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Efficacy Foliar Spraying of NPK Nano Fertilizer on Yield Attributes of Wheat

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NANO FERTILIZERS significantly enhance crop growth, yield, and quality parameters in agriculture, enhancing nutrient use efficiency. The present study investigated the effect of NPK nano-fertilizers' foliar application on the attributes and yield of two wheat genotypes in semi-arid land conditions of North Sinai. The experiment was laid out in a split-split plot design within a randomized complete block design with three replications. An area of 240 m² was plowed and divided into two blocks for each wheat genotype, Sakha-95, and Ismalia-1 (main plots). The sub-plots were assigned to the different nano NPK foliar spray fertilization treatments coupled with varying percentages of conventional fertilization, as follows: T1: 100% conventional fertilization (control); T2: a foliar spray of nano NPK + 10% conventional NPK; T3: a foliar spray of nano NPK + 25% conventional NPK; T4: a foliar spray of nano NPK + 50% conventional NPK; T5: a foliar spray of nano NPK + 75% conventional NPK. The measured yield parameters were plant height (cm), number of spikes/m2, number of spikelets, number of tillers/m2, spike length (cm), number of kernels /spike, 100-grain weight (g), biological yield (ton/fed), grain yield (ton/fed) and harvest index (%). The results revealed that Ismalia-1 under 75% conventional NPK coupled with nano NPK foliar spray application at two ml/l was the superior practice for increasing all studied traits. Based on the findings of this study, it is recommended to explore the potential of integrating nano NPK fertilizers with reduced conventional fertilizer doses in different environmental conditions and crops to enhance nutrient use efficiency and sustainability.

Keywords: NPK nano-fertilizer, Foliar spray, Wheat, Sakha-95, Ismalia-1.

Introduction

Wheat (*Triticum aestivum* L.) is regarded as one of the most vital staple food crops for over 35% of the global population. In Egypt, wheat is one of the most essential food grain crops, and it is used to make pasta and bread. For animals, wheat straw served as an essential roughage diet. Wheat is ranked first among cereal grains because it has 12% protein, 1.72% fat, 69.60% carbohydrate, and 27.20% minerals. The estimated wheat area in Egypt is 1.43 million hectares. Less than half of the 18.9 million metric tonnes of wheat it consumes annually comes from domestic production; the other half is obtained through imports. (FAOSTAT, 2021).

Nano-fertilizers (NFs) are widely used in plant nutrition as spray-based and soil-based applications (Pruthviraj *et al.,* 2022). Because of their rapid and increased translocation to various plant parts, NFs provide high-efficiency nutrients and little waste. Following their penetration of the cuticle tissue of leaves or roots, NFs follow various pathways (symplastic, apoplastic, lipophilic, and hydrophilic) that affect their effectiveness and final destiny. They may also change their properties, responsiveness, transportation, and transfer within plant tissues, resulting in varying reactions from different plant parts to the same nanoparticle (Mirji *et al.,* 2023).

Nano-fertilizers, due to their small size and increased penetrability, can significantly impact plant growth and development processes, with their effects varying depending on concentration and consumption time (Rame Gowda *et al.,* 2022). Nano Particles have high permeability into plant tissues, causing adverse effects when applied in high concentrations. They are applied at low concentrations to achieve higher yields and reduce damage, minimizing chemical fertilizers and financial costs. (Mirji *et al.,* 2023). Lately, increasing requirements for the application of

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nanotechnology in modern agriculture and environmental sciences have been witnessed, mainly due to their remarkable and multipurpose attributes (Hermes *et al.*, 2020; Suriya Prabha *et al.*, 2022). Numerous studies have shown how unique nanomaterials are at preventing transmission through cell walls and membranes as functional barriers. (Su *et al.*, 2019).

