The impact of NPK and biochar spray levels on the availability and concentration of NPK in plants, In wheat growth

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Abstract

The study was carried out at the second research station of the College of Agriculture, Al-Muthanna University. The purpose was to investigate the impact of different amounts of nano-NPK fertilizer and biochar on the availability and concentration of NPK in wheat plants, as well as their growth and yield. The experiment was conducted using a mixed soil. The experiment involved the application of five different concentrations of nano-NPK fertilizer, which were labeled as follows: (A0) Control treatment,(A1) Full recommendation of traditional agrarian NPK, (A2) 2/1 recommendation of traditional agrarian NPK + 2/1 recommendation of nano-NPK, (A3) Full recommendation of nano-NPK + 2/1 recommendation of traditional agrarian NPK, (A4) Double recommendation of nano-NPK + 2/1 recommendation of traditional agrarian NPK. There are four levels of biochar represented by the symbols (B0:0%), (B1:1%), (B2: 2%), and (B3: 3%). The addition was based on the measurement of the volume of dry soil. A factorial experiment was conducted using a randomized complete block design (RCBD) with three repetitions. The averages were compared using the least significant difference (L.S.D) test. With a significance threshold of 0.05. The results indicated notable variations in the effects of applying different amounts of spraying with nano NPK fertilizer and biochar, as well as their interaction, on the levels of nitrogen, phosphorous, and potassium in both the soil and plants during the flowering stage and grain production.

Keywords: NPK nano, biochar, wheat crop

Introduction

Nanofertilizers are a crucial approach to combat the low wheat production by promoting plant growth and stimulating the division of meristematic cells through the regulation of hormones and production of necessary compounds. Additionally, they enhance the plant's biomass by facilitating the development of a robust root and vegetative system. Nanofertilizers enhance soil fertility and play a crucial role in contemporary agriculture by reducing the reliance on chemical fertilizers. This not only cuts down on material expenses but also mitigates the environmental harm caused by the use of chemical fertilizers (1.(

Biochar impacts the soil's physical, chemical, and fertility characteristics, including soil stability, structure, apparent density, permeability, and water retention capacity. Charcoal enhances soil aggregation by elevating the concentration of calcium ions, hence inhibiting the dispersion of soil particles. Biochar impacts the top layer of the soil by decreasing the concentration of salts and the proportion of exchangeable sodium (2 .(

Wheat is a vital grain that is rich in many substances, including carbs, amino acids, and proteins. According to a study by (3), wheat provides 50% of the calories that humans consume. The growth of wheat production encounters numerous challenges, particularly with the availability of essential elements, including nitrogen, phosphorus, and potassium (NPK), due to the characteristics of the calcareous alkaline soils that retain them.

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Additionally, there is a significant issue of ammonia loss and evaporation. The objective of this research was to address the requirement for increased quantity and enhanced quality of human meals .

Materials and methods:

A field experiment was carried out in the agricultural fields of the College of Agriculture - Al-Muthanna University during the 2023-2024 agricultural season. The objective was to investigate the impact of different amounts of nano-NPK fertilizer and biochar spraying on the availability of NPK on wheat growth and yield. Random samples were collected from the research field, and the salinity as well as various physical and chemical parameters of the soil were measured.

The study employed a randomized complete block design (RCBD) with three replicates and three sectors, each containing 20 experimental units.

The experiment included the use of two factors, the first factor is the nano-NPK fertilizer with five levels, which are:

)A0) Control treatment,(A1) Full recommendation of traditional agrarian NPK, (A2) 2/1 recommendation of traditional agrarian NPK + 2/1 recommendation of nano-NPK, (A3) Full recommendation of nano-NPK + 2/1 recommendation of traditional agrarian NPK, (A4) Double recommendation of nano-NPK + 2/1 recommendation of traditional agrarian NPK

The second factor is biochar with four levels, represented by the symbols (B0:0%), (B1:1%), (B2: 2%), and (B3: 3%.(

Examined attributes:

The study investigates the impact of varying concentrations of nano NPK fertilizer and biochar on soil properties during the flowering stage.

