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# Effects of Some Agricultural and Fertilization Treatments on Growth Parameters and Productivity of Growing Wheat Grown on A Salt-Affected Soil in IRAQ

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**Abstract**

The present research was carried out in Al-Saniyah district, Al-Diwaniyah Governorate, Iraq, on a salt-affected soil (EC>4 dSm-1). To counteract the negative effects of salt on wheat plant development metrics and productivity, as well as the quantity of N, P, and K in the plant, it was developed In addition to the biocher, nano-5, amino acids and K fertiliser, the other amendments utilised for their functions were KCl and nano-K. It was thought that K would increase plant tolerance to drought. The research found that these supplements had a favourable impact on all plant development metrics, including grain production and biological output.

**Key words:** Wheat, Biocher, Nano-fertilizer, Salt-affected soil, Amino acids.

## 1. Introduction

In agriculture, wheat (Triticum aestivum L.) is a vital crop. Nutritional value of wheat grain can be determined by its amino acid (AA) composition and content in wheat straw [19].

To this end, it is commonly cultivated in areas with saline or alkaline soils. Plant growth and global crop productivity are both harmed by soil salinity, a significant abiotic stress in semi-arid regions [7]. Water scarcity, poor irrigation, poor drainage, and high evaporation are all possible causes of the salinity issues in these regions [1].

Arid and semi-arid conditions prevail across the vast majority of Iraq's land area. At 3550 metres above sea level, mountains encircle the Tigris-Euphrates basin to the north and east, while deserts cover a larger area, accounting for more than 40% of the land surface [8].

Biochar might be used as an amendment to boost agricultural yield by reducing the detrimental effects of salt stress on crops [3].

By applying 5–20 Mg/ha biochar, NUE (nitrogen usage efficiency) in wheat increased by 5.2–37.9 percent and GY (grain yield) by 2.9–19.4 percent. However, wheat's NUE and GY were severely influenced by high biochar application rates (more than 30 Mg/ha) [17]. Depending on the rate of application, biochar has a considerable impact on the amino acids (AAs).

When compared to the control and traditional (NPK+TE) fertiliser treatments, SMP nano-fertilizer spraying resulted in significant increases in plant height, spike length, tasselled yield, and all other growth and yield parameters of wheat (Fig. 4). The corresponding increases in spray foliar (SMP) were 3.17 percent, 0.66 percent, and 2.88 percent, respectively, when compared to the control and traditional (NPK+TE) fertiliser spraying treatments. With the same treatment yielding 5.996 Mg/ha of grain and 13.69 percent of protein, the control and conventional fertiliser treatments yielded (4.060 Mg/ha and 11.94 percent) and (5.198 Mg/ha and 11.94 percent) respectively. The harvest index ranged from 35.27 to 44.96 percent for the control and nano SMP fertiliser application. When spraying treatments with nano SMP and tri nano mixtures of (N+P+K) fertilisers (1936.0 and 1581.0 kg/kg) were compared to conventional fertiliser (569.0 kg/kg), the maximum fertiliser productivity was attained.

(17) found that biochar treatments had a substantial impact on straw biomass and harvest index. Wheat straw biomass and the harvest index show similar tendencies to the impacts of biochar addition. According to their findings, they observed that biochar amendments had no influence on the three yield components (effective number of panicles, number of grains per panicle and thousand-grain weight).

It is the primary objective of this research to examine the effects of various agricultural and fertiliser treatments on wheat plant development characteristics and yield in Iraqi soils.

## 2. Materials And Methods

**Site description:**

The site of implementing the experiment was in Al-Saniyah district, Al-Diwaniyah Governorate, Iraq (see the attached maps).

**Experiment design:**

The experiment was designed to study the effect of some agricultural and fertilization treatments on the productivity of wheat plant grown salt-affected soil. Two factors were put under study in this experiment its.

The first factor was potassium in form as fertilizer potassium, nano potassium fertilizer at a rate of 1 mg/L, nano potassium fertilizer at a rate of 2 g/L.

The second factor was biochar whose used treatments were without addition (comparison) and addition a rate of . The third factor involved four treatments i.e. non-fertilizer: comparison, nano-silicon (K1) applied at a rate of fertilizer, amino acid (K2) at a rate of nano silicon + amino acid (K3).

**Materials:**

The soil of the field was prepared before planting by conducting plowing, smoothing and leveling operations by means of a hydraulic agricultural machine. A representative sample was taken from soil by a random method, dried pneumatically and ground using a ceramic mortar, and then sieved through a sifter with holes of 2 mm in diameter. Chemical and physical analyses of the prepared sample were conducted on it in the central laboratory of the College of Agriculture - University of Baghdad according to the standard methods outlined

Page *et al.* (1980) and Klate (1986) as described these after.

**Table (1)** Properties of the investigated soil

| Property | Value |
|---|---|
| **Particle size distribution (%):** | |
| **Clay** | 12 |
| **Silt** | 58 |
| **Sand** | 30 |
| **Texture** | Silt clay loam |
| **CEC cmolc/kg soil** | 23.1 |
| **OM g/kg soil** | 11.2 |
| **Carbonates g/kg soil** | 201 |
| **pH** | 7.7 |
| **EC (1:1) (dS/m)** | 2.4 |
| **Available macronutrients (mg/kg soil):** | |
| **N** | 17 |
| **P** | 11 |
| **K** | 199 |
| **Available micronutrients (mg/kg soil):** | |
| **Cu** | 0.19 |
| **Zn** | 0.17 |
| **Fe** | 0.30 |
| **Mn** | 0.30 |
| **Bulk density Mg $m^{-3}$** | 1.31 |

Slim and Ali (2017) and Landon (1984).

Biochar: The biochar used in this experiment was manufactured in the laboratories of the College of Agriculture - University of Baghdad Table (1) shows some of its.

The potassium chemical, physical properties: The ordinary potassium fertilizer.

Nano-potassium fertilizer: Granular nano-silicon (K1) fertilizer purchased from the local markets ( اسم الشركة ). A procedure was conducted to measure the size of nano-potassium particles using a scanning electron microscope (SEM) to ascertain the size of the particles within the range of 1-100 nanometer. Secondary. Liquid nano-silicon (K) fertilizer was used and was prepared in the local markets, and the measurement of the size and particles of nano-silicon was carried out by means of an electronic scanner (SEM).

Nano-enriched and purchased from the local markets.

**The experimental design was factorial randomized complete block design with two factors, in three replicates, as follows:**

**Plant sampling and measurement:**

At the vegetative growth of wheat plants, different growth and yield parameters i.e plant height (cm), spike length (cm), weight of 1000 grains (g), grain yield (Mg/ha), biological yield (Mg/ha), harvest index (%), N (%), P (%) and K (%) content were recorded for all treatments in both seasons.

**Chemical composition:**

- Chlorophyll a, b and β-carotene contents were determined according to the protocol devised by [14].
- Nitrogen was determined by Micro-Kjeldahl method according to the procedure described by [12].
- Phosphorus was determined colorimetrically using ascorbic acid method [12].
- Potassium was determined by flame photometer.

**Statistical analysis:**

The experiments were statistically arranged in completely randomized block design with three replicates. The analysis of varience for the final data was carried out using ANOVA system and the values of LSD at 0.05 level by SPSS (ver. 22) according to [16].

**3. Results And Discussion**

**1. Effect of the agricultural and fertization treatments on the chlorophyll content (SPAD unit):**

Agricultural and fertilisation treatments have a significant impact on wheat chlorophyll content in the first and second seasons, as shown in Table (2).

There was a lot of variability in the first season's chlorophyll content due to the various treatments that were used. The contro treatment B0K0A0, which did not receive charcoal, fertiliser, or K, had the lowest chlorophyll content, at 37.20 SPAD. In the B1K3A3 treatment, biochar+high such as a rate of nano-K spray baside of Si+amino acid provided the maximum chlorophyll content, 58.00 SPAD. There was a 55.91 percent difference between the two treatments. A significant increase in chlorophyll content may be achieved by combining biochar with amino acids and potassium.