Nano-fertilizers (NFs) significantly improve crop productivity, plant growth performance, and soil quality. NFS may increase plant defense mechanisms, develop stress resistance by boosting nutritional capacity, and enhance nutrient uptake and plant production by regulating fertilizer availability in the rhizosphere. (Verma *et al.*, 2022), yield and nutritional quality (Rajput *et al.*, 2021) will increase the products' nutritional value and food security worldwide (Mandal & Lalrinchhani, 2021). On maize, Gomaa *et al.*, 2017 found that applying mineral fertilizer in the soil and foliar application of nano-fertilizers significantly improved plant growth criteria and yield components compared to the control. (Naimeh *et al.*, 2018) proved that applying 41 kg/ha of nano N fertilizers greatly enhanced seed yield, reaching up to 98% compared to the control. Additionally, it was discovered that nano-nitrogen applications could counteract the 50% recommended dose of conventional nitrogen fertilizer, potentially lessening the negative effects of chemical fertilizers. (Meena *et al.*, 2023).

Considering those mentioned above, the current study aimed to determine how foliar spraying with nano NPK could lower chemical NPK levels while increasing wheat yield, yield components, and quality.

Materials and Methods

Study Area

Field experiment was carried out at the experimental farm, Faculty of Environmental Agricultural Sciences, Arish University, North Sinai (31° 08' 04.3" N, 33° 49' 37.2" E), Egypt during the two seasons of 2022/2023 and 2023/2024. The climate of the study area is semi-arid (meteorological data are presented in Table 1).

Table 1. Meteorological data of El-Arish, North Sinai, region during wheat growing seasons of 2022/2023 and 2023/2024.

Months	Average Temperature (°C)	Minimum Air Temperature [°C]	Maximum Air Temperature [°C]	Average Relative Humidity (%)	Total Precipitation (mm)	Solar Radiation (MJ/m^2/day)
First season 2022-2023						
November-2022	20.38	17.36	24.40	66.75	5.35	12.57
December-2022	17.06	13.82	21.36	70.09	6.95	9.90
January-2023	14.54	10.67	19.61	69.40	15.75	12.04
February-2023	12.70	9.62	16.47	71.61	20.10	13.32
March-2023	17.12	12.71	22.72	62.81	11.95	18.77
April-2023	19.28	14.67	25.28	63.95	14.60	23.50
May-2023	22.27	17.72	28.21	63.61	1.35	25.42
Average and Sum	17.62	13.80	22.58	66.89	152.10	16.50
Second Season 2023-2024						
November-2023	21.88	18.84	26.15	69.31	5.45	12.49
December-2023	17.19	13.54	21.92	69.69	6.55	9.68
January-2024	14.89	11.23	19.36	67.18	22.25	11.36
February-2024	13.42	10.09	17.50	75.76	19.65	14.32
March-2024	16.13	11.96	21.43	68.82	5.95	19.78
April-2024	20.36	15.90	26.30	68.78	2.30	23.33
May-2024	22.56	18.13	28.29	61.92	1.05	25.33
Average and Sum	18.06	14.24	22.99	68.78	126.40	16.61

Plant materials

Two genotypes of wheat crops are used as plant materials. Wheat cultivar (Sakha-95) was obtained by the Wheat Research Department, Field Crops Research Institute (FCRI), Agricultural Research Center (ARC), Giza, Egypt. The new variety (Ismailia-1) was obtained by the Faculty of Agriculture, Suez Canal University, and Ismailia, Egypt. (This new variety is still under the stages and steps of approval for registration by the Genotypes Registration Committee of the

Agricultural Research Center, Egyptian Ministry of Agriculture).

Nano fertilization

The Nano NPK fertilization as a commercial product (19:19:19) was procured from Bio-Nano Technology Company, Egypt. It contains 19% nitrogen (N), 19% phosphorus (P_2O_5), and 19% potassium (K_2O).

Soil mechanical and chemical analyses

The soil mechanical and chemical analyses, which were performed during the two seasons at the Soil and Water Department (SWD), are presented in Tables 2 and 3.

Table 2. Mechanical analysis of soil (Average of the two seasons).

