

Effect of some organic substances and foliar application of nano-Si on some soil properties and yield of wheat under saline conditions

Abstract

Ensuring food security under climate change scenario requisites amending degraded soils and sustainably boost staple crops yield in a biologically viable way through effective plant nutrition management strategies. Two multi-year lysimeter experiments were conducted to investigate the impact of soil organic substances and foliar application of Nano-Si on some soil properties and yield of wheat under saline conditions (2017/18 and 2018/19 winter seasons). The experiment was executed in split plot with three replicates having organic substances (Molas (M), Compost tea (CT), K-humate (KH), M+CT, M+HK, CT + KH, M+CT+HK and control treatment in main plots while sub plots had foliar application of (tap water and Nano-Silica). The results showed that physico-chemical properties (bulk density, porosity cation exchange capacity, electrical conductivity, exchangeable sodium percentage etc.) and fertility (available of Nitrogen, Phosphor and Potassium) of the soil were significantly influenced by all organic substances, however co-application of Molas+K-humate+ compost tea remained unmatched. The same treatment combination also remained effective in boosting nitrogen and protein in grain along with wheat yield during both seasons. With foliage applied nano silicon remained superior by recording the highest yield attributes and grain yield of wheat. Therefore, it is inferred that co-application of organic substances and foliage applied Nano-Si could be developed as an effective approach to restore and conserve the soil and increase wheat productivity under saline environment arid and semi-arid regions.

Key words: soil properties, organic substances, Nano-Si, wheat

1.Introduction

Wheat (*Triticum aestivum L.*) is one of the leading cereal crops regarding in terms of area under cultivation, and the most strategic crop in Egypt (1). However, there exists a wide gap regarding wheat consumption and production, which necessitates developing strategies to boost wheat yield on per unit soil basis. Furthermore, fast growth of population and rapid urbanization have made it necessary to increase per feddan yield of wheat and effective plant nutrition and amending salt affected soil with organic substances can be used as a potential tools to achieve the goal of food and nutritional security(2, 3 and 4).Nanotechnology represents an opportunity to improve the use of elements in agriculture. A new approach to fertilization of plants is the use of nano-particles.The changing climate has multiplied the adverse effects of salinity which seriously deteriorate crop productivity across the world (5). Salinity causes abrupt decline in the assimilation of essential nutrients which leads to specific ions toxicity and significant reduction in wheat productivity (6 and 7).

Humic substances (HS) are the major components of soil organic matter and impart multiple benefits to the soil in terms of improved physic-chemical characteristics as well as higher microbial growth the root zone of crop plants (8). soil bulk density and total porosity (9),1000-grain weight, grain and straw yield and grain protein content (10). Compost tea (CT), in modern terminology, is a compost extract brewed with a microbial food source like molasses, rock dust and humic-fulvic acids, etc. The CT brewing technique, an aerobic process usually under forced aeration, extracts and grows population of microbial community (11 and 12). It has been reported that organic amendments such as compost tea, and molasses of sugar beet contain organic acids, amino acids, humic and fulvic acids which have the potential role to boost the

plant growth sweet pepper plants (13)., nutrients uptake and wheat yield (14).

Silicon (Si) is the second most abundant trace element in the soil that has the potential to alleviate adverse effects of abiotic stresses including salt, drought, chilling etc.in crop plants (15 and 16). Nano-Si mediates the synthesis of protein, amino acids, nutrient uptake and stimulates the antioxidant enzyme activity (17 and 18). The importance of nano-Si for improving plant growth, chlorophyll content, nitrogen content of maize and faba bean has been reported by (19)., however research gaps exists regarding its effect on salt stressed wheat crop which necessitates conducting in-depth studies. The application of micro-nutrients in nano-formulations (1–100 nanometers in size) has recently emerged as effective exogenous source of plant nutrients (2 and 20). Considerable higher nutrient uptake by crop plants, greater nutrient use efficiency and negligible losses are few of the advantages offered by nano micro-nutrients over their bulky application (21, 22, 23, 24, 25 and 26). Notably, because nanoparticles are more reactive than their bulk-scale equivalents, these materials may cause greater toxicity or beneficial effects on agricultural crops. Thus, with better understanding and management, the beneficial aspects of nano-enabled fertilizers can become a highly valued tool for addressing the problem of global food security (26).

This work aimed to determine the effects of some organic substances and foliar spraying of nano- Si on physico-chemical properties, fertility of soil and yield of wheat as well as Nitrogen and protein content (%) in grain of wheat under salt affected soil.

