield (Issa, 2018). The following could be the causes: (i) nanoNPK encourages plants to take up nutrients and water from the soil, which improves photosynthesis (Wu, 2013); (ii) nano-NPK is thought of as a biological pump that helps plants take up water and nutrients (Ma et al., 2009). According to Mahmoodzadeh et al. (2013), when wheat plants are directly exposed to kinds of nanoparticles, all growth variables measured at the optimal concentrations of nano solution significantly increase. Nanoparticles also possess high surface energy and activated characteristics. According to Abd El-Aziz et al. (2016), applying traditional NPK fertilizers and nano-NPK fertilizers at progressively higher concentrations to wheat plants grown on sandy soil for the duration of the experiment appeared to generally significantly reduce the number of ions that leaked from the differently treated plants below the levels of the control plants; the response was more pronounced with the nano-NPK fertilizers. The reason for the high absorption of nano fertilizers can be attributed to the possibility that sprayed nano composite-NPK nanoparticles will translocate within the plant after absorbing through the stomata of wheat leaves. Plant height was increased and growth parameters were improved by applying nano fertilizer. Hussein and Colleagues (2018) validated these results. According to Benzon et al. (2015), even at low rates, plant height was more enhanced when nano fertilizer was added in combination with traditional fertilizer than when it was applied alone. These imply that nano fertilizers may either supply nutrients to the plant or aid in the plant's absorption of existing nutrients, improving crop growth. According to Nair et al. (2010), different plants have different uptake efficiencies and different effects of different nanoparticles on growth and metabolic processes. Another approach for this goal could be through foliar uptake, or the absorption of nanoparticles by plants through their leaves. According to Nadakavukaren and McCracken (1985), photosynthesis, transpiration, and gas exchange are the three main functions of leaves in plants. Using transmission electron microscopy (TEM), the intracellular penetration of NPK nanoparticles applied to wheat plants was monitored. Given the unique characteristics of the epidemic outer cell wall, particularly its considerable thickness, a potential nanoparticle penetration points through the stomata and the substomatal chamber, and other factors, the cell wall opens the possibility of applying these nanotechnology tools for agronomical purposes (Corredor et al., 2009). According to Oancea et al. (2009), another practical solution for organic agriculture might be the controlled release of other chemicals and active plant growth stimulators contained in nanocomposites made of layered double hydroxides (anionic clay). These results are interesting because they may suggest that NPK fertilizers in nanocomposite form reduced the increase in plasma membrane permeability and cell death caused by nanoparticle effects in wheat plants (Du et al., 2011). Following the foliar uptake of the nanocomposite, Wang et al. (2013) found similar outcomes in watermelon plants.

Table 1. Effect of different Nano NPK on vegetative growth of wheat cv. Giza 139

Treatments	Plant height (cm)	Dry matter accumulation (g/ plant)	Leaf area index (cm^2)	Total chlorophyll (SPAD)	No. of tillers (m^2)
Control	68.12	12.57	4.65	41.39	294.79
20% Nano NPK	74.49	21.11	5.88	43.09	347.91
40% Nano NPK	79.11	22.34	6.27	45.63	350.10
60% Nano NPK	88.14	23.93	6.48	46.61	357.46
80% Nano NPK	92.98	24.71	6.7	48.43	366.67
100% Nano NPK	102.20	19.08	6.9	48.98	383.04
$LSD_{(0.05)}$	**4.26**	**1.30**	**3.56**	**0.53**	**13.28**

