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Effect of Adding A Salinity Regulator and Enriching Organic Fertilizer with Nano-Compound Fertilizer (NPK) on Some Chemical and Physical Properties of the Soil

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ABSTRACT: The experiment was carried out in the fields of the College of Agriculture, University of Diyala, during the period of 2025-2026 agricultural season. The study aimed to examine the effect of the addition of the salinity regulator and enrichment of the organic fertilizer with the nano-NPK fertilizer on some properties of the soil. The experiment used the Randomized Complete Block Design (RCBD), a split-plot design with three replicates, which constituted a total number of 36 experimental units. Three levels of the salinity regulator were used in the main plots as follows: without addition, 10 mL L⁻¹ per seedling, and 20 mL L⁻¹ per seedling. Also, four levels of organic and nano-NPK fertilizer treatments were used in the sub-plots as follows: without addition, 5% sheep manure, 5% sheep manure + 5 kg ha⁻¹ nano-NPK fertilizer, and 5 kg ha⁻¹ nano-NPK fertilizer only. The data collected were statistically analyzed by comparing their means using Duncan's Multiple Range Test at a probability level of 0.05. It was found that the addition of 5% sheep manure (O2) was better than the control (O1) in relation to nitrogen, phosphorus, potassium, and organic matter contents of the soil; the mean values of these parameters were

INTRODUCTION:

Soil is a fundamental natural resource for feeding the world's growing population and is essential for achieving most of the Sustainable Development aims. However, there are many challenges causing the degradation of agricultural land in arid and semi-arid regions, most notably salinity [1], which has contributed significantly to The deterioration of soil infrastructure has highlighted the need for sustainable agricultural practices that can mitigate the effects of soil salinity. Among these techniques is the use of Anti-salinity, which reduce the accumulation of harmful ions by breaking the bond between sodium and soil particles and replacing it with calcium. This leads to improved physical and chemical soil properties [2].

Applied fertilizer models have evolved, particularly the "enrichment" technique, which involves loading NPK nano-fertilizers onto organic manure. This combination offers several advantages for the soil due to its high efficiency, the small size of the nano-fertilizer particles, and the reduction of the negative effects of traditional inorganic fertilizers. It also increases organic carbon and improves soil quality and fertility in the long term [3], while mitigating salinity.

This study aims to:

1-Investigate the effect of adding Anti-salinity on treating soil salinity and improving its properties.

2. Investigate the effect of enriching organic manure with NPK nano-compound fertilizer on improving soil fertility.
3. A study of the effect of the interaction between a salinity regulator and a nano-loaded organic fertilizer on modifying and improving some chemical and physical properties.

MATERIALS AND METHODS

The field experiment was conducted in a field belonging to the College of Agriculture, University of Diyala, located at longitude 44° 45' East and latitude 33° 17' 41" North. The study targeted saline soils over a period of approximately one year, until 2025. The aim was to evaluate the effect of Anti-salinity and the enrichment of organic fertilizer with nano-NPK fertilizer on certain soil properties. This experiment was conducted to study the effect of different levels of organic fertilizer and nano-NPK compound, in conjunction with different levels of Anti-salinity, on plant growth.

First: Fertilization Levels

- 1- Factor 1 (Control): No addition, denoted as O1.
- 2- Factor 2 (Sheep manure at 5% by volume), denoted as O2.
- 3- Factor 3 (Enrichment with 5% sheep manure + 5 kg ha⁻¹ nano-compound fertilizer), denoted as O3.
- 4- Factor 4 (Nano-compound fertilizer, 5 kg ha⁻¹), denoted as O4.

Second: Salinity control: The salinity control levels were the main treatments and included three levels:

Control factor W1

10ml L⁻¹ per seedling W2

20ml L⁻¹ per seedling W3

Applying was done in three doses (at planting, 45 days after the first dose, and 90 days after the first dose).