In general, biochar (B) treatment raised chlorophyll content by 18.71%, while biochar, K, or nanomaterials (B0K0A0) did not result from the treatment.

There is a strong reaction to potassium fertilisation, especially when it is added in nanoform. The major impact of potassium fertilisation (K) shows increases of 4.68, 6.74, and 19.60 percent on average owing to K1, K2, and K3.

The treatments A1, A2, and A3 (nano Si, amino acid, and nano Si+amino acids) all resulted in increases averaging 3.00, 3.43, and 7.86 percent in the main effect

(A). When coupled with A0, amino acids significantly increased the amount of chlorophyll in the plant.

Under all of the nano-K fertiliser treatments, the results collected reveal that there are substantial changes in chlorophyll content between the various treatments compared to the control. Biochar-added treatments also had a greater chlorophyll content than those without it in all nano-K fertiliser interactions, according to the data.

Compared to the control, the chlorophyll content of Bio fertiliser is significantly higher under all circumstances of biochar and potassium treatment.

There were no significant changes between treatments using silicon + amino acids and treatments using amino acids just when charcoal and potassium were applied, as was discovered by examining the nano-fertilizer treatment.

General conclusions of first-season outcomes show that charcoal addition resulted in much higher chlorophyll content than no addition. In comparison to the control group, the nano-fertilization treatments resulted in considerable increases as well.

In addition, the preceding data shows that chlorophyll content rises significantly when calcium is added in the normal- or nano-scale form. The addition of nano-silicon and amino acids coefficient fertiliser resulted in considerable increases above the control. Silicon and amino acids had the highest scores.

The chlorophyll concentration in the second season was likewise affected by the various treatments. The treatment B0K0A0, which did not get biochar, fertiliser, or nano materials, had the lowest chlorophyll concentration of 37.20 SPAD. There was a 55.91 percent difference between treatments B1K3A3 (biochar+higher nano-K spray rate and Si+amino acids) and B1K3A1 (biochar+si+amino acids). In this study, the increase in wheat chlorophyll content was attributed to the use of biochar in combination with amino acids and vitamin K, particularly in its washed form.

More control was gained by 18.71% as a result of using biochar (B) (no-nano materials no K fertilizer).

Due to the addition of potassium fertiliser (K), the main effect shows increases of 4.68, 6.74, and 19.60 percent, respectively, for K1, K2, and K3.

nano-materials (A) have a primary effect on nanomaterials (A) that results in an average increase of 3.43 percent for A1 treatment, 3.43 percent for A2 treatment, and 7.86 percent for A3 treatment (Si+amino acid). Chlorophyll concentration increased significantly when amino acids were coupled with A0.

There was a statistically significant difference in chlorophyll content between treatments with and without biochar in all nano-fertilizer transactions.

(A) Significant increases in chlorophyll content compared to the control when either of the nano materials (A) are applied.

The treatment with silicon + amino acids resulted in a higher chlorophyll content than the other treatments, but the differences between the silicon + amino acid treatment and the amino acid treatment alone were not significant under any of the biochar or potassium conditions.

**Table (2)** Effect of some agricultural and fertilization treatments on chlorophyll content (SPAD unit) of wheat grown a saline soil (EC of 4.7 $dSm^{-1}$ .

| Biochar (B) | K fertilizer (K) | Nano materials (N) A0 | A1 | A2 | A3 | Mean |
|---|---|---|---|---|---|---|
| 2018-2019 season | | | | | | |
| | K0 | 37.20 | 38.43 | 39.63 | 40.20 | 38.87 |
| | K1 | 39.10 | 40.33 | 41.61 | 42.23 | 40.82 |
| B0 | K2 | 40.93 | 42.33 | 43.63 | 44.20 | 42.77 |
| | K3 | 44.63 | 46.10 | 47.63 | 48.33 | 46.67 |
| | Mean | 40.47 | 41.80 | 43.13 | 43.74 | 42.28 |
| | K0 | 45.63 | 46.10 | 47.53 | 48.57 | 46.96 |
| | K1 | 47.00 | 48.43 | 50.00 | 50.63 | 49.02 |
| B1 | K2 | 49.10 | 50.77 | 42.33 | 53.07 | 48.82 |
| | K3 | 53.50 | 55.33 | 57.00 | 58.00 | 55.96 |
| | Mean | 48.81 | 50.16 | 49.22 | 52.57 | 50.19 |
| General mean | | 44.64 | 45.98 | 46.17 | 48.15 | |
| Mean of K | | | | | | Mean |
| K0 | | $41.42^{dB}$ | $42.27^{dB}$ | $43.58^{cA}$ | $44.38^{dA}$ | $42.91^{d}$ |
| K1 | | $43.05^{cC}$ | $44.38^{cB}$ | $45.81^{bA}$ | $46.43^{cA}$ | $44.92^{c}$ |
| K2 | | $45.02^{bC}$ | $46.55^{bB}$ | $42.98^{dD}$ | $48.63^{bA}$ | $45.80^{b}$ |
| K3 | | $49.07^{aC}$ | $50.72^{aB}$ | $52.32^{aA}$ | $53.17^{aA}$ | $51.32^{a}$ |
| L.S.D. at 0.05 | B 0.0673 K 0.0952 | N 0.0952 | BK 0.1346 | BN 0.1346 | NK 0.1903 | BKN 0.2692 |
| 2019-2020 season | | | | | | |
| | K0 | 37.94 | 39.20 | 40.43 | 41.00 | 39.64 |
| B0 | K1 | 39.88 | 41.14 | 42.44 | 43.08 | 41.64 |
| | K2 | 41.75 | 43.18 | 44.51 | 45.08 | 43.63 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | K3 | | 45.53 | 47.02 | 48.59 | 49.30 | 47.61 |
| | Mean | | 41.28 | 42.64 | 43.99 | 44.62 | 43.13 |
| | K0 | | 46.55 | 47.02 | 48.48 | 49.54 | 47.90 |
| | K1 | | 47.94 | 49.40 | 51.00 | 51.65 | 50.00 |
| B1 | K2 | | 50.08 | 51.78 | 43.18 | 54.13 | 49.79 |
| | K3 | | 54.57 | 56.44 | 58.14 | 59.16 | 57.08 |
| | Mean | | 49.78 | 51.16 | 50.20 | 53.62 | 51.19 |
| General mean | | | 45.53 | 46.90 | 47.10 | 49.12 | |
| Mean of K | | | | | | | Mean |
| K0 | | | 42.25 | 43.11 | 44.46 | 45.27 | 43.77 |
| K1 | | | 43.91 | 45.27 | 46.72 | 47.36 | 45.82 |
| K2 | | | 45.92 | 47.48 | 43.84 | 49.61 | 46.71 |
| K3 | | | 50.05 | 51.73 | 53.36 | 54.23 | 52.34 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0686 | 0.0971 | 0.0971 | 0.1373 | 0.1373 | 0.1941 | 0.2746 |

Treatment designation:
B0 and B1: no biochar and Mgha$^{-1}$, respectively. K0, K1, K2 and K3: non, normal 2 gL$^{-1}$, nano 1 gL$^{-1}$ and nano 2 gL$^{-1}$ spray solution, respectively. A0, A1 A2 and A3: non treated, Si, amino acid and Si+amino acid, respectively. N.S: non-significant ($P \geq 0.05$)

Once agaiu data revealed, generally, significant increases in chlorophyll content as a result of adding biochar compared to no addition. Also, significant increases occurred due to application of the nano-materials (A) compared to the control.

Likewise, there wer a significant increases in chlorophyll content as a result of adding K in the normal- or nano-scale form compared to the control. There were also significant s in the chlorophyll content due to adding nano-materials. The highest values were attached due to application silicon + amino acids.

**2. Plant height (cm) Table (3):**

The data presented in Table (3) show the effects of some agricultural and fertilization treatments on plant height (cm) of wheat grown a saline soil (EC of 4.7 dSm$^{-1}$ (the first and second seasons).