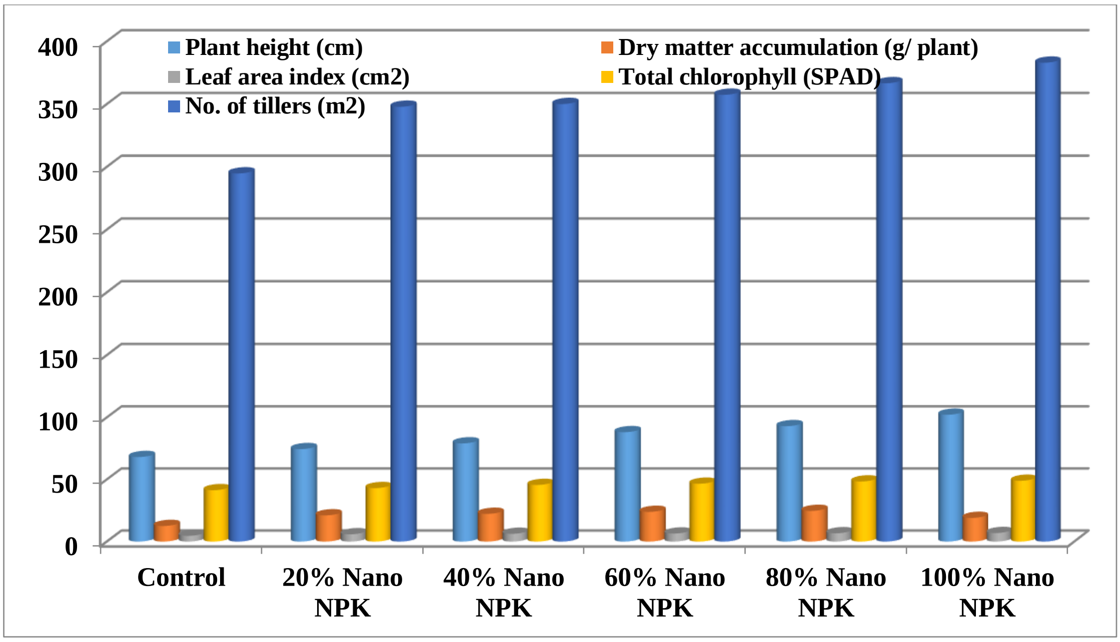

Figure 1. Effect of different Nano NPK on vegetative growth of wheat cv. Giza 139

3.2 Yield and yield components

Results in Table (2) and Figure (2) showed that positive effect of foliar application of nano NPK at different concentrations on yield and yield components of wheat cv. "Giza 139". However, increasing concentration of nano NPK up to 100% increased all yield and yield components were studied i.e. spike length (10.95 cm), number of spike (485.2/ m^2), 1000-grain weight (41.93 g), biological yield (9.05 t/ ha^{-1}), grain yield (4.65t/ ha^{-1}) and harvest index (51.38 %), followed by 80% nano NPK which recorded spike length (10.18 cm), number of spike (481.8/ m^2), 1000-grain weight (38.63 g), biological yield (8.33 t/ ha^{-1}), grain yield (3.84 t/ ha^{-1}) and harvest index (46.10 %), as compared to control treatment which recorded the lower values of spike length (7.63 cm), number of spike (440.3/ m^2), 1000-grain weight (31.89 g), biological yield (5.34 t/ ha^{-1}), grain yield (1.54 t/ ha^{-1}) and harvest index (28.84 %), respectively. Crop productivity can be increased and soil quality can be improved by combining organic manures with mineral fertilizers to meet a portion of crop nutrient needs (Khalil et al. 2002). The observed increase in grain yield may be the result of nitrogen nutrition's beneficial effects in maximizing the crop's natural capacity for vegetative and reproductive growth. Strong dependence of crop productivity on vegetative and reproductive growth is also supported by the estimated interrelationship between grain yield and various yield attributes in the current investigation. These are in line with the findings of (Yadav et al., 2023; Teshome, 2020; Gessesew et al., 2022). According to Liu and Liao, (2008), the addition of nanomaterials enhanced the water's activity. The plants absorbed N, P, and K along with the absorbed water, which increased production. Moosapoor et al. (2013) also documented noteworthy impacts on the weight of 100 peanut plant seeds treated with Bohr nanofertilizer, total biomass, harvest index, number of green pods, number of mature pods, number of seeds/ bush, number of pods/mature pods, yield of pod, and yield of dry seed.

Table 2. Effect of different Nano NPK on yield and yield components of wheat cv. Giza 139

Treatments	Spike length (cm)	No. of spike/ m^2	1000-grain weight (g)	Biological yield (t/ ha^{-1})	Grain yield (t/ ha^{-1})	Harvest index (%)
Control	7.63	440.3	31.89	5.34	1.54	28.84
20% Nano NPK	8.83	457.7	33.87	6.46	2.38	36.84
40% Nano NPK	9.26	462.1	35.00	7.27	2.65	36.45
60% Nano NPK	9.41	476.4	36.39	7.96	3.03	38.07
80% Nano NPK	10.18	481.8	38.63	8.33	3.84	46.10
100% Nano NPK	10.95	485.2	41.93	9.05	4.65	51.38
$LSD_{(0.05)}$	**1.11**	**0.41**	**1.35**	**0.60**	**0.29**	**4.26**