Study traits:

- 1- Electrical conductivity (EC): Estimated using a conductivity bridge according to the method described by [4].
- 2- pH: Measured using a pH meter according to the method described by [4].
- 3- Soil organic matter content: Estimated by the wet digestion method according to the Walky and Black method described by [4].
- 4- Soil available nitrogen concentration (mg/s). N kg⁻¹ soil: The concentration was determined by soil extraction using potassium chloride (2(N)₂). Magnesium oxide was added, and nitrogen was converted from nitrate to ammonium by adding Devarde alloy as a reducing agent, as described in [5] as outlined in [6].
- 5- Soil phosphorus concentration (mg P kg⁻¹ soil): The concentration was determined using sodium bicarbonate (0.5 M) at pH 8.5. Ammonium molybdate and ascorbic acid were added until a blue color developed. A spectrophotometer was used at a wavelength of 882 nm, as described by [7] cited in [4].
- 6- Soil potassium concentration (mg K kg⁻¹ soil): The concentration was determined using ammonium acetate and a flame spectrometer, as described in [4].
- 7- Cation exchange capacity (CEC): Estimated by saturation with ammonium acetate (1M) and extraction with ammonium acetate (1M), as reported by [8].

RESULTS AND DISCUSSION

1- Soil available nitrogen concentrations

The results in the table show the effect of adding Anti-salinity and enriching organic fertilizer with NPK nano-compound fertilizer, and the interaction between them, on soil available nitrogen concentrations. The results showed a significant effect when adding Anti-salinity, as treatments w2 and w3 were significantly excelled, reaching the highest average concentrations of 25.9583 and 30.3333 mg kg⁻¹, respectively, compared to the control treatment w1, which reached 20.6500 mg kg⁻¹, with increases of 25.71% and 46.89%. As for the effect of adding organic fertilizer and NPK nano-compound fertilizer, the results showed that treatments O4 and O3 were excelled. The two treatments gave 26.989 and 35.313 mg g⁻¹ respectively, compared

to the control treatments O1 and O2, which gave 21.10 mg g⁻¹, representing increases of 57.73% and 106.36%. The results showed a significant interaction effect on this trait. The W3O3 treatment gave the highest value at 40.367 mg g⁻¹, while the W1O1 treatment had the lowest value at 11.900 mg g⁻¹, representing an increase of 239.22%.

Table 1. Effect of adding Anti-salinity, enriching organic fertilizer with NPK nano-compound fertilizer, and their interaction on soil nitrogen concentrations (mg kg⁻¹)

Anti-salinity	Organic fertilizer and nano-compound fertilizer NPK				Anti-salinity averages
	O1	O2	O3	O4	
W1	11.900 f	17.500 Ef	31.033 Cadb	22.167 ed	20.6500 C
W2	21.467 ed	23.100 Ed	34.533 Ab	24.733 ced	25.9583 B
W3	17.967 ef	28.933 Cdb	40.367 A	34.067 cab	30.3333 A
Average organic fertilizer and nano-compound fertilizer NPK	17.111 C	23.178 B	35.311 A	26.989 B	

- The symbols in the table indicate W = Anti-salinity, where W1 = 0 (no addition), W2 = 10 kg ha⁻¹, W3 = 20 kg ha⁻¹, and O1 = 0 (no addition). O2 = sheep manure, O3 = enrichment of organic fertilizer with NPK nano-compound fertilizer, and O4 = NPK nano-fertilizer. *Means with different letters differ significantly from each other according to Duncan's multiple range test at a probability level of 0.05.