In the first season, values of the plant height was lowest (44.30 cm) given by the treatment B0K0A0 which did not receive biochar, fertilizer or the nano materials. The highest value (80.26 cm) was given by the treatment B1K3A3 which received biochar+higher nano-K spray rate and Si+amino acids. The increase was as high as 81.17%. This demonstrates considerable positive effects of applying biochar combined with amino acids and K on increasing of plant height.

The main effect of biochar (B) averaged 10.10% more than the control treatment no-nano materials and no K fertilizer.

The main effect of potassium fertilizer (K) shows increases averaged 21.47, 32.86 and 46.94% due to K1, K2 and K3, respectively indicating a high response of the plant height to K addition particularly when it was applied in its nano form.

**Table (3)** Effect of some agricultural and fertilization treatments on plant height (cm) of wheat grown a saline soil (EC of 4.7 dSm$^{-1}$.

| **Biochar (B)** | **K fertilizer (K)** | **Nano materials (N)** A0 | A1 | A2 | A3 | **Mean** |
|---|---|---|---|---|---|---|
| 2018-2019 season | | | | | | |
| | K0 | 44.30 | 45.60 | 47.30 | 53.50 | 47.68 |
| | K1 | 55.50 | 56.30 | 57.60 | 60.30 | 57.43 |
| B0 | K2 | 61.05 | 61.93 | 63.36 | 63.33 | 62.42 |
| | K3 | 66.60 | 68.12 | 69.70 | 72.96 | 69.35 |
| | Mean | 56.86 | 57.99 | 59.49 | 62.52 | 59.22 |
| | K0 | 48.73 | 50.16 | 52.03 | 55.50 | 51.61 |
| | K1 | 61.05 | 61.93 | 63.36 | 66.33 | 63.17 |
| B1 | K2 | 67.16 | 68.12 | 69.70 | 72.96 | 69.49 |
| | K3 | 74.26 | 74.93 | 76.67 | 80.26 | 76.53 |
| | Mean | 62.80 | 63.79 | 65.44 | 68.76 | 65.20 |
| General mean | | 59.83 | 60.89 | 62.47 | 65.64 | |
| Mean of K | | | | | | Mean |
| K0 | | 46.52 | 47.88 | 49.67 | 54.50 | 49.64 |
| K1 | | 58.28 | 59.12 | 60.48 | 63.32 | 60.30 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| K2 | | | 64.11 | 65.03 | 66.53 | 68.15 | 65.95 |
| K3 | | | 70.43 | 71.53 | 73.19 | 76.61 | 72.94 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.1164 | 0.1645 | 0.1645 | 0.2327 | 0.2327 | 0.3291 | 0.4654 |
| 2019-2020 season | | | | | | | |
| | K0 | | 42.08 | 43.32 | 44.94 | 50.82 | 45.29 |
| | K1 | | 52.73 | 53.48 | 54.72 | 57.29 | 54.56 |
| B0 | K2 | | 57.99 | 58.84 | 60.19 | 60.17 | 59.30 |
| | K3 | | 63.27 | 64.71 | 66.21 | 69.31 | 65.88 |
| | Mean | | 54.02 | 55.09 | 56.52 | 59.40 | 56.25 |
| | K0 | | 46.30 | 47.65 | 49.43 | 52.72 | 49.03 |
| | K1 | | 58.00 | 58.83 | 60.20 | 63.02 | 60.01 |
| B1 | K2 | | 63.81 | 64.72 | 66.21 | 69.31 | 66.01 |
| | K3 | | 70.55 | 71.19 | 72.84 | 76.25 | 72.71 |
| | Mean | | 59.67 | 60.60 | 62.17 | 65.33 | 61.94 |
| General mean | | | 56.84 | 57.84 | 59.34 | 62.36 | |
| Mean of K | | | | | | | Mean |
| K0 | | | 44.19 | 45.49 | 47.19 | 51.77 | 47.16 |
| K1 | | | 55.37 | 56.16 | 57.46 | 60.16 | 57.28 |
| K2 | | | 60.90 | 61.78 | 63.20 | 64.74 | 62.66 |
| K3 | | | 66.91 | 67.95 | 69.53 | 72.78 | 69.29 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.1105 | 0.1563 | 0.1563 | 0.2211 | 0.2211 | 0.3127 | 0.4422 |
| See footnotes of Table (2) | | | | | | | |

The main effect of nano materials (A) show increases of 1.77, 4.41, and 9.71% due to the treatments A1, A2 and A3 i.e. Si, amino acids and Si+amino acids, respectively. The amino acids caused marked increases in plant height particularly when combined with A0.

In the second season, values of plant height were lowest was (42.08 cm) due to the treatment B0K0A0 which did not receive biochar, K-fertilizer or the nano materials. The highest value (76.25 cm) was given by the B1K3A3 treatment whose value was 81.20% higher than that of B0K0A0 treatment. This demonstrates the considerable positive effect of applying biochar combined with amino acids and K on increasing plant height.

The main effect of biochar (B) exceeded the plant height by 10.12% that of B0K0A0.

The main effect of potassium fertilizer (K) shows plant height increases averaged 21.46, 32.87 and 46.93% due to K1, K2 and K3, respectively as compared the B0K0A0 treatment.

The main effect of nano materials (A) shows increases of 1.76, 4.40, and 9.71% due to the treatments A1, A2 and A3, respectively.

**3. Spike length (cm) Table( 4):**

In the first season, value of spike length varied was lowest (4.20 cm) given by the treatment B0K0A0. The highest one was 9.10 cm was given by the treatment B1K3A3. The difference between the two treatments was 116.67%. This demonstrates the considerable positive effect of applying biochar combined with amino acids and K on increasing spike length.

The main effect of biochar (B) recorded 29.63% increase in spike length more than B0K0A0 treatment.

**Table (4)** Effect of some agricultural and fertilization treatments on wheat spike length (cm) grown a saline soil (EC of 4.7 $dSm^{-1}$.

| **Biochar (B)** | **K fertilizer (K)** | **Nano materials (N)** | | | | **Mean** |
|---|---|---|---|---|---|---|
| | | A0 | A1 | A2 | A3 | |
| 2018-2019 season | | | | | | |
| | K0 | 4.20 | 4.90 | 5.33 | 5.77 | 5.05 |
| | K1 | 4.63 | 5.43 | 5.83 | 6.33 | 5.56 |
| B0 | K2 | 4.63 | 5.73 | 6.13 | 6.70 | 5.80 |
| | K3 | 5.63 | 6.03 | 6.43 | 7.03 | 6.28 |
| | Mean | 4.77 | 5.52 | 5.93 | 6.46 | 5.67 |
| | K0 | 5.53 | 6.40 | 6.90 | 7.43 | 6.57 |
| | K1 | 6.03 | 7.10 | 7.50 | 8.17 | 7.20 |
| B1 | K2 | 6.00 | 7.43 | 7.87 | 8.63 | 7.48 |
| | K3 | 7.33 | 7.80 | 8.33 | 9.10 | 8.14 |
| | Mean | 6.22 | 7.18 | 7.65 | 8.33 | 7.35 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| General mean | | | 5.50 | 6.35 | 6.79 | 7.40 | |
| Mean of K | | | | | | | Mean |
| K0 | | | 4.87 | 5.65 | 6.12 | 6.60 | 5.81 |
| K1 | | | 5.33 | 6.27 | 6.67 | 7.25 | 6.38 |
| K2 | | | 5.32 | 6.58 | 7.00 | 7.67 | 6.64 |
| K3 | | | 6.48 | 6.92 | 7.38 | 8.07 | 7.21 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0150 | 0.0213 | 0.0213 | 0.0301 | 0.0301 | 0.0425 | 0.0602 |
| 2019-2020 season | | | | | | | |
| | K0 | | 4.07 | 4.75 | 5.17 | 5.59 | 4.90 |
| | K1 | | 4.49 | 5.27 | 5.66 | 6.14 | 5.39 |
| B0 | K2 | | 4.49 | 5.56 | 5.95 | 6.50 | 5.63 |
| | K3 | | 5.46 | 5.85 | 6.24 | 6.82 | 6.09 |
| | Mean | | 4.63 | 5.36 | 5.76 | 6.26 | 5.50 |
| | K0 | | 5.37 | 6.21 | 6.69 | 7.21 | 6.37 |
| | K1 | | 5.85 | 6.89 | 7.28 | 7.92 | 6.98 |
| B1 | K2 | | 5.82 | 7.21 | 7.63 | 8.37 | 7.26 |
| | K3 | | 7.11 | 7.57 | 8.08 | 8.83 | 7.90 |
| | Mean | | 6.04 | 6.97 | 7.42 | 8.08 | 7.13 |
| General mean | | | 5.33 | 6.16 | 6.59 | 7.17 | |
| Mean of K | | | | | | | Mean |
| K0 | | | 4.72 | 5.48 | 5.93 | 6.40 | 5.63 |
| K1 | | | 5.17 | 6.08 | 6.47 | 7.03 | 6.19 |
| K2 | | | 5.16 | 6.39 | 6.79 | 7.44 | 6.44 |
| K3 | | | 6.29 | 6.71 | 7.16 | 7.82 | 7.00 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0146 | 0.0206 | 0.0206 | 0.0292 | 0.0292 | 0.0413 | 0.0584 |