2. Materials and Methods

2.1. Experimental site, treatments, design and experimentation

Two lysimeter (82 cm diameter x 110 cm depth) experiments were conducted at Sakha Agricultural Research Station Farm, Kafr El Sheikh, Egypt during two growing winter seasons to study the effect of soil organic substances and foliar applied of nano-Si on some soil properties, wheat growth and its yield.. Therefore, the i) T1: Check treatment, ii) T2: Molas (M), T3: Compost tea (CT), iii) T4: K-humate (KH), iv) T5: M+CT, T6: M+HK, T7: CT + KH and T8: M+CT+HK organic substances were considered as main plots in this study. While sub-plots were conducted with nano-fertilizer treatments viz., i) N1 tap water and ii) N2: Nano-Silica)

Twenty Kg of maturing compost tea was soaked into 200 liters of tap water in dilution ratio 1: 10 (w/v), in plastic tanks, the mixture was turned daily and filtrated after 10 days. The chemical composition of compost tea as shown (Table 1). The chemical composition (in mg kg⁻¹) of humate potassium were humic acid (75), K₂O (10), fluvic (4) and iron (2), pH (6.70). The used nano-Si were provided by National Research Center (NRC), Egypt, and have characterized by specific surface area (300-330 m²g⁻¹), pH (4.0-4.5), and mean diameter is (10 nm). Compost tea and K-humate (10% K₂O) were added at 400 Lfed⁻¹ and 6 KgFed⁻¹. Molas includes 48 % sucrose, 20 % water, 1 % starch and polysaccharides, 3 % dextrin and cellulose, 10 % total N content, 9.5 % crude protein, 2.5 % glutamic acid, and some vitamins (in mg kg⁻¹) including pyridoxine or B₆ (5), thiamine or B₁ (1.3), riboflavin or B₂ (0.4). Some non-nitrogenous organic acids (in %) also are included in molas such as lactic (1.3), citric, glycolic, malic (0.75), oxalic, succinic (0 – 0.2), acetic (0 – 0.2), propionic (0 – 0.2), and putyric (0.2). Compost tea, K-humate (10% K₂O) and molas were added at 400Lfed.⁻¹, 6 KgFed.⁻¹ and 30Lfed.⁻¹. All of its were added equally with 1st irrigation

and 2nd irrigation *via* a soil application, while nano-Si was added as twice at 25 and 50 days after sowing (DAS) as a foliar application.

2.2. Wheat Experiment

In the winter seasons of 2017/18 and 2018/19, wheat seeds (*Triticum aestivum vulgar*) were sown in lines on November 20 under flooding irrigation methods. The wheat plants were harvested at 135 days after planting for each season. All the agriculture practices were applied as commonly used for growing wheat and carried out according to the recommendations set by the Ministry of Agriculture. Nitrogen (N) fertilizer was applied as urea (46.5% N) at rate of 75kgNFed.⁻¹ in two equal doses at 21 and 55 DAS with the first and second irrigations. The recommended dose of phosphorus, mono phosphate (15.5% P₂O₅) and potassium as potassium, sulfate (48% K₂O) and fertilizers at rates of 15KgP₂O₅Fed.⁻¹ and 30K₂OFed.⁻¹ were applied to the wheat plants before planting (at final tillage).

2.3. Data collection

Flag leaf area was measured using LAI 3000 meter and estimated at booting stage of wheat for each experimental unite as cm². Total chlorophyll was measured at booting stage using spectrophotometer (SPAD). Weight of 1000-grain were recorded as (g). Grain and straw yield were determined at harvesting stage as Mgfed.⁻¹ for each experimental unit. (Mg=1000Kg)

2.4. Plant analysis

Plant samples were taken at harvesting stage in each season, washed with distilled water. For the determination of N% in plants samples, the samples were digested and analyzed for N% according the standard methods described by (27). Protein in grain of wheat was calculated according to Protein % = N% * 6.25

2.5. Soil analysis

Soil samples were taken from each treatment from 0-20, 20-40 and 40-60 cm layers before experiment and after harvesting. Electrical conductivity (EC-dSm⁻¹), soluble cations, and anions were determined in soil paste extract and cation exchange capacity (CEC), exchangeable sodium percentage (ESP) and organic matter (OM) content was determined using the Walkley and Black method according to (27). Particle size distribution of soil was measured using pipette method according to (28). Soil bulk density and total porosity were determined for each treatment according to (29). Field capacity and permanent wilting point were calculated from soil moisture tension curve (30). Some chemical and physical properties of the experimental soil are shown in Table (1). Climatological data of Sakha Agricultural Research Station during the two wheat growing seasons 2017/2018 and 2018/2019 as show in Table (2)

Table 1 Some Chemical and physical characteristics of the experimental soil (2017-2018 and 2018-2019)

| Chemical characteristics of the experimental soil | | | | | | | | | |
|---|------|----------------------|-------|---------------------------|-----------------------|-------------------|--------------------|------|-----|
| Soil depth | pH | EC | ESP | CEC | OM | CaCO ₃ | N | P | K |
| (cm) | | (dSm ⁻¹) | (%) | (cmole kg ⁻¹) | (g kg ⁻¹) | (gkg-1) | mgkg ⁻¹ | | |
| 0-20 | 8.18 | 6.33 | 13.45 | 39.46 | 187 | 297 | 34 | 11.5 | 295 |
| 20-40 | 8.20 | 7.05 | 14.87 | 38.21 | 152 | 286 | 31 | 9.6 | 281 |
| 40-60 | 8.35 | 8.13 | 15.7 | 37.18 | 141 | 233 | 27 | 8.4 | 274 |

| Physical characteristics of the experimental soil | | | | | | | | | | |
|---|-------------------------------|-------|-------|--------------------|----------------|----------------------------|-------|-------|------|--------------|
| Soil depth | Soil moisture characteristics | | | | | Particle size distribution | | | | Soil texture |
| | F.C | W.P | A.W. | B.D. | Total porosity | Sand | Silt | Clay | | |
| cm | % | | | kg m ⁻³ | % | gkg ⁻¹ | | | | |
| 0-20 | 43.20 | 22.15 | 21.05 | 1.32 | 50.19 | 173.1 | 255.1 | 571.8 | clay | |
| 20-40 | 40.60 | 20.46 | 20.14 | 1.35 | 49.06 | 188.5 | 247.6 | 563.9 | clay | |