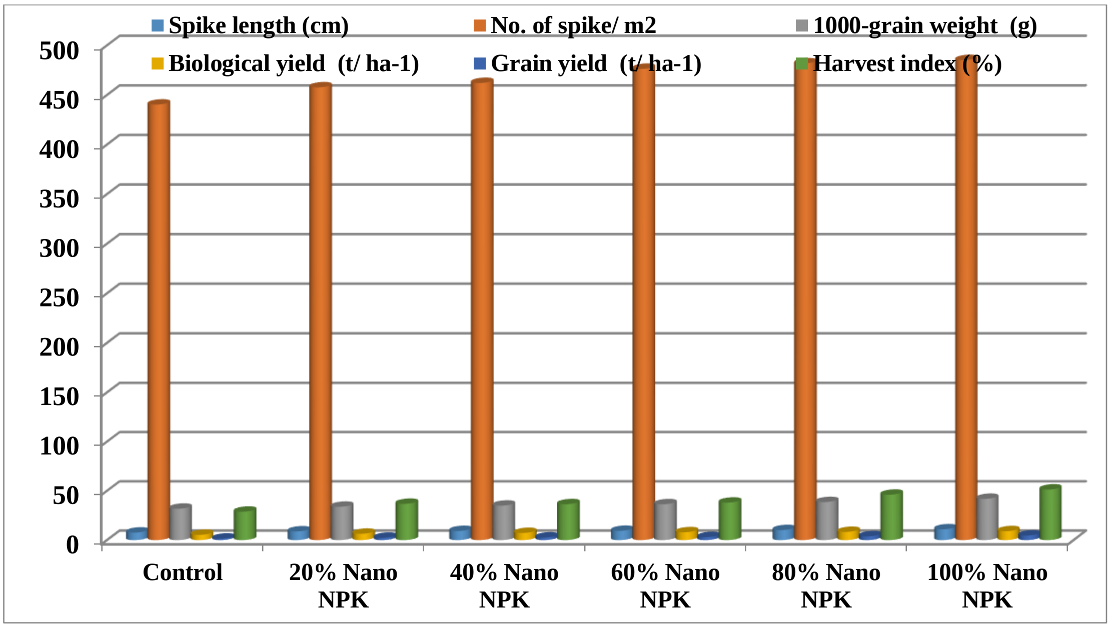

Figure 2. Effect of different Nano NPK on yield and yield components of wheat cv. Giza 139

3.3 Chemical composition

Results in Table (3) and Figure (3) showed that positive effect of foliar application of nano NPK at different concentrations on chemical composition of wheat cv. "Giza 139". However, increasing concentration of nano NPK up to 100% increased all chemical composition were studied i.e. nitrogen (2.25 %), phosphorus (0.753 %), potassium (1.13 %), protein (13.12 %), and total carbohydrate (65.38 %), followed by 80% nano NPK which recorded nitrogen (2.13 %), phosphorus (0.707 %), potassium (0.890 %), protein (12.42 %), and total carbohydrate (64.21 %), as compared to control treatment which recorded the lower values of nitrogen (1.29 %), phosphorus (0.523 %), potassium (0.647 %), protein (7.52 %), and total carbohydrate (54.13 %), respectively. Increased crop yields may have contributed to the increases in nutrient uptake observed in plots treated with organic manure. The yield of the crop was directly correlated with the increase in uptake. It can be explained by the fact that applying fertilizers in addition to manures enhanced the early stages of plant growth, including cell division and the number of root hairs. This allowed the plant to develop a healthy root system, which in turn improved the plant's ability to absorb moisture and nutrients from the soil Thind et al. (2007) also have reported a positive influence of nutrients on crop yields and uptake. The lowest yield observed in these control plots can be attributed to the crop's reduced uptake of N, P, and K.

The wheat grain and straw in the control group had noticeably lower protein content. The observed rise in protein content could potentially be attributed to elevated levels of N, P, and K in the soil, which could stimulate greater root activity and enhance plant uptake and assimilation of nitrogen. Additionally, it may facilitate the transfer of nitrogen from vegetation to grains, potentially impacting protein concentration indirectly. The outcomes concur with the research conducted by Mishra et al. (2008) and Chandal et al. (2014). The action of the nanoparticles is to activate the metabolism of the enzymes, which increases the movement of nutrients from their adsorption positions to the new growth parts. It also increases the activity of enzymes and hormones that work to organize biological reactions and play a role in the factors that influence photosynthesis, such as chlorophylls, enzymes, and factors of energy transfer. Additionally, the action of the nanoparticles encourages an increase in metabolic materials and rates in the green plastids, speeding up the construction of the metabolic units as carbohydrates and this movement to the active positions as grains. Furthermore, the role of nutritional fertilizer elements works to activate the movement and organization of organic and mineral elements flowing to the gate (Grover et al., 2012). The analysis of post-harvest grain samples showed a notable rise in the P and K content. More thorough research is required to fully understand the cellular-level promotive effects of nanoscale NPK fertilizers. The current findings match those of Setia and Sharma (2007) and Vig et al. (2000) regarding the phosphorus content of grains produced by wheat plants treated with either normal NPK or nanoscale NPK on clay, clay-sandy, and sandy soils. It could be caused by higher concentrations of naturally occurring phytohormones with higher nitrogen supplies and chemicals that promote growth. These improvements in plant nutrition status at different stages of crop growth suggest that early and abundant nitrogen availability contributed to these gains by creating an optimal environment for root zone growth and development. The findings of Ghafoor et al. (2021); Sharma et al. (2022) are in line with these. Perhaps because of higher amounts of naturally occurring phytohormones with higher nitrogen supplies and growth-promoting chemicals. These benefits could be attributed to early and abundant availability of nitrogen, as demonstrated by improvements in plant nutritional status at different crop growth stages, which improved the nutritional environment for root zone development and growth. According to Satyanarayana et al. (2017), Rehman et al. (2021), and Yadav et al. (2023), these findings are consistent.