2- Available Potassium Concentrations in the Soil

The results in the table show the effect of adding Anti-salinity, enriching organic fertilizer with NPK nano-compound fertilizer, and their interaction on available potassium concentrations in the soil. The results showed a significant effect when fertilizer was added. The O3 treatment had the highest average concentration of 411.78 mg kg⁻¹, followed by the O2 treatment with 311.52 mg kg⁻¹, respectively, compared to the control treatment O1. The increase in potassium concentration in the soil (mg kg⁻¹) was 181.01 mg.kg⁻¹, representing increases of 127.49% and 72.10%, respectively. The effect of adding the Anti-salinity did not show significant differences between the treatments, as the mean values for treatments W1, W2, and W3 were similar, recording 299.41, 290.76, and 287.48 mg.kg⁻¹, respectively. The results showed a significant interaction effect on this trait, with treatment W3O3 exhibiting the highest value at 433.69 mg.kg⁻¹, while treatment W2O1 had the lowest value at 179.49 mg.kg⁻¹, representing an increase of 141.62%.

Table 2. Effect of adding the Anti-salinity and enriching organic fertilizer with NPK nano-compound fertilizer on soil potassium concentrations (mg kg⁻¹).

Anti-salinity	Organic fertilizer and nano-compound fertilizer NPK				Anti-salinity averages
	O1	O2	O3	O4	
W1	180.46 d	325.26 b	401.37 a	255.96 c	290.76 A
W2	179.49 d	310.05 bc	400.30 a	260.07 c	287.48 A
W3	183.08 d	299.24 bc	433.69 a	281.62 bc	299.41 A
Average organic fertilizer and nano-compound fertilizer NPK	181.01 D	311.52 B	411.78 A	265.88C	

The symbols in the table represent W = salt antagonist, where W1 = 0 without addition, W2 = 10 kg e1-, W3 = 20 kg e1-, and O1 = 0 without addition, where O2 = sheep manure, O3 = enrichment of organic fertilizer with NPK nano-compound fertilizer, and O4 = NPK nano-fertilizer. The means with different letters differ significantly from each other according to Duncan's polynomial test at a probability level of 0.05.

The symbols in the table represent W = salt antagonist, where W1 = 0 without addition, W2 = 10 kg e1-, W3 = 20 kg e1-, and O1 = 0 without addition, where O2 = sheep manure, O3 = enrichment of organic fertilizer with NPK nano-compound fertilizer, and O4 = NPK nano-fertilizer. The means with different letters differ significantly from each other according to Duncan's polynomial test at a probability level of 0.05. 0.05

3-Soil Available Phosphorus Concentrations

The results in the table show the effect of adding Anti-salinity and enriching organic fertilizer with NPK nano-compound fertilizer, and the interaction between them, on soil available phosphorus concentrations. The results showed no significant differences when adding the Anti-salinity between treatments, as the mean values were similar. The effect of the Anti-salinity also did not show significant differences between treatments, with treatments W1, W2, and W3 recording mean values of 32.126, 31.693, and 27.241 mg kg⁻¹, respectively. The results also showed that the effect of organic fertilizer and NPK nano-compound fertilizer did not show significant differences individually for treatments O1, O2, O3, and O4, recording 36.024, 32.857, 27.881, and 24.650 mg kg⁻¹, respectively. The results showed a significant interaction effect on this trait. The W1O4 interaction treatment gave the highest value of 53.91 mg kg⁻¹, while the W1O3 interaction treatment had the lowest value of 18.45 mg kg⁻¹, representing an increase of 192.20%.

Table 3. Effect of adding Anti-salinity, enriching organic fertilizer with NPK nano-compound fertilizer, and their interaction on soil phosphorus concentrations (mg kg⁻¹).

Anti-salinity	Organic fertilizer and nano-compound fertilizer NPK				Anti-salinity averages
	O1	O2	O3	O4	
W1	21.24 ab	33.17 ab	18.45 b	53.91 A	31.693 A
W2	48.01 ab	21.74 ab	20.40 ab	18.81 B	27.241 A
W3	38.82 ab	28.73 ab	35.10 ab	25.85 Ab	32.126 A
Average organic fertilizer and nano-compound fertilizer NPK	36.024 A	27.881 A	24.650 A	32.857 A	