Soil Depth (cm)	Organic carbon g.kg^{-1}	pH	EC (dS m^{-1})	$CaCO_3$ (%)	Organic matter g.kg^{-1}
0-30	1.08	8.515	1.6	3.93	2.05
Soluble Cations (meq L^{-1})				**Soluble Anions (meq L^{-1})**	
K^+	Na^+	Mg^{++}	Ca^{++}	Cl^-	HCO_3^-
0.48	2.64	2.19	2.9	1.286	2.405

Source: Central Laboratory for Agricultural Climate (CLAC, Egypt).

Table 3. Chemical analysis of soil (Average of the two seasons).

Soil Depth (cm)	Coarse Sand(%)	Fine Sand (%)	Silt (%)	Clay (%)	Soil Texture
0-30	67.1	18.9	2.6	11.4	Sandy loam

Experiment layout

A split-split plot design was used in a randomized complete block design with three replications. An area of 240 m^2 was plowed and divided into two blocks for each wheat genotype, Sakha-95 C.V. and Ismalia-1 (main plots), and nano NPK foliar spray fertilizers coupled with conventional fertilization arranged in the subplots. The fertilizer treatments consisted of 5 treatments viz., T1: 100% conventional fertilization; T2: a foliar spray of nano NPK + % 10 conventional NPK; T3: a foliar spray of nano NPK + 25%conventional NPK; T4: a foliar spray of nano NPK + 50% conventional NPK; T5: foliar spray nano NPK+ 75% conventional NPK.

Row spacing was 20 cm apart; grains were sown by Handel drilling. For both seasons, grains were sown on the 15th of November. During land preparation, an organic manure source (farmyard manure) was added at a rate of 20 m^3.fed^{-1}. The study included two types of fertilizers: conventional NPK and nano-NPK Fertilizers. The mineral fertilizers were soil-applied as recommended by the Egyptian Ministry of Agriculture, which is the same as the conventional dose commonly used in local farming practices (178.57 kg N ha^{-1}, 35.71 kg P_2O_5 ha$^{-1,}$ and 57.14 kg K_2O ha^{-1}, in the forms of urea (46.5% N), mono superphosphate (15.5% P_2O_5), and potassium sulfate (48% K_2O), respectively). Nitrogen fertilizer was added three times: 20% before planting irrigation, 40% before the first irrigation, and 40% before the second irrigation. Phosphorus and potassium fertilizers were added before seeding. Nano-NPK 19-19-19 fertilizer at a rate of 2 ml/l was added as a foliar spray. Foliar sprays were given as 1st application 30 days after sowing and 2nd application 45 days after sowing. Agricultural practices were carried out as recommended for wheat growing under the conditions of North Sinai as a semi-arid land.

Recorded data

The following data were recorded 140 days after sowing: (plant height (cm), number of spikes/m^2, number of spikelet/spike, number of tillers/m^2, spike length (cm), number of kernel /spikes, 100-grain weight (g), biological yield (ton/fed), grain yield (ton/fed), harvest index (%))

Statistical analysis

The MSTAT-C computer program was used to statistically analyze data from two seasons (Snedecor, Cochran 1990). The multiple range test compared mean values at $P \leq 0.05$ (Duncan, 1955).

Results and Discussion

1. Effect of foliar spray with nano NPK on yield and yield components of two wheat genotypes

Regarding the genotypes, wheat genotype Ismalia - 1 produced higher values of most studied traits, as shown by the data in (Tables 4 & 5) compared to Sakha-95. Applying nano-fertilizer foliar significantly improved all the attributes studied in the two wheat genotypes (Tables 4 & 5). Application of (75% conventional NPK coupled with a spray of Nano NPK spray at the rate of 2 ml/l) increased the percentage of all studied criteria, viz. plant height by (9.42 and 9.93%), number of spike/m^2 by (21.33 and 22.28%), number of spikelet/spike by (22.44 and 22.97%), number of tillers by (26.87 and 29.22%), spike length by (27.51 and 27.35%), number of kernel /spike by (22.43 and 24.77%), 100-grain weight by (17.80 and 19.00%), biological yield by (15.66 and 17.13%), grain yield by (32.34 and 35.40%), and harvest index by (18.83 and 20.25%) compared to control in seasons one and two, respectively. It is noted that implementing the foliar spray application with NPK nano fertilizer combined with 25% of the recommended fertilizer gave very similar results. There were no significant differences compared to the recommended fertilizer at 100% in all the studied characteristics. On the other hand, when implementing both applications (foliar spray with NPK nano fertilizer combined with 50% of the recommended fertilizer and foliar spray with nano fertilizer combined with 75% of the recommended fertilizer), it was found that all the characteristics under study increased significantly compared to the standard treatment. Wheat yield characteristics increase with the foliar treatment of NPK nano-fertilizers in combination with conventional fertilizers. These results accord well with those previously reported by (Abdel-Aziz *et al.,* 2016 Gomaa *et al.,* 2017; Naimeh *et al.,* 2018; Rajput *et al.,* 2021; Mandal & Lalrinchhani, 2021; Verma *et al.,* 2022; Meena *et al.,* 2023).