See footnotes of Table (2)

The main effect of potassium fertilization (K) shows increase averaged 9.81, 14.29 and 20.10% due to K1, K2 and K3, respectively as compared to B0K0A0 treatment.

The main effect of nano materials (A) shows increases of 15.45, 23.45, and 34.55% due to A1, A2 and A3 as compared to B0K0A0 treatment.

In the second season, values of spike length was lowest (4.07 cm) given by B0K0A0 treatment. The highest one (8.83 cm) was given by the B1K3A3 treatment. The difference between its was as high as 116.95%. This demonstrates the considerable positive effect applying biochar combined with amino acids and K on increasing of spike length.

The main effect of biochar (B) on spike length was 29.63% as compared to B0K0A0 treatment.

The main effect of potassium fertilizer (K) shows increases averaged 9.95, 14.39 and 24.33% as compared B0K0A0 treatment due to K1, K2 and K3, respectively indicating a high response to K addition particularly when it was applied in the nano form. The main effect of potassium fertilizerization (K) shows increase averaged 9.81, 14.29 and 20.10% due to K1, K2 and K3, respectively as compared to B0K0A0 treatment.

The main effect of nano materials (A) shows increases of 15.45, 23.45, and 34.55% due to A1, A2 and A3 as compared to B0K0A0 treatment.

In the second season, values of spike length was lowest (4.07 cm) given by B0K0A0 treatment. The highest one (8.83 cm) was given by the B1K3A3 treatment. The difference between its was as high as 116.95%. This demonstrates the considerable positive effect applying biochar combined with amino acids and K on increasing of spike length.

The main effect of biochar (B) on spike length was 29.63% as compared to B0K0A0 treatment.

The main effect of potassium fertilizer (K) shows increases averaged 9.95, 14.39 and 24.33% as compared B0K0A0 treatment due to K1, K2 and K3, respectively indicating a high response to K addition particularly when it was applied in the nano form.

The main effect of nano materials (A) shows increases of 15.57, 23.64, and 34.52% due to A1, A2 and A3 as compared to B0K0A0 treatment.

**4. Weight 1000 grains (g) Table (5):**

In first season, values of weight of 1000 grains were lowest (26.50 g) given by control treatment B0K0A0. The highest corresponding value was 39.50 g given by the treatment B1K3A3 i.e. biochar + nano-K spray at 2 $gL^{-1}$ and Si+amino acids. The difference between the two treatment was as high as 49.06%.

The main effect of biochar (B) was 22.43% more than the control treatment B0K0A0.

Increases averaged 2.75, 6.31 and 11.37% over that of the control treatment were activated due to K1, K2 and K3, respectively.

The nano materials (A) caused increases of 1.81, 3.25, and 5.06% over the control treatment due to the treatments.

In the second season, values of weight of 1000 grains were lowest (25.97 g) given by the treatment B0K0A0

whereas the highest corresponding value was 38.71 g given by the treatment B1K3A3. the increase occurred due to the latter treatment was as high as 49.06% as compared to the 1000 grain weight due to the control treatment.

**Table (5)** Effect of some agricultural and fertilization treatments on weight of 1000 grain (g) of wheat grown in a salt-affected soil.

| **Biochar (B)** | **K fertilizer (K)** | **Nano materials (N)** A0 | A1 | A2 | A3 | **Mean** |
|---|---|---|---|---|---|---|
| 2018-2019 season | | | | | | |
| | K0 | 26.50 | 27.67 | 28.00 | 28.50 | 27.67 |
| | K1 | 28.00 | 28.77 | 29.20 | 29.67 | 28.91 |
| B0 | K2 | 29.57 | 29.87 | 30.30 | 31.00 | 30.18 |
| | K3 | 30.50 | 31.00 | 31.63 | 32.00 | 31.28 |
| | Mean | 28.64 | 29.33 | 29.78 | 30.29 | 29.51 |
| | K0 | 34.33 | 34.64 | 34.87 | 35.30 | 34.78 |
| | K1 | 34.70 | 35.00 | 35.40 | 36.00 | 35.28 |
| B1 | K2 | 35.47 | 35.90 | 36.37 | 37.10 | 36.21 |
| | K3 | 37.03 | 37.87 | 38.67 | 39.50 | 38.27 |
| | Mean | 35.38 | 35.85 | 36.33 | 36.98 | 36.13 |
| General mean | | 32.01 | 32.59 | 33.05 | 33.63 | |
| Mean of K | | | | | | Mean |
| K0 | | 30.42 | 31.15 | 31.43 | 31.90 | 31.23 |
| K1 | | 31.35 | 31.88 | 32.30 | 32.83 | 32.09 |
| K2 | | 32.52 | 32.88 | 33.33 | 34.05 | 33.20 |
| K3 | | 33.77 | 34.43 | 35.15 | 35.75 | 34.78 |
| L.S.D. at 0.05 | B K | N | BK | BN | NK | BKN |
| | 0.0451 0.0638 | 0.0638 | 0.0903 | 0.0903 | 0.1277 | 0.1806 |
| 2019-2020 season | | | | | | |
| | K0 | 25.97 | 27.11 | 27.44 | 27.93 | 27.11 |
| | K1 | 27.44 | 28.19 | 28.62 | 29.07 | 28.33 |
| B0 | K2 | 28.98 | 29.27 | 29.69 | 30.38 | 29.58 |
| | K3 | 29.89 | 30.38 | 31.00 | 31.36 | 30.66 |
| | Mean | 28.07 | 28.74 | 29.19 | 29.69 | 28.92 |
| | K0 | 33.65 | 33.94 | 34.17 | 34.59 | 34.09 |
| | K1 | 34.01 | 34.30 | 34.69 | 35.28 | 34.57 |
| B1 | K2 | 34.76 | 35.18 | 35.64 | 36.36 | 35.48 |
| | K3 | 36.29 | 37.11 | 37.89 | 38.71 | 37.50 |
| | Mean | 34.68 | 35.13 | 35.60 | 36.24 | 35.41 |
| General mean | | 31.37 | 31.94 | 32.39 | 32.96 | |
| Mean of K | | | | | | Mean |
| K0 | | 29.81 | 30.53 | 30.80 | 31.26 | 30.60 |
| K1 | | 30.72 | 31.25 | 31.65 | 32.18 | 31.45 |
| K2 | | 31.87 | 32.23 | 32.67 | 33.37 | 32.53 |
| K3 | | 33.09 | 33.74 | 34.45 | 35.04 | 34.08 |
| L.S.D. at 0.05 | B K | N | BK | BN | NK | BKN |
| | 0.0442 0.0626 | 0.0626 | 0.0885 | 0.0885 | 0.1251 | 0.1770 |

See foot notes of Table (2).

The main effect of biochar (B) on 1000 grain weight averaged 22.44% more the control treatment.

Potassium fertilization (K) showed increases averaged 2.78, 6.31 and 11.37% due to K1, K2 and K3, respectively as compared the control treatment.