40-60 38.70 19.10 19.60 1.43 46.04 190.6 251.2 558.2 clay

Chemical composition of compost tea

| Item | pH | EC | NO ₃ | NH ₄ | P | K | Ca | Mg | Na | Fe | Mn | Zn |
|-------|------|----------------------|--------------------|-----------------|------|-------|-----|-----|------|------|------|------|
| | | (dSm ⁻¹) | mg l ⁻¹ | | | | | | | | | |
| Value | 8.11 | 5.81 | 67.0 | 0.73 | 21.0 | 1.544 | 463 | 240 | 58.0 | 22.8 | 1.18 | 0.93 |

pH: was determined in soil water suspension (1:2.5); **EC:** was determined in saturated soil paste extract; **ESP:** Exchangeable Sodium Percent; **CEC:** Cation Exchange Capacity. **OM:** Organic Matter. **N, P and K:** Available of nitrogen, phosphors and potassium. **F.C.:** Field Capacity; **W.P.:** Wilting Point; **A.W.:** Available Water; **B.D.:** Bulk Density

Table 2: Climatological data of Sakha Agricultural Research Station during the two wheat growing seasons 2017/2018 and 2018/2019

| Season | Month | T (C°) | R.H. (%) | W.V. km day ⁻¹ | P. E. (cm day ⁻¹) |
|-----------|-------|--------|----------|---------------------------|-------------------------------|
| 2017/2018 | Nov. | 21.2 | 70.6 | 24.2 | 0.160 |
| | Dec. | 16.7 | 67.8 | 33.1 | 0.108 |
| | Jan. | 15.6 | 72.6 | 28.6 | 0.114 |
| | Feb. | 17.0 | 72.2 | 45.7 | 0.178 |
| | Mars | 21.0 | 65.3 | 46.4 | 0.422 |
| | April | 23.2 | 57.2 | 68.4 | 0.413 |
| 2018/2019 | Nov. | 21.5 | 70.8 | 24.3 | 0.161 |
| | Dec. | 17.1 | 67.9 | 33.3 | 0.109 |
| | Jan. | 15.8 | 72.5 | 28.9 | 0.115 |
| | Feb. | 17.0 | 72.55 | 28.6 | 0.117 |
| | Mars | 19.65 | 72.2 | 45.7 | 0.285 |
| | April | 23.2 | 64.9 | 44.8 | 0.413 |

T. (C°), average of maximum and minimum temperature; **R.H.:** relative humidity; **W.V.:** wind velocity (at 2 m height); **P.E.:** Pan Evaporation. **Source:** Meteorological station at Sakha Agric. Res. Station.

2.6. Statistical analysis

The collected data were subjected to the statistical analysis, the technique of analysis variance (ANOVA) in a split- plot design according to (31). The treatments means were compared by using the least significant differences (LSD) at 5% probability level to determine the level of significance.

3. Results and Discussion

3.1 Soil chemical properties

The effect of molas (M), compost tea (CT) and K-humate (KH) on soil chemical properties are presented in (Table 3). The results revealed that the electrical

conductivity (EC), exchangeable sodium percentage (ESP) and cation exchange capacity (CEC) were significantly ($P \leq 0.05$) influenced by soil amendments applied individually or combined to each other.

The same data showed that soil salinity (E_{c_e}) was significant decreased with application of organic substances and recorded lowest values (6.28 and 6.07dSm⁻¹) for 1st season and 2nd season with combined of M+CT+KH. Also ESP took the same trend and recorded lowest values (13.43 and 13.12%) for 1st season and 2nd season. These results may be due to the role of these treatments on improving chemical soil properties. These results are supported by (9). Table (3) pointed out that the application of organic substances have positive effect on increasing of CEC significantly ($P \leq 0.01$) with soil application of M, CT, KH, and their combination (M+CT+KH). The combined effect of three organic materials together (M+CT+KH) was the most effective treatment via recording the highest values (49.0 and 51.47cmolekg⁻¹) for 1st season and 2nd season. This result was probably due to the effect of these organic materials on increasing the specific surface and thus increasing soil exchangeable capacity soil as reported by (32)