4-Soil Organic Matter Concentrations

The results in the table show the effect of adding Anti-salinity and enriching organic fertilizer with NPK nano-compound fertilizer, and the interaction between them on organic matter. The results showed a significant effect when adding the Anti-salinity, as treatment W1, which reached 1.61500 g kg⁻¹, was superior to the control treatment W2 and treatment W3, which reached 1.08917 and 0.75500 g kg⁻¹, respectively, by an increase of 48.28%. This was compared to treatment W2, and by an increase of 113.91% compared to treatment W3. As for the effect of adding organic fertilizer and NPK nano-compound fertilizer, the results showed that treatment O1, which gave 1.5511 g kg⁻¹, was superior to the other treatments, compared to treatment O3, which recorded the lowest average of 0.7333 g kg⁻¹, by an increase of 111.52%. The results also showed a significant interaction effect on this trait. Treatments O2 and O4 ranked second with values of 1.2633 and 1.0644, respectively, with no significant difference between them. The results also showed a significant interaction effect on this trait, with treatment W1O1 yielding the highest value of 2.0267, while treatment W3O3 had the lowest value of 0.1733, representing an increase of 1069.47%.

Table 4. Effect of adding a salinity inhibitor, enriching organic fertilizer with NPK nano-compound fertilizer, and their interaction on organic matter concentrations (g kg⁻¹).

Anti-salinity	Organic fertilizer and nano-compound fertilizer NPK				Anti-salinity averages
	O1	O2	O3	O4	
W1	2.0267 a	1.5500 ab	1.3767 b	1.5067 b	1.61500 A

W2	1.4200 a	1.1200 cb	0.6500 cd	1.1667 cb	1.08917 B
W3	1.2067 b	1.1200 cb	0.1733 d	0.5200 d	0.75500 C
Average organic fertilizer and nano-compound fertilizer NPK	1.5511 A	1.2633 B	0.7333 C	1.0644 B	

5- Electrical Conductivity (EC)

The results in the table show the effect of adding Anti-salinity and enriching the organic fertilizer with NPK nano-compound fertilizer, and the interaction between them, on the electrical conductivity (dSm^{-1}) in the soil. The results showed a significant effect when adding the organic fertilizer and NPK nano-compound fertilizer; the O3 treatment was superior, recording the lowest average salinity of 2.88 dSm^{-1} compared to the control treatment O1, which recorded 16.1667 dSm^{-1} , with a decrease of 42.26%. This was followed by the O2 treatment, which gave 11.4000, representing a 29.48% decrease compared to the O1 control treatment. The results in the same table show the effect of adding the Anti-salinity; no significant differences were observed between the treatments, as the mean values for treatments W1, W2, and W3 were very close, registering 12.6250, 12.2833, and 12.4500 dSm^{-1} , respectively. The interaction had a significant effect on the same trait, as the W1O3 treatment gave a value of 9.2333 dSm^{-1} compared to the W1O1 treatment without the addition, which recorded 16.3667 dSm^{-1} , representing a 43.58% decrease.

Table 5. Effect of adding the Anti-salinity, enriching the organic fertilizer with NPK nano-compound fertilizer, and their interaction on electrical conductivity (dSm^{-1}).

Anti-salinity	Organic fertilizer and nano-compound fertilizer NPK				Anti-salinity averages
	O1	O2	O3	O4	
W1	16.3667 a	11.5333 de	9.2333 f	13.3667 b	12.6250 A
W2	16.0000 a	10.9667 e	9.5000 f	12.6667 c	12.2833 A
W3	16.1333 a	11.7000 d	9.2667 f	12.7000 c	12.4500 A
Average organic fertilizer and nano-compound fertilizer NPK	16.1667 A	11.4000 C	9.3333 D	12.9111 B	

6- pH

The results in the table show the effect of adding salinity regulator, organic fertilizer, and nano-compound fertilizer, as well as their interaction, on pH. The results showed a significant effect when adding salinity regulator, with treatment W3 recording 8.39083, compared to treatment W1, which recorded the lowest value of 8.17585, representing an increase of 2.62%. The results in the same table also showed the effect of adding organic fertilizer and nano-compound fertilizer (NPK). The results showed that treatment O3 was superior, yielding the highest value of 8.66111, compared to treatment O1, which reached 7.61889, representing an increase of 13.67%. The interaction had a significant effect on this characteristic, as treatment W3O3 gave the highest value of 8.7000, compared to the interaction treatment W1O1 without the addition of any fertilizer, which recorded 7.5900, representing an increase of 14.62%.