The nano materials (A) showed increases of 1.82, 3.25, and 5.07% due to the treatments A1, A2 and A3 as compared to the control treatment.

**5. Grains yield (tonha$^{-1}$) Table(6):**

In first season, values of grains yield were lowest (0.87 Mg ha$^{-1}$) given by the treatment B0K0A0 whereas the highest corresponding value 1.90 Mg ha$^{-1}$ was given by the treatment B1K3A3 which received biochar + nano-K spray at a rate of 2 g L$^{-1}$ and nano materials together once in yield between these two treatments was as high as 118.39%.

The main effect of biochar (B) averaged of 39.45% more than the B0K0A0 treatment.

Potassium fertilization (K) showed increases averaged 4.17, 9.17 and 20.00% due to K1, K2 and K3, respectively as compared to the control treatment B0K0A0.

The nano materials (A) showed increases averaged 11.50, 19.47 and 30.09% due to A1, A2 and A3, respectively caused to B0K0A0 treatments.

In the second season, values of grains yield were lowest (0.83 $Mgha^{-1}$) given by the treatment B0K0A0 whereas the highest corresponding value was 1.82 $Mgha^{-1}$ given by the treatment B1K3A3 which received biochar+high nano-K spray Si+amino acid; an increase of as high as 119.28%. This demonstrates the considerable positive effect of applying biochar combined with amino acids and K on increasing grain yield.

The main effect of biochar (B) averaged 40.38% more than the control treatment B0K0A0.

**Table (6)** Effect of some agricultural and fertilization treatments on grains yield ($Mgha^{-1}$) of wheat grown in a salt-affected soil.

| **Biochar (B)** | **K fertilizer (K)** | **Nano materials (N)** A0 | A1 | A2 | A3 | **Mean** |
|---|---|---|---|---|---|---|
| 2018-2019 season | | | | | | |
| | K0 | 0.87 | 0.97 | 1.04 | 1.13 | 1.00 |
| | K1 | 0.91 | 1.02 | 1.09 | 1.18 | 1.05 |
| B0 | K2 | 0.95 | 1.04 | 1.14 | 1.24 | 1.09 |
| | K3 | 1.04 | 1.17 | 1.25 | 1.35 | 1.20 |
| | Mean | 0.94 | 1.05 | 1.13 | 1.22 | 1.09 |
| | K0 | 1.21 | 1.36 | 1.45 | 1.58 | 1.40 |
| | K1 | 1.27 | 1.43 | 1.46 | 1.66 | 1.46 |
| B1 | K2 | 1.33 | 1.46 | 1.60 | 1.74 | 1.53 |
| | K3 | 1.46 | 1.64 | 1.75 | 1.90 | 1.68 |
| | Mean | 1.32 | 1.47 | 1.56 | 1.72 | 1.52 |
| General mean | | 1.13 | 1.26 | 1.35 | 1.47 | |
| Mean of K | | | | | | Mean |
| K0 | | 1.04 | 1.17 | 1.24 | 1.35 | 1.20 |
| K1 | | 1.09 | 1.23 | 1.28 | 1.42 | 1.25 |
| K2 | | 1.14 | 1.25 | 1.37 | 1.49 | 1.31 |
| K3 | | 1.25 | 1.40 | 1.50 | 1.62 | 1.44 |
| L.S.D. at 0.05 | B 0.0033 | K 0.0047 | N 0.0047 | BK 0.0067 | BN 0.0067 | NK 0.0094 | BKN 0.0133 |
| 2019-2018 season | | | | | | |
| | K0 | 0.83 | 0.94 | 1.00 | 1.08 | 0.96 |
| | K1 | 0.87 | 0.98 | 1.05 | 1.13 | 1.01 |
| B0 | K2 | 0.91 | 1.00 | 1.10 | 1.19 | 1.05 |
| | K3 | 1.00 | 1.12 | 1.20 | 1.30 | 1.15 |
| | Mean | 0.90 | 1.01 | 1.08 | 1.18 | 1.04 |
| | K0 | 1.16 | 1.31 | 1.39 | 1.51 | 1.34 |
| | K1 | 1.22 | 1.37 | 1.40 | 1.59 | 1.40 |
| B1 | K2 | 1.28 | 1.40 | 1.54 | 1.67 | 1.47 |
| | K3 | 1.40 | 1.57 | 1.68 | 1.82 | 1.62 |
| | Mean | 1.27 | 1.41 | 1.50 | 1.65 | 1.46 |
| General mean | | 1.08 | 1.21 | 1.29 | 1.41 | |
| Mean of K | | | | | | Mean |
| K0 | | 1.00 | 1.12 | 1.19 | 1.30 | 1.15 |
| K1 | | 1.05 | 1.18 | 1.22 | 1.36 | 1.20 |
| K2 | | 1.10 | 1.20 | 1.32 | 1.43 | 1.26 |
| K3 | | 1.20 | 1.35 | 1.44 | 1.56 | 1.38 |
| L.S.D. at 0.05 | B 0.0032 | K 0.0045 | N 0.0045 | BK 0.0064 | BN 0.0064 | NK 0.0090 | BKN 0.0127 |

See foot notes of Table (2).

The main effect of potassium fertilization (K) showed increases averaged 4.35, 9.57 and 20.00% due to K1, K2 and K3 treatments, respectively as compared to corresponding yield of the control treatment B0K0A0.

The main effect of nano materials (A) shows increases averaged 12.04, 19.44 and 30.56% over the control treatment due to the treatments A1, A2 and A3, respectively.

**6. Biological yield (Mgha$^{-1}$) Table ( 7):**

In the first season, values of the biological yield were lowest (2.40 Mgha$^{-1}$) given by the treatment B0K0A0 whereas the highest corresponding value i.e. (4.36 Mgha$^{-1}$) was given by the treatment B1K3A3 which caused an increase higher by 81.67% than the biological yield attained by B0K0A0 treatment.

The main effect of biochar (B) on the biological yield averaged 40.51% more than the corresponding one attained due to the treatment B0K0A0.

The main effect of potassium fertilization (K) showed increases averaged 3.93, 9.18 and 19.02% due to K1, K2 and K3, respectively as compared to the corresponding one attained due to the treatment B0K0A0.

The main effect of the applied nano materials (A) showed increases in biological yield of 4.76, 6.03 and 7.30% due to the treatments A1, A2 and A, respectively as compared to the corresponding yield attained due to the control treatment B0K0A0.

In the second season, values of the biological yield were lowest (2.64 Mgha$^{-1}$) given by the treatment B0K0A0 whereas the highest corresponding one was 4.79 Mgha$^{-1}$ given by the treatment B1K3A3 which recorded an increase as high as 81.44% over the control treatment.

**Table (7)** Effect of some agricultural and fertilization treatments on biological yield (Mgh$^{-1}$) of wheat grown in a salt-affected soil