.1 Soil nitrogen availability: Soil nitrogen availability was assessed using the methodology described by (4.(

.2 Phosphorus availability: Phosphorus availability in the soil was determined using a Sepectro Photo Meter, following the (5.(

.3 The available potassium: content was determined using the ammonium acetate 1N extraction method, as described by (4.(

Secondly, this study examines the impact of different quantities of nano NPK fertilizer and biochar on the concentration of NPK in the plant during the flowering stage.

.1 Total nitrogen: Assessed utilizing a Microkjeldal apparatus as per the methodology outlined by (6.(

.2 Total potassium: Potassium was quantified using a Flam Photo Meter, as described by (6.(

.3 Total phosphorus: The measurement of total phosphorus was conducted using a Spectrophotometer equipment, as indicated by (6.(

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Table No. (1) shows the chemical and physical properties of soil samples before planting .

Properties	**Unit**	**value**
pH	7.70	---------
Ece	8.12	dS m^{-1}
Organic matter	0.4	%
Available nitrogen	18.9	mg Kg^{-1} soil
Available phosphorus	14.7	mg Kg^{-1} soil
Available potassium	195	mg Kg^{-1} soil
Soil texture		Sandy loam
Silt	33.4	%
Sand	48.2	%
Clay	18.4	%
Calcium carbonate	250	g Kg^{-1} soil

Results and discussion:

Effect of spray levels of NPK and biochar on NPK availability in the soil at the flowering stage.

-1Available nitrogen in the soil at the flowering stage (mg N kg soil-1.(

The findings from Table (2) indicate that treatment A1 exhibited superiority, with the greatest average of 31.06 mg N kg-1 soil. Treatment A4, with an average of 29.32 mg N kg-1 soil, did not show a significant difference compared to A1. In contrast, treatment A0 had the lowest average of 19.40. The rise in soil nitrogen levels can be attributed to the presence of the applied ground NPK and the application of nano-NPK fertilizer, which resulted in a decrease in nitrogen uptake by the plants. This aligns with the findings of (7.(

The findings from Table (2) indicate that treatment B3 outperformed the others, with the highest average of 29.82 mg N kg-soil-1. In contrast, the comparison treatment had the lowest value of available nitrogen in the soil, with an average of 23.31 mg N kg-soil-1. These results align with the findings of (8), who observed that the addition of charcoal to the soil leads to an increase in the concentration of available nitrogen.

The findings from Table (2) suggest that there are no notable variations in the interaction between the quantities of nano-NPK fertilizer and biochar in terms of nitrogen content in the soil.

Table (2) The effect of spraying levels of nano-NPK fertilizer and biochar and the interaction between them on the concentration of available nitrogen in the soil at the flowering stage (mg N kg-1 soil.(

A / B	A0	A1	A2	A3	A4	Mean
B0	16.43	28.93	23.83	21.33	26.03	23.31
B1	20.08	29.31	25.97	24.90	30.68	26.19
B2	20.04	31.26	27.38	26.89	29.42	27.00
B3	21.04	34.76	29.02	33.17	31.14	29.82
mean	19.40	31.06	26.55	26.57	29.32	
L.S.D	A- 1.97		B- 1.68		AB- N.S	

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-2Available phosphorus in the soil at the flowering stage (mg P kg soil-1.(

The results from Table (3) demonstrate that treatment A1 exhibited superiority, with the highest average of 27.49 mg P kg soil-1. This average did not show a significant difference compared to treatment A4, which recorded an average of 27.19 mg P kg soil-1. On the other hand, treatment A0 had the lowest value of available phosphorus in the soil, measuring 16.31 mg P kg soil-1. This can be attributed to the amount of phosphorus added to the soil in its ground form, as well as the nano fertilizer that provided an ample supply for the plants. Alternatively, the reduced soil pH resulting from the addition of nitrogen fertilizer may have contributed to increased phosphorus availability.