E_c and ESP were significant decreased ($P \leq 0.05$) with foliar application of Nano-Si as compared without application during two growing seasons except E_c was non-significant in the 1st season. Where CEC took the opposite trend was significant increased with Nano-Si (45.03 and 45.83 cmolekg⁻¹) for 1st season and 2nd season. Table (3) pointed out that EC was significant decreased and recorded lowest values (6.3 and 6.1dSm⁻¹) for 1st season and 2nd season due to the interaction between M + CT + KH * Nano-Si. In the other hand ESP was non-significant affect due to the interaction between A*B. Also CEC was significant decreased ($P \leq 0.05$) and recorded highest values (38.41 and 38.26 cmolekg⁻¹) for 1st season and 2nd season due

to the interaction between M + CT + KH * Nano-Si

| Treatments | 1 st season | | | 2 nd season | | |
|------------|----------------------------|------------|---------------------------------|----------------------------|------------|---------------------------------|
| | EC (dSm ⁻¹) | ESP (%) | CEC (cmolekg ⁻¹) | EC (dSm ⁻¹) | ESP (%) | CEC (cmolekg ⁻¹) |

Table 3. Mean values of EC (dSm⁻¹), Exchangeable sodium percentage (ESP %) and Cation Exchange capacity (cmolekg⁻¹) as affected by the organic substances, foliar application of Nano Si and its interaction in 2017/18 and 2018/19 seasons.

| Organic substances (A) | | | | | | | |
|------------------------|-----------|--------|--------|--------|-------|--------|--------|
| Control | | 7.21a | 14.71a | 38.42h | 7.20a | 14.64a | 38.26h |
| Molas (M) | | 7.11b | 14.30b | 42.54g | 7.10b | 14.10b | 42.68g |
| Compost tea (CT) | | 7.10b | 13.85c | 44.56f | 7.04c | 13.69c | 45.16f |
| K-Humat (KH) | | 7.01c | 13.83d | 45.69e | 6.98d | 13.64d | 46.19e |
| M + CT | | 6.81d | 13.80e | 45.98d | 6.77 | 13.60e | 46.90d |
| M + KH | | 6.72e | 13.68f | 46.96c | 6.67f | 13.54f | 47.28c |
| CT + KH | | 6.51f | 13.62g | 47.17b | 6.38g | 13.40g | 49.01b |
| M + CT + KH | | 6.28g | 13.43h | 49.00a | 6.07h | 13.12h | 51.47a |
| LSD 0.05 | | 0.015 | 0.007 | 0.030 | 0.020 | 0.006 | 0.029 |
| Nano-Si(B) | | | | | | | |
| Without | | 6.84 | 13.91 | 45.05 | 6.79 | 13.72 | 45.90 |
| Nano-Si | | 6.84 | 13.90 | 45.03 | 6.76 | 13.71 | 45.83 |
| LSD _{0.05} | | ns | 0.005 | 0.018 | 0.018 | 0.006 | 0.022 |
| Interaction(A*B) | | | | | | | |
| Control | tab water | 7.21a | 14.71a | 49.04a | 7.21a | 14.65a | 51.49a |
| | Nano Si | 7.21a | 14.71a | 48.96b | 7.20a | 14.64a | 51.46b |
| Molass (M) | tab water | 7.11b | 14.30b | 47.21c | 7.10b | 14.10b | 49.08c |
| | Nano Si | 7.11b | 14.29c | 47.13d | 7.10b | 14.09b | 48.94d |
| Compost tea (CT) | tab water | 7.11b | 13.85d | 46.98e | 6.99c | 13.70c | 47.33e |
| | Nano Si | 7.10bc | 13.84e | 46.94f | 6.98c | 13.69c | 47.22f |
| K-Humat (KH) | tab water | 7.02d | 13.83f | 45.99g | 7.11b | 13.64d | 46.88g |
| | Nano Si | 7.01d | 13.82f | 45.97g | 6.97c | 13.63d | 46.24h |
| M + CT | tab water | 6.81e | 13.80g | 45.69h | 6.79d | 13.60e | 46.13i |
| | Nano Si | 6.81e | 13.79h | 45.69h | 6.74e | 13.59e | 45.21j |
| M + KH | tab water | 6.72f | 13.69i | 44.57i | 6.66g | 13.55e | 45.11k |
| | Nano Si | 6.72f | 13.67j | 44.56i | 6.69f | 13.53f | 45.11l |
| CT + KH | tab water | 6.51g | 13.63k | 42.56j | 6.40h | 13.41h | 42.69m |
| | Nano Si | 6.50g | 13.61l | 42.53k | 6.36i | 13.39g | 42.68m |
| M + CT + KH | tab water | 6.30h | 13.44m | 38.44l | 6.10j | 13.14i | 38.26n |
| | Nano Si | 6.27i | 13.43n | 38.41m | 6.04k | 13.11k | 38.26n |
| LSD _{0.05} | | 0.013 | ns | 0.029 | 0.021 | ns | 0.025 |

Means of each factor followed by the same letter are not significantly different at 5 % level according to Duncan's multiple range test.*and NS indicate $p < 0.05$ and not significant.