| **Biochar (B)** | **K fertilizer (K)** | | **Nano materials (N)** A0 | A1 | A2 | A3 | **Mean** |
|---|---|---|---|---|---|---|---|
| 2018-2019 season | | | | | | | |
| | K0 | | 2.40 | 2.53 | 2.56 | 2.59 | 2.52 |
| | K1 | | 2.52 | 2.65 | 2.69 | 2.72 | 2.64 |
| B0 | K2 | | 2.64 | 2.78 | 2.82 | 2.85 | 2.77 |
| | K3 | | 2.87 | 3.03 | 3.07 | 3.11 | 3.02 |
| | Mean | | 2.60 | 2.75 | 2.78 | 2.82 | 2.74 |
| | K0 | | 3.55 | 3.54 | 3.58 | 3.63 | 3.58 |
| | K1 | | 3.52 | 3.72 | 3.74 | 3.81 | 3.70 |
| B1 | K2 | | 3.69 | 3.89 | 3.94 | 3.99 | 3.88 |
| | K3 | | 4.02 | 4.25 | 4.30 | 4.36 | 4.23 |
| | Mean | | 3.70 | 3.85 | 3.89 | 3.95 | 3.85 |
| General mean | | | 3.15 | 3.30 | 3.34 | 3.38 | |
| K | | | Biochar × Nano materials | | | | Mean |
| K0 | | | 2.97 | 3.03 | 3.07 | 3.11 | 3.05 |
| K1 | | | 3.02 | 3.19 | 3.21 | 3.27 | 3.17 |
| K2 | | | 3.16 | 3.34 | 3.38 | 3.42 | 3.33 |
| K3 | | | 3.45 | 3.64 | 3.69 | 3.73 | 3.63 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0075 | 0.0106 | 0.0106 | 0.0150 | 0.0150 | 0.0212 | 0.0300 |
| 2019-2020 season | | | | | | | |
| | K0 | | 2.64 | 2.78 | 2.82 | 2.85 | 2.77 |
| | K1 | | 2.77 | 2.92 | 2.96 | 2.99 | 2.91 |
| B0 | K2 | | 2.90 | 3.06 | 3.10 | 3.14 | 3.05 |
| | K3 | | 3.16 | 3.34 | 3.38 | 3.42 | 3.33 |
| | Mean | | 2.87 | 3.02 | 3.06 | 3.10 | 3.01 |
| | K0 | | 3.91 | 3.89 | 3.94 | 3.99 | 3.93 |
| | K1 | | 3.87 | 4.09 | 4.11 | 4.19 | 4.07 |
| B1 | K2 | | 4.06 | 4.28 | 4.34 | 4.39 | 4.27 |
| | K3 | | 4.43 | 4.67 | 4.73 | 4.79 | 4.66 |
| | Mean | | 4.07 | 4.23 | 4.28 | 4.34 | 4.23 |
| General mean | | | 3.47 | 3.63 | 3.67 | 3.72 | |
| Mean of K | | | | | | | Mean |
| K0 | | | 3.27 | 3.34 | 3.38 | 3.42 | 3.35 |
| K1 | | | 3.32 | 3.50 | 3.53 | 3.59 | 3.49 |
| K2 | | | 3.48 | 3.67 | 3.72 | 3.77 | 3.66 |
| K3 | | | 3.79 | 4.01 | 4.06 | 4.11 | 3.99 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0082 | 0.0116 | 0.0116 | 0.0165 | 0.0165 | 0.0233 | 0.0329 |

See foot notes of Table (2).

The main effect of biochar (B) on the biological yield averaged 40.53% more than the corresponding control treatment B0K0A0.

The main effect of potassium fertilization (K) showed increases averaged 4.18, 9.25 and 19.10% due to K1, K2 and K3, respectively as compared to the corresponding biological yield of the control treatment B0K0A0.

The applied nano materials (A) showed increases of 4.61, 5.76 and 7.20% over the corresponding biological yield of the control treatment due to A1, A2 and A3, respectively.

**7. Harvest index (%) Table (8):**

In the first season, values of harvest index were lowest (34.14%) given by the treatment B1K0A0 while the highest corresponding one was 43.48% given by the treatment B1K3A3 which caused increase as high as 27.36% over the control treatment B0K0A0.

The main effect of biochar (B) on the harvest index averaged 0.23% over the corresponding one of the control treatment B0K0A0.

The main effect of potassium fertilization (K) showed increases averaged 0.74 and 0.68% due to K1 and K3, respectively over the corresponding one of the control treatment B0K0A0.

The main effect of applied nano materials (A) showed increases in the harvest index of 5.84, 11.70 and 20.14% due to the treatments A1, A2 and A3 as compared to the control treatment.

In the second season, value of the harvest index were lowest (29.79%) given by the treatment B1K0A0 while the corresponding highest value (37.95%) related due to the treatment B1K3A3 which caused increase as high as 27.39% over that attained by B0K0A0 treatment.

The main effect of biochar (B) in the harvest index averaged 0.23% over the corresponding one of the control treatment.

**Table (8)** Effect of some agricultural and fertilization treatments on harvest index (%) of wheat grown in a salt-affected soil.

| **Biochar (B)** | **K fertilizer (K)** | | **Nano materials (N)** A0 | A1 | A2 | A3 | **Mean** |
|---|---|---|---|---|---|---|---|
| 2018-2019 season | | | | | | | |
| | K0 | | 36.18 | 38.54 | 40.57 | 43.41 | 39.68 |
| | K1 | | 36.10 | 38.51 | 40.58 | 43.44 | 39.66 |
| B0 | K2 | | 36.14 | 37.44 | 40.60 | 43.43 | 39.40 |
| | K3 | | 36.15 | 38.52 | 40.61 | 43.41 | 39.67 |
| | Mean | | 36.14 | 38.25 | 40.59 | 43.42 | 39.60 |
| | K0 | | 34.14 | 38.60 | 40.48 | 43.44 | 39.17 |
| | K1 | | 38.15 | 38.51 | 39.03 | 43.35 | 39.76 |
| B1 | K2 | | 36.17 | 37.41 | 40.58 | 43.45 | 39.40 |
| | K3 | | 36.15 | 38.55 | 40.61 | 43.48 | 39.70 |
| | Mean | | 36.15 | 38.27 | 40.18 | 43.43 | 39.51 |
| General mean | | | 36.15 | 38.26 | 40.38 | 43.43 | |
| K | | | Biochar × Nano materials | | | | Mean |
| K0 | | | 35.16 | 38.57 | 40.53 | 43.43 | 39.42 |
| K1 | | | 37.13 | 38.51 | 39.81 | 43.40 | 39.71 |
| K2 | | | 36.16 | 37.43 | 40.59 | 43.44 | 39.40 |
| K3 | | | 36.15 | 38.54 | 40.61 | 43.45 | 39.69 |
| L.S.D. at 0.05 | B 0.0264 | K 0.0373 | N 0.0373 | BK 0.0528 | BN 0.0528 | NK 0.0746 | BKN 0.1056 |
| 2019-2020 season | | | | | | | |
| | K0 | | 31.58 | 33.64 | 35.41 | 37.89 | 34.63 |
| | K1 | | 31.50 | 33.61 | 35.41 | 37.91 | 34.61 |
| B0 | K2 | | 31.54 | 32.67 | 35.43 | 37.90 | 34.39 |
| | K3 | | 31.55 | 33.62 | 35.44 | 37.89 | 34.63 |
| | Mean | | 31.54 | 33.39 | 35.42 | 37.90 | 34.56 |
| | K0 | | 29.79 | 33.69 | 35.33 | 37.91 | 34.18 |
| | K1 | | 33.30 | 33.61 | 34.06 | 37.83 | 34.70 |
| B1 | K2 | | 31.57 | 32.65 | 35.41 | 37.92 | 34.39 |
| | K3 | | 31.55 | 33.64 | 35.44 | 37.95 | 34.65 |
| | Mean | | 31.55 | 33.40 | 35.06 | 37.90 | 34.48 |
| General mean | | | 31.55 | 33.39 | 35.24 | 37.90 | |
| Mean of K | | | | | | | Mean |
| K0 | | | 30.69 | 33.67 | 35.37 | 37.90 | 34.41 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| K1 | | | 32.40 | 33.61 | 34.74 | 37.87 | 34.65 |
| K2 | | | 31.56 | 32.66 | 35.42 | 37.91 | 34.39 |
| K3 | | | 31.55 | 33.63 | 35.44 | 37.92 | 34.64 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0229 | 0.0323 | 0.0323 | 0.0457 | 0.0457 | 0.0646 | 0.0914 |

See foot notes of Table (2).

The main effect of potassium fertilization (K) shows increases harvest index averaged 0.70 and 0.67% due to K1 and K3, respectively over the control treatment. value (37.95%) related due to the treatment B1K3A3 which caused increase as high as 27.39% over that attained by B0K0A0 treatment.

The main effect of biochar (B) in the harvest index averaged 0.23% over the corresponding one of the control treatment.

The main effect of potassium fertilization (K) shows increases harvest index averaged 0.70 and 0.67% due to K1 and K3, respectively over the control treatment.

The main effect of the applied nano materials (A) shows increases in harvest index of 5.83, 11.70 and 20.13% as compared to that of the treatments A1, A2 and A3, respectively.