Table 4. Effect of foliar spray with nano NPK on (plant height (cm), number of spikes/m^2, number of spikelets/spike, number of tillers /m^{2,} and spike length (cm)) of two wheat genotypes during two successive growing seasons number of tillers /m^2 and spike length (cm)) of two wheat genotypes during two successive growing seasons, 2022/23 and 2023/24.

Factors \ Characters	Plant height(cm)	No of Spike/m^2	No. Spikelet	No. Tillers/m^2	Spike Length(cm)
First season 2022/23					
Genotypes:					
Sakha 95	91.77b	334.19b	29.79b	269.46b	9.65b
Ismalia 1	104.33a	599.87a	36.29a	452.88a	12.09a
Fertilizer treatments					
T_1: Control	96.00c	440.87c	30.27d	325.18d	9.91d
T_2: Nano +NPK 10%	91.82d	388.68d	27.88e	288.45e	7.95e
T_3: Nano +NPK 25%	96.88c	457.95c	31.53c	348.72c	10.75c
T_4: Nano +NPK 50%	99.58b	487.23b	36.47b	398.85b	12.08b
T_5: Nano +NPK 75%	105.98a	560.42a	39.03a	444.65a	13.67a
Second season 2023/24					
Fertilizer treatments					
Sakha 95	87.84b	306.39b	27.73b	232.34b	9.01b
Ismalia 1	99.72a	576.38a	34.29a	415.90a	11.52a
Fertilizer treatments					
T_1: Control	91.45d	418.47c	28.21d	288.15d	9.43d
T_2: Nano +NPK 10%	88.33e	353.37d	26.27e	249.05e	7.24e
T_3: Nano +NPK 25%	92.13c	433.47c	29.32c	314.18c	10.18c
T_4: Nano +NPK 50%	95.45b	463.20b	34.63b	361.92b	11.48b
T_5: Nano +NPK 75%	101.53a	538.42a	36.62a	407.30a	12.98a

Numbers followed by the same letter in the same columns are not significantly different at 5% DMR.

Table 5. Effect of foliar spray with nano NPK on (number of kernels /spike-100-grain weight (g) - biological yield (ton/fed) - grain yield (ton/fed) harvest index (%) of two wheat genotypes during two successive growing seasons number of tillers /m^2 and spike length (cm) of two wheat genotypes during two successive growing seasons, 2022/23 and 2023/24.

Characters / Factors	No. kernel /spike	100-Grain Weight(g)	Biological Yield(ton/fed)	Grain Yield(ton/fed)	Harvest index (%)
First season 2022/23					
Genotypes:					
Sakha 95	56.06b	2.67b	5.11b	2.28b	44.59a
Ismalia 1	62.73a	3.93a	7.08a	2.91a	40.72b
Fertilizer treatments					
T_1: Control	57.22c	3.14b	5.98d	2.26d	38.16c
T_2: Nano +NPK 10%	43.53d	3.11b	4.76e	1.90e	40.82b
T_3: Nano +NPK 25%	58.42c	3.22b	6.15c	2.43c	40.10b
T_4: Nano +NPK 50%	64.03b	3.27b	6.47b	3.05b	47.19a
T_5: Nano +NPK 75%	73.77a	3.82a	7.09a	3.34a	47.01a
Second season 2023/24					
Genotypes:					
Sakha 95	48.87b	2.47b	4.44b	1.90b	42.61a
Ismalia 1	55.15a	3.75a	6.41a	2.49a	38.49b
Fertilizer treatments					
T_1: Control	50.25d	2.94b	5.32d	1.88d	36.11b
T_2: Nano +NPK 10%	34.75e	2.90b	4.10e	1.51e	38.07b
T_3: Nano +NPK 25%	51.17c	3.01b	5.48c	2.03c	37.62b
T_4: Nano +NPK 50%	57.08b	3.07b	5.80b	2.65b	45.65a
T_5: Nano +NPK 75%	66.80a	3.63a	6.42a	2.91a	45.28a