3.2 Soil physical properties

Remarkable reduction in the soil bulk density (BD) was observed with individually application of the organic amendments and their combination with each other (Table 4). The soil BD ranged from 1.32 to 1.43 Mgm^{-3} before to setup the experiments, while their corresponding values ranged from 1.299 to 1.369 Mgm^{-3}

after the trail harvest. Although all soil amendments significantly decreased BD, the combined application of M+KH+ CT was recorded to be superior in comparison to

| Treatments | 1 st season | 2 nd season |
|------------|------------------------|------------------------|
|------------|------------------------|------------------------|

other treatments. In addition, soil porosity is also considered one of the most important soil factors which affect plant growth and it depends on soil texture. Figure (Table 4) showed that total porosity (%) which was significantly increased with application of M, CT, KH, and CT+KH, and the highest values were recorded with M+CT+KH. Also, the data revealed that applied nano-fertilizer had no significant effect on the soil porosity (Table 4). This may be reflected the role of these amendments in increasing the soil aggregation consequently increasing the soil porosity and decreasing the soil BD as well as improving soil properties. These results were supported by (33), who opined that the organic amendments improved soil physical characteristics including soil porosity and bulk density.

Also Bd was significant decreased ($P \leq 0.05$) and recorded lowest values (1.30 and 1.299) for 1st season and 2nd season due to the interaction between M + CT + KH * Nano-Si

| | | Bd (kgm ⁻³) | Porosity (%) | Bd (kgm ⁻³) | Porosity (%) |
|-------------------------------|-----------|-----------------------------------|---------------------|-----------------------------------|---------------------|
| Organic substances (A) | | | | | |
| Control | | 1.367a | 48.38g | 1.361a | 48.63g |
| Molass (M) | | 1.353b | 48.91f | 1.351b | 49.02f |
| Compost tea (CT) | | 1.349c | 49.06e | 1.340c | 49.41e |
| K-Humat (KH) | | 1.344d | 49.25d | 1.331d | 49.76d |
| M + CT | | 1.334e | 49.64c | 1.320e | 50.16c |
| M + KH | | 1.334e | 49.65c | 1.320e | 50.16c |
| CT + KH | | 1.319f | 50.20b | 1.311f | 50.52b |
| M + CT + KH | | 1.305g | 50.75a | 1.299g | 50.95a |
| LSD_{0.05} | | 0.0009 | 0.037 | 0.001 | 0.042 |
| Nano-Si(B) | | | | | |
| tab water | | 1.339 | 49.50 | 1.329 | 49.83 |
| Nano-Si | | 1.338 | 49.56 | 1.329 | 49.83 |
| LSD_{0.05} | | ns | ns | ns | ns |
| Interaction(A*B) | | | | | |
| Control | tab water | 1.369a | 48.31i | 1.361a | 48.63g |
| | Nano Si | 1.366b | 48.45h | 1.361a | 48.63g |
| Molass (M) | tab water | 1.354c | 48.93g | 1.351b | 49.02f |
| | Nano Si | 1.353c | 48.89g | 1.351b | 49.02f |
| Compost tea (CT) | tab water | 1.350d | 49.04f | 1.340c | 49.41e |
| | Nano Si | 1.349d | 49.08f | 1.340c | 49.42e |
| K-Humat (KH) | tab water | 1.345e | 49.23e | 1.331d | 49.76d |
| | Nano Si | 1.344e | 49.27e | 1.331d | 49.77d |
| M + CT | tab water | 1.334f | 49.63d | 1.321e | 50.15c |
| | Nano Si | 1.334f | 49.66d | 1.320 e | 50.16c |
| M + KH | tab water | 1.334f | 49.64d | 1.320 e | 50.16c |
| | Nano Si | 1.334f | 49.66d | 1.320e | 50.17c |
| CT + KH | tab water | 1.320g | 50.19c | 1.311f | 50.51b |
| | Nano Si | 1.319g | 50.21c | 1.311f | 50.53b |
| M + CT + KH | tab water | 1.306h | 50.71b | 1.299g | 50.95a |
| | Nano Si | 1.304i | 50.79a | 1.299g | 50.95a |
| LSD_{0.05} | | 0.001 | 0.046 | ns | ns |

Table (4). Mean values of bulk density (kgm⁻³) and soil porosity (%) as affected by the organic substances and foliar application of Nano Si in 2017/18 and 2018/19 seasons.

Means of each factor followed by the same letter are not significantly different at 5 % level according to Duncan's multiple range test.*and NS indicate $p < 0.05$ and not significant. (Mg=1000Kg)

3.3. Soil fertility:

The data showed that available of Nitrogen was significant increased with application of organic substances and recorded highest values (42.74 and 43.42mgkg⁻¹) for 1st season and 2nd season with combined of M+CT+KH. Also Available of phosphor took the same trend and recorded highest values (11.93 and 12.15 mgkg⁻¹) for both of two growing seasons. The same data showed that Potassium was recorded highest values with application of M+CT+KH.

The same data showed that N, P and K were significant increased with foliar of Nano -Si as compared without treatment.