**8. N content Table (9):**

In the first season, content of N varied according to the lowest value in the grains was 23.0 $gkg^{-1}$ given by the treatment B0K0A0 while the highest corresponding 39.3 $gkg^{-1}$ given by the treatment B1K3A3 which caused increase in N content of the grains as high as 70.87%.

The main effect of biochar (B) on N content in grains averaged 23.93% over the corresponding one of the treatment B0K0A0.

**Table (9)** Effect of some agricultural and fertilization treatments on the N content ($gkg^{-1}$) in the grains of the wheat grown a saline soil (EC of 4.7 $dSm^{-1}$).

| **Biochar (B)** | **K fertilizer (K)** | **Nano materials (N)** A0 | A1 | A2 | A3 | **Mean** |
|---|---|---|---|---|---|---|
| 2018-2019 season | | | | | | |
| | K0 | 23.0 | 24.0 | 25.0 | 26.0 | 24.5 |
| | K1 | 25.0 | 26.3 | 27.3 | 28.0 | 26.7 |
| B0 | K2 | 28.0 | 29.0 | 30.3 | 31.0 | 29.6 |
| | K3 | 30.0 | 31.3 | 32.0 | 32.0 | 31.3 |
| | Mean | 26.5 | 27.7 | 28.7 | 29.3 | 28.0 |
| | K0 | 30.0 | 31.3 | 32.0 | 33.3 | 31.7 |
| | K1 | 32.3 | 33.3 | 34.0 | 35.0 | 33.7 |
| B1 | K2 | 34.0 | 35.0 | 36.0 | 38.3 | 35.8 |
| | K3 | 36.0 | 37.3 | 38.3 | 39.3 | 37.7 |
| | Mean | 33.1 | 34.2 | 35.1 | 36.5 | 34.7 |
| General mean | | 29.8 | 31.0 | 31.9 | 32.9 | |
| | | Mean of K | | | | Mean |
| K0 | | 26.5 | 27.7 | 28.5 | 29.7 | 28.1 |
| K1 | | 28.7 | 29.8 | 30.7 | 31.5 | 30.2 |
| K2 | | 31.0 | 32.0 | 33.2 | 34.7 | 32.7 |
| K3 | | 33.0 | 34.3 | 35.2 | 35.7 | 34.5 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0054 | 0.0076 | 0.0076 | 0.0107 | 0.0107 | 0.0152 | 0.0215 |
| 2019-2020 season | | | | | | | |
| | K0 | | 14.4 | 14.9 | 15.4 | 15.8 | 15.1 |
| | K1 | | 15.4 | 15.9 | 16.3 | 16.8 | 16.1 |
| B0 | K2 | | 15.9 | 16.1 | 16.3 | 17.0 | 16.3 |
| | K3 | | 16.3 | 16.7 | 17.0 | 17.5 | 16.9 |
| | Mean | | 15.5 | 15.9 | 16.2 | 16.8 | 16.1 |
| | K0 | | 17.7 | 18.0 | 18.2 | 18.5 | 18.1 |
| | K1 | | 18.6 | 18.8 | 19.0 | 19.2 | 18.9 |
| B1 | K2 | | 19.2 | 19.7 | 20.0 | 20.4 | 19.8 |
| | K3 | | 21.1 | 21.6 | 22.1 | 22.6 | 21.8 |
| | Mean | | 19.2 | 19.5 | 19.8 | 20.2 | 19.7 |
| General mean | | | 17.3 | 17.7 | 18.0 | 18.5 | |
| Mean of K | | | | | | | Mean |
| K0 | | | 16.1 | 16.5 | 16.8 | 17.2 | 16.6 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| K1 | | | 17.0 | 17.3 | 17.7 | 18.0 | 17.5 |
| K2 | | | 17.5 | 17.9 | 18.2 | 18.7 | 18.1 |
| K3 | | | 18.7 | 19.2 | 19.5 | 20.0 | 19.4 |
| L.S.D. at 0.05 for: | B | K | N | BK | BN | NK | BKN |
| | 0.0027 | 0.0038 | 0.0038 | 0.0053 | 0.0053 | 0.0075 | 0.0106 |

See foot notes of Table (2).

The main effect of potassium fertilization (K) shows increases in N content of wheat grains averaged 7.47, 16.37 and 22.78% due to K1, K2 and K3, respectively as compared to that attained due to the control treatment B0K0A0.

The main effect of the nano materials (A) shows increases in N content of the grains of 4.03, 7.05, and 10.40% among to the treatments A1, A2 and A3, respectively.

In the second season, content of N were lowest (14.4 $gkg^{-1}$) given by the treatment B0K0A0 while the highest N content in the wheat grains was (22.6 $gkg^{-1}$) due to the treatment B1K3A3 which resulted in increase in N content of the wheat grains as high as 56.94%.

The main effect of biochar (B) on N content of the grains averaged 22.36% more than the corresponding content achieved due to the control treatment.

The main effect of potassium fertilization (K) shows increases in N content of the grains averaged 5.42, 9.04 and 16.87% due to the treatments K1, K2 and K3, respectively.

The main effect of the applied nano materials (A) showed increases in N content of the grains of 2.31, 4.05, and 6.94% due to the treatments A1, A2 and A3, respectively.

**9. P content Table (10):**

In the first season, content of P was lowest (3.0 $gkg^{-1}$) due to the treatment B0K0A0. The corresponding highest value (8.3 $gkg^{-1}$) was given by the treatment B1K3A3 which caused increase in P content as high as 176.67% as compared to that attained due to the control treatment.

The main effect of biochar (B) on P content of the garins averaged 62.5% more than that achieved due to the control treatment.

**Table (10)** Effect of some agricultural and fertilization treatments on the P content ($gkg^{-1}$) in the grains of the wheat grown a saline soil (EC of 4.7 $dSm^{-1}$).

| **Biochar (B)** | **K fertilizer (K)** | **Nano materials (N)** A0 | A1 | A2 | A3 | **Mean** |
|---|---|---|---|---|---|---|
| 2018-2019 season | | | | | | |
| | K0 | 3.0 | 3.3 | 3.5 | 3.7 | 3.4 |
| | K1 | 3.5 | 3.7 | 3.9 | 4.1 | 3.8 |
| B0 | K2 | 4.0 | 4.2 | 4.3 | 4.5 | 4.3 |
| | K3 | 4.5 | 4.6 | 4.7 | 4.9 | 4.7 |
| | Mean | 3.8 | 4.0 | 4.1 | 4.3 | 4.0 |
| | K0 | 5.5 | 5.6 | 5.7 | 5.9 | 5.7 |
| | K1 | 5.7 | 5.9 | 6.1 | 6.3 | 6.0 |
| B1 | K2 | 6.2 | 6.4 | 6.7 | 6.9 | 6.6 |
| | K3 | 7.0 | 7.3 | 7.7 | 8.3 | 7.6 |
| | Mean | 6.1 | 6.3 | 6.6 | 6.9 | 6.5 |
| General mean | | 4.9 | 5.1 | 5.3 | 5.6 | |
| Mean of K | | | | | | Mean |
| K0 | | 4.3 | 4.5 | 4.6 | 4.8 | 4.5 |
| K1 | | 4.6 | 4.8 | 5.0 | 5.2 | 4.9 |
| K2 | | 5.1 | 5.3 | 5.5 | 5.7 | 5.4 |
| K3 | | 5.8 | 6.0 | 6.2 | 6.6 | 6.1 |
| L.S.D. at 0.05 for: | B | K | N | BK | BN | NK | BKN |
| | 0.0016 | 0.0023 | 0.0023 | 0.0032 | 0.0032 | 0.0045 | 0.0064 |
| 2019-2020 season | | | | | | | |
| | K0 | 2.8 | 3.1 | 3.3 | 3.4 | 3.1 |
| | K1 | 3.3 | 3.4 | 3.7 | 3.8 | 3.5 |
| B0 | K2 | 3.7 | 3.9 | 4.0 | 4.2 | 4.0 |
| | K3 | 4.2 | 4.3 | 4.4 | 4.6 | 4.4 |
| | Mean | 3.5 | 3.7 | 3.8 | 4.0 | 3.8 |
| | K0 | 5.1 | 5.2 | 5.3 | 5.5 | 5.3 |
| | K1 | 5.3 | 5.5 | 5.7 | 5.9 | 5.6 |
| B1 | K2 | 5.8 | 6.0 | 6.3 | 6.4 | 6.1 |
| | K3 | 6.5 | 6.8 | 7.2 | 7.7 | 7.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Mean | | 5.7 | 5.9 | 6.1 | 6.4 | 6.0 |
| General mean | | | 4.6 | 4.8 | 5.0 | 5.2 | |
| Mean of K | | | | | | | Mean |
| K0 | | | 4.0 | 4.1 | 4.3 | 4.5 | 4.2 |
| K1 | | | 4.3 | 4.5 | 4.7 | 4.8 | 4.6 |
| K2 | | | 4.7 | 4.9 | 5.1 | 5.3 | 5.0 |
| K3 | | | 5.3 | 5.5 | 5.8 | 6.1 | 5.7 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0017 | 0.0024 | 0.0024 | 0.0034 | 0.0034 | 0.0049 | 0.0069 |

See foot notes of Table (2).