Treatment B3 exhibited the highest concentration of available phosphorus in the soil, as indicated by Table No. (3). The average concentration reached 28.74 mg P kg soil-1. In contrast, the comparison treatment displayed the lowest concentration of available phosphorus in the soil, with an average of 21.54 mg P kg soil-1. The cause can be ascribed to the biochar, which conserved the accessible phosphorus by preventing its adsorption and precipitation, and facilitated the dissolution of nutrients, including phosphorus, by microorganisms (9). The findings from Table (3) indicate that there were notable variations in the interaction between the quantities of nano-NPK fertilizer and biochar in terms of the phosphorus content in the soil during the flowering stage. Treatment A1B3 had the highest average of 29.92 mg P kg soil-1 for accessible phosphorus in the soil, whereas the comparison treatment had the lowest value with an average of 7.04 mg P kg soil-1 .

Table (3) The effect of spraying levels of nano-NPK fertilizer and biochar and the interaction between them on the concentration of available phosphorus in the soil at the flowering stage (mg P kg-1 soil.(

A / B	A0	A1	A2	A3	A4	Mean
B0	7.04	26.47	24.09	23.34	26.75	21.54
B1	14.80	24.55	24.16	25.01	26.25	22.96
B2	16.06	29.01	26.41	26.60	27.05	25.03
B3	27.33	29.92	28.82	28.93	28.71	28.74
Mean	16.31	27.49	25.87	25.97	27.19	
L.S.D	A- 1.08		B- 0.97		AB- 2.17	

-3Potassium available in soil at flowering stage (mg K kg soil-1.(

Table (4) demonstrates the notable impact of NPK fertilizer treatment. Treatment A1 exhibited the highest level of available potassium in the soil during the flowering stage, with an increase rate of 43.99% compared to the comparison treatment which had the lowest value of 184.1 mg K kg soil-1. This discrepancy can be attributed to the amount of potassium fertilizer applied to the soil, which supplied ample quantities of available potassium. Additionally, the plant absorbed suitable amounts of potassium when treated with nano fertilizer. The results from Table (4) demonstrated that treatment B3 exhibited superiority and achieved the highest average of 254.3 mg K kg soil-1. In contrast,

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the comparison treatment had the lowest average of 222.0 mg K kg soil-1. This finding aligns with the findings of (10), which indicated that the levels of added charcoal were directly proportional to the increase in soil potassium quantities. The study found significant differences in the available potassium levels in the soil when examining the interactions between nano-NPK fertilizer and biochar. Treatment A4B3 had the highest average of 275.8 mg K kg-1 soil, while the comparison treatment had the lowest value of 158.7. This demonstrates the function of nano-fertilizer in providing plants with potassium, as well as the significant significance of biochar in safeguarding potassium from loss and fixation processes by enhancing the activity of microorganisms, which aligns with the findings of (11.(

Table (4) The effect of spraying levels of nano-NPK fertilizer and biochar and the interaction between them on the concentration of ready potassium in the soil at the flowering stage (mg K kg-1 soil.(

A / B	A0	A1	A2	A3	A4	Mean
B0	158.7	250.1	229.1	224.8	247.2	222.0
B1	172.0	263.1	220.5	242.0	256.8	230.9
B2	193.7	272.3	246.6	251.2	264.4	245.7
B3	212.1	274.8	256.7	251.8	275.8	254.3
Mean	184.1	265.1	238.2	242.5	261.0	
L.S.D	A- 6.92		B- 6.19		AB- 13.83	

Effect of spray levels of NPK and biochar on NPK in the plant during the flowering stage.

-1Total nitrogen in the plant at the flowering stage.%

The findings from Table (5) indicate that there were notable variations in the application of nano fertilizer NPK. Specifically, the concentration of nitrogen in the plant increased as the level of foliar spraying with nano fertilizer NPK increased. Treatment A4 demonstrated the highest average concentration of 2.85%, while the comparison treatment had the lowest value of 2.11%. These results align with the findings of (12), which also observed an increase in nitrogen concentration in plants when using nano fertilizer NP .

Table (5) demonstrates the superiority of biochar treatment B3, which achieved the highest average of 2.75%. This can be linked to the biochar's provision of an ample amount of nitrogen to the plant, as stated by (13). Significant changes in nitrogen concentration in the plant during the blooming stage were seen as a result of the interactions between the amounts of nano NPK fertilizer and biochar. Treatment A1B3 achieved the greatest average of 2.98%, while the comparison treatment had the lowest value of 2.04%.