Table 5 showed that the Nitrogen was significant increased and recorded highest values (42.96 and 43.70) due to the interaction between of Si*M + CT for both of two growing seasons. Where both of Phosphor and Potassium was significant increased due to the same previous treatment and recorded highest values due to the interaction between of Si and M + CT .Table 5 showed that the effect of molas (M), compost tea (CT) and K-humate (KH) on soil available of Nitrogen, Phosphor and Potassium. The results revealed that the N, P and K were significantly ($P \leq 0.05$) influenced by soil amendments applied individually or combined to each other.

| Treatments | 1 st season | 2 nd season |
|------------|------------------------|------------------------|
|------------|------------------------|------------------------|

Table (5). Mean values soil available of Nitrogen, Phosphor and Potassium (mgkg^{-1}) as affected by the organic amendments and foliar of Nano Si and its interaction in 2017/18 and 2018/19 seasons.

| | N | P | K | N | P | K | |
|-------------------------------|--------------------|--------|---------|----------|--------|---------|---------|
| | mgkg ⁻¹ | | | | | | |
| Organic substances (A) | | | | | | | |
| Control | 30.95h | 9.12h | 282.59h | 30.61h | 8.28h | 283.02h | |
| Molass (M) | 32.59g | 10.05e | 286.79f | 33.84f | 10.06e | 287.02f | |
| Compost tea (CT) | 33.68f | 9.79g | 285.79g | 33.03g | 9.96g | 286.04g | |
| K-Humat (KH) | 33.72e | 9.83f | 290.22d | 34.05e | 10.03f | 291.70d | |
| M + CT | 36.68d | 11.03c | 287.05e | 37.06d | 11.11c | 288.03e | |
| M + KH | 37.72c | 11.59b | 291.28c | 39.13b | 11.68b | 292.26c | |
| CT + KH | 39.21b | 10.89d | 294.13b | 38.05c | 11.03d | 294.65b | |
| M + CT + KH | 42.74a | 11.93a | 296.09a | 43.42a | 12.15a | 297.66a | |
| LSD _{0.05} | 0.015 | 0.009 | 0.193 | 0.014 | 0.021 | 0.056 | |
| Nano-Si(B) | | | | | | | |
| tab water | 35.78b | 10.47b | 288.95b | 36.03b | 10.43b | 289.77b | |
| Nano-Si | 36.04a | 10.58a | 289.53a | 36.25a | 10.64a | 290.33a | |
| LSD _{0.05} | 0.011 | 0.003 | 0.136 | 0.009 | 0.014 | 0.063 | |
| Interaction(A*B) | | | | | | | |
| Control | tab water | 30.95o | 9.10p | 282.53m | 30.55p | 8.11o | 282.97p |
| | Nano Si | 30.96o | 9.15o | 282.65m | 30.66o | 8.46n | 283.07o |
| Molass (M) | tab water | 33.69k | 9.90j | 286.61j | 33.79l | 9.96l | 286.95l |
| | Nano Si | 33.76j | 10.11i | 286.97hi | 33.90k | 10.17i | 287.09k |
| Compost tea (CT) | tab water | 32.57n | 9.76n | 285.62l | 32.92n | 9.86m | 285.91n |
| | Nano Si | 32.62m | 9.82l | 285.95k | 33.14m | 10.06k | 286.17m |
| K-Humat (KH) | tab water | 33.52l | 9.80m | 290.28g | 33.93j | 9.95l | 291.50h |
| | Nano Si | 33.84i | 9.85k | 290.16g | 34.17i | 10.10j | 291.90f |
| M + CT | tab water | 36.52h | 10.92g | 286.83ij | 36.96h | 10.97g | 287.88j |
| | Nano Si | 36.84g | 11.14e | 287.26h | 37.16g | 11.24e | 288.18i |
| M + KH | tab water | 38.95d | 11.57d | 290.62f | 39.12d | 11.60d | 291.60g |
| | Nano Si | 39.48c | 11.62c | 291.94e | 39.15c | 11.77c | 292.93e |
| CT + KH | tab water | 37.58f | 10.81h | 293.60d | 37.87f | 10.90h | 294.15d |
| | Nano Si | 37.87e | 10.97f | 294.66c | 38.14e | 11.16f | 295.15c |
| M + CT + KH | tab water | 42.51b | 11.90b | 295.52b | 43.15b | 12.12b | 297.19b |
| | Nano Si | 42.96a | 11.97a | 296.67a | 43.70a | 12.19a | 298.14a |
| LSD _{0.05} | | 0.015 | 0.007 | 0.297 | 0.019 | 0.017 | 0.081 |

Means of each factor followed by the same letter are not significantly different at 5 % level according to Duncan's multiple range test.*and NS indicate $p < 0.05$ and not significant.

3.4. Growth attributes

The data illustrated in Table 6 indicated that the flag leaf area (cm²), chlorophyll and 1000-GW (g) of wheat were increased significantly ($p < 0.01$) by

organic substances additions. The data showed that flag leaf area (cm^2) was significant increased ($p < 0.05$) with application of organic substances and recorded highest values (37.17 and 39.28 cm^2) for 1st season and 2nd season with combined of M+CT+KH. Also chlorophyll of wheat took the same trend and recorded highest values (39.37 and 39.63) for both of two growing seasons. The same data showed that 1000-GW (g) was recorded highest values (41.95 and 42.30g) with application of M+CT+KH. The foliar application of Nano-Si also significantly ($p < 0.05$) increased these parameters compared without application. The significant increases of leaf area index, flag leaf area (cm^2), chlorophyll content and 1000-GW (g) may be due to an increase in the accumulation of nutrients, antioxidant enzymes activity by application of the Nano-Si, thereby improving the tolerance of plants to abiotic stress. These results are supported by (18).