Table 3. Effect of different Nano NPK on chemical composition of wheat cv. Giza 139

Treatments	**N (%)**	**P (%)**	**K (%)**	**Protein (%)**	**Carbohydrate (%)**
Control	1.29	0.523	0.647	7.52	54.13
20% Nano NPK	1.43	0.589	0.697	8.34	56.98
40% Nano NPK	1.95	0.607	0.773	11.37	59.98
60% Nano NPK	2.07	0.641	0.833	12.07	62.54
80% Nano NPK	2.13	0.707	0.890	12.42	64.21
100% Nano NPK	2.25	0.753	1.13	13.12	65.38
$LSD_{(0.05)}$	**0.10**	**0.03**	**0.05**	**0.51**	**1.45**

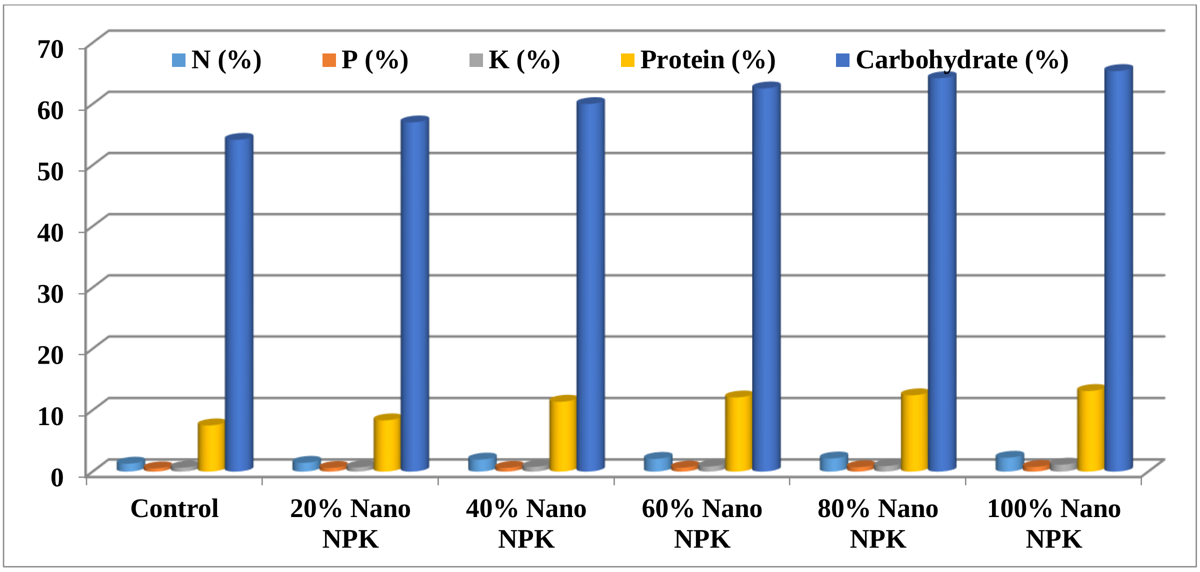

Figure 3. Effect of different Nano NPK on chemical composition of wheat cv. Giza 139

4. Conclusion

Based on earlier literature reviews and research on the use of nano NPK fertilizer, it was determined that this fertilizer is more effective than conventional NPK fertilizer and can enhance wheat crop growth and productivity in a variety of environmental settings. Consequently, using nano NPK fertilizer, whether by foliar application or grains soak, improves wheat growth, yield, and grain quality. Numerous earlier studies also showed that adding more conventional NPK fertilizer as a foliar application can lower the rate of conventional NPK fertilizer applied to the soil, which lowers agricultural production costs. More research should be done to determine the exact mechanism by which Nano-NPK fertilizer enhances the quality of wheat grains, with a focus on human safety.

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