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Table (5) Effect of spraying levels of nano NPK fertilizer and biochar and the interaction between them on the percentage of nitrogen concentration in the plant % at the flowering stage.

A / B	A0	A1	A2	A3	A4	Mean
B0	2.04	2.10	2.36	2.37	2.53	2.28
B1	2.08	2.39	2.68	2.70	2.93	2.55
B2	2.14	2.48	2.73	2.75	2.97	2.61
B3	2.19	2.67	2.94	2.96	2.98	2.75
Mean	2.11	2.41	2.67	2.69	2.85	
L.S.D	A- 0.019		B- 0.017		AB- 0.039	

-2The percentage of total phosphorus concentration in the plant at the flowering stage.%

The findings from Table (6) indicate that there were notable variations in the application of NPK nano fertilizer. Specifically, the concentration of nitrogen in the plant increased as the level of foliar spraying with NPK nano fertilizer increased. Treatment A4 achieved the highest average concentration of 0.68%, while treatment A0 had the lowest phosphorus value in the plant, measuring 0.52%. These results align with the findings of (14), who observed an increase in phosphorus concentration with the addition of nano fertilizer.

Treatment B3 demonstrated superior performance, as evidenced by the data presented in Table (6), with an average of 0.62%. In contrast, the comparison treatment exhibited the lowest value of 0.57%. This disparity can be attributed to the gradual release of phosphorus into the soil solution due to the addition of biochar, which was subsequently absorbed by the plant.

Table (6) The effect of spraying levels of nano-NPK fertilizer and biochar and the interaction between them on the percentage of phosphorus concentration in the plant % in the flowering stage.

A / B	A0	A1	A2	A3	A4	Mean
B0	0.50	0.56	0.57	0.62	0.62	0.57
B1	0.52	0.57	0.58	0.64	0.68	0.59
B2	0.53	0.58	0.58	0.65	0.70	0.60
B3	0.54	0.59	0.60	0.67	0.72	0.62
Mean	0.52	0.57	0.58	0.64	0.68	
L.S.D	A-0.014		B-0.012		AB-N.S	

-3The percentage of total potassium concentration in the plant at the flowering stage.%

Table (7) displays the notable impact of the NPK nano fertilizer treatment. Treatment A4 achieved the greatest average of 2.50%, whilst treatment A0 exhibited the lowest potassium value in the plant, measuring 1.45%. The rise

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in potassium levels in the plant can be linked to the increased application of nano fertilizer through spraying, which aligns with the findings of (14 .(

Treatment B3 demonstrated superior performance, as evidenced by the data presented in Table 7. It achieved the highest average of 2.28%, while treatment A0 had the lowest value of 1.73%. This finding aligns with the conclusions reached by (15), who found that charcoal effectively preserves nutrients in a readily absorbable form for an extended duration. The findings from Table (7) demonstrate the notable impact of the interaction between nano NPK fertilizer and biochar on the potassium concentration characteristic in the plant. The therapy A4B3 had the greatest average of 2.71%, whilst the comparable treatment A0B0 had the lowest value of 1.33%. The potential reason for this phenomenon could be attributed to the function of nano fertilizer and biochar. Nano fertilizer supplies essential components to the plant, while biochar acts as a reservoir for these elements, gradually releasing them to the plant

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Table (7) Effect of spray levels with nano NPK fertilizer and biochar and the interaction between them on the percentage of potassium concentration in the plant % in the flowering stage.

A / B	A0	A1	A2	A3	A4	Mean
B0	1.33	1.48	1.81	1.82	2.24	1.73
B1	1.47	1.52	1.92	1.94	2.48	1.86
B2	1.51	1.81	2.55	2.58	2.58	2.20
B3	1.50	2.05	2.53	2.59	2.71	2.28
Mean	1.45	1.71	2.20	2.23	2.50	
L.S.D	A-0.037		B- 0.033		AB- 0.075	

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