Numbers followed by the same letter in the same columns are not significantly different at 5% DMR.

2. Interaction of foliar spray with nano NPK and two wheat genotypes

Data displayed in Tables 6 and 7 revealed that the interaction of foliar spray with nano NPK and Ismalia-1 variety significantly increased the percentage of all studied traits which were sored up to plant height (20.12 and 20.15%), number of spike/m^2 (54.76 and 56.35%), number of spikelets (38.25 and 38.57%), number of tillers (54.75 and 58.77%), spike length(42.45 and43.08%), number of kernel /spike (30.53 and 32.35%), 100-grain weight (43.62 and 46.37%), biological yield (37.48 and 40.90%), grain yield (45.67 and48.51%) and harvest index (13.20 and12.94%) in the first and second seasons, respectively. These findings were obtained when the Ismalia-1 genotype was fertilized with 75% conventional NPK coupled with a spray of Nano NPK spray at a rate of 2 ml/l.

The superior performance of a 75% recommended fertilizer dose combined with a nano-fertilizer foliar spray at 2 ml/l, compared to the 100% recommended fertilizer control, can be attributed to the enhanced nutrient uptake and efficiency of nano-fertilizers under semi-arid conditions. Nano-fertilizers significantly improve nutrient absorption, leading to better plant growth and increased yield compared to conventional fertilizers alone (Naveed *et al.*, 2020). This improvement stems from their unique physicochemical properties, where the large surface area of nanoparticles provides abundant active sites that facilitate enzyme activity and accelerate biochemical reactions, leading to increased cell division, improved nutrient utilization, and enhanced plant development (Morteza *et al.*, 2013; Mohammed & Salman, 2017). In addition to enhancing nutrient uptake, nano-fertilizers play a crucial role in regulating plant hormones, particularly auxins, which are essential for cell division and elongation. This phytohormonal regulation improves plant growth parameters, such as increased plant height and dry matter accumulation, throughout various growth stages (Navya *et al.*, 2022). Furthermore, nanoparticles can target specific cellular structures, improving solubility and proliferation and optimizing biochemical pathways, which in turn mitigates oxidative stress and enhances vegetative growth by inhibiting the formation of reactive oxygen species (ROS) (Morteza *et al.,* 2013; Mohammed & Salman, 2017). The foliar application of nano-fertilizers significantly impacts nutrient efficiency by increasing the bioavailability of macronutrients like nitrogen, phosphorus, and potassium. Nitrogen supports amino acid and protein synthesis, cell division, and elongation, while phosphorus plays a crucial role in energy transfer, and potassium regulates enzymatic activities and osmotic balance. These nutrients contribute to enhanced root development, vegetative growth, and overall crop yield (Saad *et al.,* 2014; Saad *et al.,* 2015; Ajirloo *et al.,* 2015; Issa *et al.,* 2017; Issa, 2017). Additionally, the foliar uptake of nano-fertilizers ensures rapid nutrient absorption, leading to immediate physiological responses and improved plant performance (Alimam & Al-Qasim, 2022; Gomaa *et al.,* 2017; Naimeh *et al.,* 2020; Rajput *et al.,* 2021; Mandal & Lalrinchhani, 2021; Samui *et al.,* 2022; Sannathimmappa *et al.,* 2022; Singh *et al.,* 2022; Kashyap *et al.,* 2022; Ajitkumar *et al.,* 2021; Reddy *et al.,* 2022; Verma *et al.,* 2022; Meena *et al.,* 2023). Studies have also shown that nano-fertilizers influence key biological indices such as plant height, photosynthetic efficiency, and enzyme activity, demonstrating their superior performance in promoting vegetative growth and increasing crop yield compared to conventional fertilizers (Al-Juthery *et al.,* 2019). This is supported by evidence showing that nanoparticles enhance various growth characteristics by influencing gene expression, which regulates biological pathways that improve both vegetative and reproductive development (Aslani *et al.,* 2014).