Table 6. Effect of adding Anti-salinity and enriching organic fertilizer with NPK nano-compound fertilizer and their interaction on pH.

Anti-salinity	Organic fertilizer and nano-compound fertilizer NPK				Anti-salinity averages
	O1	O2	O3	O4	
W1	7.5900 d	8.3933 cab	8.6033 ab	8.1167 c	8.17585 B
W2	7.6567 d	8.4533 ab	8.6800 a	8.2867 cb	8.26917 Ab

W3	7.6100 d	8.6533 a	8.7000 a	8.6000 ab	8.39083 A
Average organic fertilizer and nano-compound fertilizer NPK	7.61889 c	8.50000 ab	8.66111 a	8.33444 b	

7- Cation Exchange Capacity (CEC) ($\text{kg}^{-1}/\text{c molc}$)

The results in the table show the effect of adding Anti-salinity and enriching the organic fertilizer with NPK nano-compound fertilizer, and the interaction between them, on the values of the soil's cation exchange capacity. The results showed a significant effect when adding the Anti-salinity, as treatment W3 was significantly excelled, reaching the highest average of $29.3725 \text{ kg}^{-1}/\text{c molc}$, followed by the control treatment W1, which reached $28.0067 \text{ kg}^{-1}/\text{c molc}$, while treatment W2 recorded the lowest average of $26.2730 \text{ kg}^{-1}/\text{c molc}$. Regarding the effect of adding organic fertilizer and NPK nano-compound fertilizer, the results showed the superiority of treatment O3, which gave the highest average CEC of $40.949 \text{ kg}^{-1}/\text{c molc}$, followed by treatments O2 and O4, which gave 30.598 and $24.030 \text{ kg}^{-1}/\text{c molc}$, respectively. In contrast, O1 recorded the lowest average of $16.789 \text{ kg}^{-1}/\text{c molc}$. The results also showed a significant interaction effect on this trait. Treatment W3O3 gave the highest value of $43.557 \text{ kg}^{-1}/\text{c molc}$, while treatment W1O1 had the lowest value of $16.377 \text{ kg}^{-1}/\text{c molc}$, representing an increase of 165.96%.

Table 7. Effect of adding Anti-salinity, enriching organic fertilizer with NPK nano-compound fertilizer, and their interaction on soil CEC values ($\text{kg}^{-1}/\text{c molc}$)

Anti-salinity	Organic fertilizer and nano-compound fertilizer NPK				Anti-salinity averages
	O1	O2	O3	O4	
W1	16.377 e	31.103 b	40.107 a	24.440 dc	28.0067 AB
W2	16.860 e	28.253 bc	39.183 a	23.283 d	26.2730 B
W3	17.130 e	32.437 b	43.557 a	24.367 dc	29.3725 A
Average organic fertilizer and nano-compound fertilizer NPK	16.789 D	30.598 B	40.949 A	24.030 C	

CONCLUSIONS

Fertilization by enriching organic fertilizer with nano-compound fertilizer at the O3 kg ha^{-1} level resulted in providing adequate quantities of nitrogen, phosphorus, and potassium in the soil. The fertilizer increased their concentrations in the soil. Adding organic fertilizer and nano-fertilizer at the O2 and O4 kg ha^{-1} levels increased the availability of nitrogen, phosphorus, and potassium, as well as other soil properties, in two stages. The interaction between organic fertilizer and nano-fertilizer produced significant and clear effects on most of the studied soil properties, including organic matter, electrical conductivity, soil pH, and cation exchange capacity. These properties, in turn, enhance soil fertility.

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