Table 6 showed that the flag leaf area (cm^2) was significant increased and recorded highest values (39.46 and 41.08) due to the interaction between of Si*M + CT for both of two growing seasons. Where both of chlorophyll and 1000-GW (g) of wheat was significant increased due to the same previous treatment and recorded highest values (41.13, 41.58) and (42.88, 43.19) due to the interaction between of Si and M + CT

Table (6). Mean values of flag leaf area, total chlorophyll content (SPAD) and 1000-GW (g) as affected by soil and foliar application of Nano-Si and its interaction in 2017/18 and 2018/19 seasons

Means of each factor followed by the same letter are not significantly different at 5 % level according to Duncan's multiple range test.* and NS indicate $p < 0.05$ and not significant.

| Treatments | 1 st season | | | 2 nd season | | | |
|-------------------------------|------------------------------|----------------|------------|------------------------------|----------------|------------|--------|
| | leaf area (cm ²) | Chlorophyll II | 1000-GW(g) | leaf area (cm ²) | Chlorophyll II | 1000-GW(g) | |
| Organic substances (A) | | | | | | | |
| Control | 30.62h | 32.88h | 40.54g | 30.18h | 33.17h | 41.27g | |
| Molas (M) | 32.28g | 34.85f | 40.72f | 33.10g | 34.94f | 41.52f | |
| Compost tea (CT) | 33.12f | 34.16g | 41.05e | 33.99f | 34.86g | 41.75e | |
| K-Humat (KH) | 34.76e | 35.01e | 41.36e | 35.48e | 35.33e | 41.74e | |
| M + CT | 35.04d | 35.97d | 41.48c | 36.08d | 36.30d | 41.89d | |
| M + KH | 35.61c | 36.20c | 41.48c | 36.78c | 36.52c | 41.97c | |
| CT + KH | 36.47b | 37.49b | 41.63b | 38.64b | 37.62b | 42.05b | |
| M + CT + KH | 37.17a | 39.37a | 41.95a | 39.28a | 39.63a | 42.30a | |
| LSD _{0.05} | 0.022 | 0.013 | 0.009 | 0.026 | 0.010 | 0.018 | |
| Nano-Si (B) | | | | | | | |
| tab water | 32.87 | 35.15 | 40.70 | 33.73 | 35.32 | 41.22 | |
| Nano-Si | 35.90 | 36.44 | 41.85 | 37.15 | 36.77 | 42.40 | |
| LSD _{0.05} | 0.003 | 0.008 | 0.009 | 0.006 | 0.014 | 0.009 | |
| Interaction(A*B) | | | | | | | |
| Control | tab water | 30.09p | 31.51o | 40.22o | 30.15 | 31.68o | 41.10m |
| | Nano Si | 31.15o | 34.25k | 40.87k | 30.22 | 34.66k | 41.45g |
| Molass (M) | tab water | 31.92n | 33.61n | 40.27n | 31.11 | 33.68n | 41.11m |
| | Nano Si | 32.64l | 36.1q | 41.17g | 35.09 | 36.20g | 41.92f |
| Compost tea (CT) | tab water | 32.02m | 34.12l | 40.62m | 32.25 | 34.26l | 41.17l |
| | Nano Si | 34.23g | 35.11i | 41.48f | 35.73 | 35.45i | 42.32e |
| K-Humat (KH) | tab water | 33.13k | 33.81m | 40.78l | 33.13 | 34.01m | 41.17l |
| | Nano Si | 36.39e | 36.22f | 42.19c | 37.82 | 36.65f | 42.32e |
| M + CT | tab water | 33.15j | 35.83h | 40.88k | 34.13 | 35.96h | 41.23k |
| | Nano Si | 36.93d | 36.11g | 41.85e | 38.03 | 36.64f | 42.56d |
| M + KH | tab water | 33.64i | 37.79c | 40.90j | 35.15 | 38.25b | 41.28j |
| | Nano Si | 37.58c | 34.61j | 42.06d | 38.42 | 34.79j | 42.66c |
| CT + KH | tab water | 34.12h | 36.97e | 40.97i | 36.49 | 37.04e | 41.34i |
| | Nano Si | 38.82b | 38.01b | 42.30b | 36.79 | 38.21c | 42.76b |
| M + CT + KH | tab water | 34.88f | 37.61d | 41.02h | 37.47 | 37.69d | 41.41h |
| | Nano Si | 39.46a | 41.13a | 42.88a | 41.08 | 41.58a | 43.19a |
| LSD _{0.05} | | 0.015 | 0.018 | 0.011 | 0.032 | 0.012 | 0.034 |