Table 6. Effect of Interaction of foliar spray with nano NPK and two wheat genotypes on (plant height (cm), number of spike/m^2, number of spikelets, number of tillers /m^2, and spike length (cm)) of two wheat genotypes during two successive growing seasons 2022/23 and 2023/24.

Genotypes	Fertilizer treatments	Plant height (cm)	No of Spike	No. Spikelet	No. Tillers	Spike Length
	First season 2022/23					
Sakha 95	T1	90.53f	319.50h	25.93h	240.07i	8.50g
	T2	85.07g	256.40i	24.10i	193.73j	7.50h
	T3	91.10f	323.37h	27.20g	263.13h	9.27f
	T4	93.53e	357.10g	34.60e	291.57g	10.43e
	T5	98.63d	414.57f	37.10c	358.80f	12.57c
Ismalia 1	T1	101.47c	562.23d	34.60e	410.00d	11.33d
	T2	98.57d	520.97e	31.67f	383.17e	8.40g
	T3	102.67c	592.53c	35.87d	434.30c	12.23c
	T4	105.63b	617.37b	38.33b	506.13b	13.73b
	T5	113.33a	706.27a	40.97a	530.50a	14.77a
	Second season 2023/24					
Sakha 95	T1	86.00g	298.30h	23.73h	203.63j	8.10g
	T2	82.00h	208.43i	22.87i	151.67i	6.73i
	T3	86.90f	298.53h	24.77g	229.77h	8.73f
	T4	89.57e	333.27g	32.67e	255.90g	9.73e
	T5	94.73d	393.40f	34.60c	320.73f	11.73c
Ismalia 1	T1	96.90c	538.63d	32.68e	372.67d	10.76d
	T2	94.67d	498.30e	29.68f	346.43e	7.74h
	T3	97.37c	568.40c	33.87d	398.60c	11.63c
	T4	101.33b	593.13b	36.60b	467.93b	13.23b
	T5	108.33a	683.43a	38.63a	493.87a	14.23a

Table 7. Effect of Interaction of foliar spray with nano NPK and two wheat genotypes on (number of kernels/spike-100 grain weight (g) - biological yield (ton/fed) - grain yield (ton/fed) harvest index (%)) of two wheat genotypes during two successive growing seasons number of tillers /m^2 and spike length (cm)) of two wheat genotypes during two successive growing seasons, 2022/23 and 2023/24.

Genotypes	Fertilizer treatments	No. kernel /spike	100 Grain Weight	Biological Yield	Grain Yield	Harvest index
	First season 2022/23					
Sakha 95	T1	54.10e	2.50e	5.02i	2.07g	41.17c
	T2	42.93f	2.53e	3.50j	1.56h	44.56b
	T3	54.67e	2.63e	5.22h	2.28f	43.63b
	T4	58.93d	2.54e	5.64g	2.65d	47.01a
	T5	69.67b	3.16d	6.14e	2.86c	46.59a
Ismalia 1	T1	60.33cd	3.79bc	6.95d	2.44e	35.15e
	T2	44.13f	3.70c	6.02f	2.23f	37.08d
	T3	62.17c	3.80bc	7.09c	2.59d	36.56d
	T4	69.13b	4.01b	7.29b	3.45b	47.37a
	T5	77.87a	4.47a	8.03a	3.81a	47.43a
	Second season 2023/24					
Sakha 95	T1	47.67g	2.29d	4.35i	1.73g	41.17c
	T2	33.80i	2.30d	2.83j	1.19h	44.56b
	T3	47.73g	2.43d	4.55h	1.87f	43.63b
	T4	52.00f	2.34d	4.97g	2.25d	47.01a
	T5	63.13b	2.99c	5.47e	2.46c	46.59a
Ismalia 1	T1	52.83e	3.59b	6.28d	2.04e	32.47d
	T2	35.70h	3.50b	5.36f	1.83f	34.16d
	T3	54.60d	3.59b	6.42c	2.19d	34.09d
	T4	62.17c	3.79b	6.62b	3.05b	46.06a
	T5	70.47a	4.27a	7.36a	3.36a	45.66a