There was an average increase of 8.89, 20.00, and 35.56 percent in the P content of wheat grains as a result of K1, K2, and K3, respectively.

P content in wheat grains increased by an average of 4.08, 8.16, and 14.29 percent as a result of the treatments A1, A2, and A3.

Control treatment B0K0A0 had the lowest P concentration in wheat grains (2.8 gkg-1) in the second season, while the greatest concentration of P was 7.7 gkg-1 in the treatment B1K3A3.

Compared to the control treatment B0K0A0, the primary impact of biochar (B) on grain P content was 57.89 percent higher.

As compared to the control, potassium fertilisation (K1), K2 and K3 resulted in increases in P content of 9.52, 19.05 and 35.71 percent, respectively; this is the predominant impact.

P content in grains increased by 4.35, 8.70, and 13.04 percent in treatments A1, A2, and A3 compared to the P content in grains in the control treatment as a result of the nanomaterials (A).

Table 11 shows the K content:

The B0K0A0 treatment had the lowest K content (18.00 gkg-1) and the highest K content (34 gkg-1) in the first season. There was an 88.89 percent difference between the lowest and highest treatments.

Compared to the control treatment B0K0A0, the primary impact of biochar (B) on wheat grain K content was 16.59 percent higher on average.

**Table (11)** Effect of some agricultural and fertilization treatments on the K content ($gkg^{-1}$) in the grains of the wheat grown a saline soil (EC of 4.7 $dSm^{-1}$).

| **Biochar (B)** | **K fertilizer (K)** | **Nano materials (N)** A0 | A1 | A2 | A3 | **Mean** |
|---|---|---|---|---|---|---|
| 2018-2019 season | | | | | | |
| | K0 | 18.0 | 19.0 | 20.0 | 21.0 | 1.9.5 |
| | K1 | 20.0 | 21.0 | 21.7 | 22.7 | 21.3 |
| B0 | K2 | 23.0 | 24.0 | 24.7 | 26.0 | 24.4 |
| | K3 | 25.0 | 26.0 | 26.7 | 27.7 | 26.3 |
| | Mean | 21.5 | 22.5 | 23.3 | 24.3 | 22.9 |
| | K0 | 21.0 | 22.0 | 23.0 | 24.0 | 22.5 |
| | K1 | 23.0 | 23.7 | 24.7 | 26.0 | 24.3 |
| B1 | K2 | 26.0 | 28.0 | 29.3 | 31.0 | 28.6 |
| | K3 | 29.0 | 31.0 | 32.0 | 34.0 | 31.5 |
| | Mean | 24.8 | 26.2 | 27.3 | 28.8 | 26.7 |
| General mean | | 23.1 | 24.3 | 25.3 | 26.5 | |
| Mean of K | | | | | | Mean |
| K0 | | 19.5 | 20.5 | 21.5 | 22.5 | 21.0 |
| K1 | | 21.5 | 22.3 | 23.2 | 24.3 | 22.8 |
| K2 | | 24.5 | 26.0 | 27.0 | 28.5 | 26.5 |
| K3 | | 27.0 | 28.5 | 29.3 | 30.8 | 28.9 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0048 | 0.0068 | 0.0068 | 0.0097 | 0.0097 | 0.0137 | 0.0193 |
| 2019-2020 season | | | | | | | |
| | K0 | | 17.1 | 18.1 | 19.0 | 20.0 | 18.5 |
| | K1 | | 19.0 | 20.0 | 20.6 | 21.5 | 20.3 |
| B0 | K2 | | 21.9 | 22.8 | 23.4 | 24.7 | 23.2 |
| | K3 | | 23.8 | 24.7 | 25.3 | 26.3 | 25.0 |
| | Mean | | 20.4 | 21.4 | 22.1 | 23.1 | 21.8 |
| | K0 | | 20.0 | 20.9 | 21.9 | 22.8 | 21.4 |
| B1 | K1 | | 21.9 | 22.5 | 23.4 | 24.7 | 23.1 |
| | K2 | | 24.7 | 26.6 | 27.9 | 29.5 | 27.2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| K3 | | | 27.6 | 29.5 | 30.4 | 32.3 | 29.9 |
| Mean | | | 23.5 | 24.9 | 25.9 | 27.3 | 25.4 |
| General mean | | | 22.0 | 23.1 | 24.0 | 25.2 | |
| Mean of K | | | | | | | Mean |
| K0 | | | 18.5 | 19.5 | 20.4 | 21.4 | 20.0 |
| K1 | | | 20.4 | 21.2 | 22.0 | 23.1 | 21.7 |
| K2 | | | 23.3 | 24.7 | 25.7 | 27.1 | 25.2 |
| K3 | | | 25.7 | 27.1 | 27.9 | 29.3 | 27.5 |
| L.S.D. at 0.05 | B | K | N | BK | BN | NK | BKN |
| | 0.0046 | 0.0065 | 0.0065 | 0.0092 | 0.0092 | 0.0130 | 0.0184 |

See foot notes of Table (2).

There were increases in wheat grain K content of 8.57, 26.19, and 37.62 percent owing to potassium fertilisation (K) in comparison with the control treatment, which showed a rise in potassium content of the grains of 8.57, 26.19, and 37.62 percent.

Compared to the comparable K content of the control treatment, the treatments A1, A2, and A3 (i.e. Si) showed increases in grain K content of 5.19 percent, 9.52 percent, and 14.72 percent attributable to the nanomaterials (A).

B0K0A0 and B1K3A3 treatments resulted in the lowest and greatest K content in wheat grains, respectively, in the second season. There was an 88.89 percent difference in K content between the two treatments.

There was a significant increase in wheat grain potassium content of 8.57, 26.19, and 37.62 percent owing to potassium fertilisation (K), respectively, as compared to the wheat grain K content produced with control treatment.

Treatments A1, A2, and A3 (Si) all increased the K content of the grains by 5.19, 9.52, and 14.72 percent, respectively, as compared to the control treatment's comparable K content.

B0K0A0 and B1K3A3 treatments resulted in the lowest and greatest K content in wheat grains, respectively, in the second season. There was an 88.89 percent difference in K content between the two treatments.

Biochar (B) had a significant impact on grain K content, with an average of 16.51 percent greater than the control treatment.

Grain K content increased 8.50, 26.00 and 37.500 percent as a result of potassium fertilisation (K) in comparison to the treatment B0K0A0, which resulted in a lower K content in wheat grains.

The primary impact of the nano materials (A) on grain K content is to raise the K content of grains by 5.00, 9.09, and 14.55 percent, respectively, as compared to the control treatments A1, A2, and A3.

Finally, the biocher, K fertilisation, and nanomaterial treatment all had a significant impact on the wheat plant's characteristics, grins, and biological yield when grown in salt-affected soil. As a result, the treatment described above has the potential to offset the detrimental effects of soil salts on wheat development and the N, P, and K content of the grain.

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