Conclusion

The present study proved the effects of nano NPK fertilizer on attributes of two wheat genotypes viz., (plant height, number of spike/m^2, number of spikelet/spike, number of tillers, spike length, number of kernels /spike, 100- grain weight, biological yield, grain yield, and harvest index) where these parameters increased significantly when ismalia-1 genotype was fertilized 75% conventional NPK coupled with nano NPK foliar spray application at the rate of 2 ml/l.In conclusion, nano-fertilizers are a promising technological advancement in agriculture, offering a sustainable and effective solution to improve crop productivity. Their ability to enhance nutrient efficiency, regulate gene expression, mitigate oxidative stress, and positively influence plant growth characteristics presents a transformative opportunity for addressing global food security challenges.

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كفاءة الرش الورقي لسماد NPK النانوي في تحسين صفات المحصول في القمح

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أجريت هذه الدراسة بغرض تقييم تأثير الرش الورقي بالأسمدة النانوية NPK في صفات وحاصل صنفين من القمح (سخا–95 وإسماعيلية–1) في ظروف الأراضي شبه القاحلة بشمال سيناء. تم تنفيذ التجربة في ثلاث مكررات باستخدام تصميم القطاعات العشوائية بواقع عشرة معاملات تشمل تطبيق السماد النانوي NPK كرش ورقي مقرونًا بنسب مختلفة من السماد الموصى به من التسميد المعدني التقليدي على النحو التالي: الجرعة الموصى بها 100٪ (المعاملة القياسية)، 10٪ من الجرعة الموصى بها مقرونة بـ الرش الورقي للنانو NPK بمعدل 2 مل/التر، 25% من الجرعة الموصى بها مقرونة بـ الرش الورقي للنانو NPK بمعدل 2 مل/التر، 50% من الجرعة الموصى بها مقرونة بـ الرش الورقي للنانو NPK بمعدل 2 مل/التر، 75% من الجرعة الموصى بها مقرونة بـ الرش الورقي للنانو NPK بمعدل 2 مل/التر، وتم تطبيقها على صنفين من القمح (سخا–95 وإسماعيلية–1). تم قياس عدة صفات تشمل :ارتفاع النبات (سم)، عدد السنابل/م²، عدد السنيبلات/السنبلة، عدد الفسائل/م²، طول السنبلة (سم)، عدد الحبوب/السنبلة، وزن 100 حبة (جم)، المحصول البيولوجي (طن/فدان)، إنتاجية الحبوب (طن/فدان)، و مؤشر الحصاد (%).أوضحت النتائج أن تسميد صنف إسماعيلية–1 ب 75% من NPK التقليدي مع الرش الورقي بالنانو NPK بمعدل 2 مل/لتر كانت الأفضل من بين المعاملات الأخرى لزيادة جميع الصفات المدروسة. بناءً على هذه النتائج، يُوصى بالاستفادة من دمج الأسمدة النانوية NPK مع تقليل جرعات الأسمدة التقليدية في ظروف بيئية متنوعة ومحاصيل مختلفة. هذا الدمج من شأنه أن يسهم بشكل كبير في تحسين كفاءة استخدام المغذيات، حيث يساعد على زيادة امتصاص النبات للعناصر الغذائية بشكل أكثر فعالية، مما يؤدي إلى تقليل الفاقد وزيادة إنتاجية المحاصيل. بالإضافة إلى ذلك، فإن استخدام الأسمدة النانوية يسهم في تعزيز الاستدامة الزراعية.