3.5. Yield of wheat

The data illustrated in Table7 indicated that the grain and straw yield of wheat were increased significantly ($p < 0.05$) by organic substances additions. The data showed that grain was significant increased ($p < 0.05$) with application of M, CT, HK and recorded highest values (2.721 and 3.188 MgFed⁻¹) for 1st season and 2nd season

with combined of M+CT+KH. Also straw yield of wheat took the same trend and recorded highest values (3.713 and 4.178 MgFed⁻¹) for both of two growing seasons. The same data showed that grain yield of wheat was recorded highest values (2.600 and 3.145 MgFed⁻¹) for 1st season and 2nd season with application of Nano-Si. Also the straw yield of wheat was significant increased up to (3.514 and 3.981 MgFed⁻¹) for both of two growing seasons with foliar application of Nano-Si.

Table 7 showed that grain yield of wheat was significant increased and recorded highest values (2.883 and 3.280 MgFed⁻¹) due to the interaction between of Si*M + CT for both of two growing seasons. Where straw yield of wheat took the same trend and recorded (3.850 and 4.391 MgFed⁻¹) Table 3 showed that application of molass, compost tea and K-humate, had significant effect on 1000-grain weight along with grain and straw yields of wheat. The highest values were recorded for M+ CT+KH while, the lowest values were obtained from the control treatment. Similar results were obtained by **(10 and 14)**, who reported that combined application of organic manures was effective one in boosting soil fertility and water holding capacity of the soil which led to higher nutrient use efficiency and grain yield. Also, data presented in Table 3 show that the weight of 1000-grain, grain and straw yield of wheat were affected significantly using nano-fertilizers in both seasons. The highest values of 1000-grain weight, grain and straw yield of wheat were obtained by the foliar spraying of nano-Si compared with the other treatments. These results are compatible with those observed by **(10 and 19)**. The interaction effect between soil organic amendments treatment and foliar spraying of nano-si showed highly significance according to the grain and straw yield of wheat during the two growing seasons and the highest values were recorded with CT +HK Combined with nano-Si application. These results were supported by **(17)**. The improvement in the grain and straw yield

of wheat plants that were developed under saline stress conditions, partially due to the presence of an increment of photosynthetic pigments in the leaves, which can improve the photosynthetic capacity of the plants. These results are similar to those obtained by (24 and 4)

3.6 Nitrogen content (%) and protein contents (%) in grain of wheat:

Data in Fig. (1.a) Nitrogen content in grain yield of wheat was significant increased by application of organic substances as compared with control. Nitrogen content in grain yield was recorded highest values (2.19 and 2.23%) for both two seasons by application of M + CT + KH

With regard to the treatment of foliar nano application of Si, nitrogen content in grain yield of wheat was significant increased due the previous treatment as compared with control. Thesis results are superseded by (17 and 18).

Nitrogen content in grain yield of wheat was significant increased (2.23 and 2.27%) due to the interaction between M + CT +KH and nano Si

Protein content in grain yield of wheat was took the same trend and recorded highest value (13.94 and 14.19%) for both two season due to the interaction between M + CT + KH and nano Si (Fig. 1.b)

Table 7: Grain and straw yield of wheat as affected by the organic substances, foliar of Nano-Si and its interaction in 2017/18 and 2018/19 seasons.

| Treatments | 1 st season | | 2 nd season | | |
|-------------------------------|------------------------|------------|------------------------|--------|--------|
| | Grain | Straw | Grain | Straw | |
| | Mg fed. ⁻¹ | | | | |
| Organic substances (A) | | | | | |
| Control | 2.495e | 2.809h | 2.703h | 3.142h | |
| Molas (M) | 2.523d | 3.182f | 2.990f | 3.488f | |
| Compost tea (CT) | 2.533d | 3.399e | 2.972g | 3.819e | |
| K-Humat (KH) | 2.539d | 3.171g | 3.019e | 3.472g | |
| M + CT | 2.566c | 3.442d | 3.157c | 4.115b | |
| M + KH | 2.577c | 3.859a | 3.144d | 4.047c | |
| CT + KH | 2.599b | 3.716b | 3.161b | 3.966d | |
| M + CT + KH | 2.721a | 3.713c | 3.188a | 4.178a | |
| LSD _{0.05} | 0.017 | 0.002 | 0.0016 | 0.0021 | |
| Nano-Si(B) | | | | | |
| tab water | 2.53 | 3.309 | 2.939 | 3.576 | |
| Nano-Si | 2.60 | 3.514 | 3.145 | 3.981 | |
| LSD _{0.05} | 0.017 | 0.001 | 0.003 | 0.002 | |
| Interaction(A*B) | | | | | |
| Control | tab water | 2.476h | 2.759p | 2.693m | 2.841o |
| | Nano Si | 2.514g | 2.859o | 2.713l | 3.444l |
| Molas (M) | tab water | 2.518g | 3.171l | 2.811j | 3.440m |
| | Nano Si | 2.529fg | 3.194k | 3.170d | 3.537k |
| Compost tea (CT) | tab water | 2.517g | 3.279i | 2.804k | 3.679j |
| | Nano Si | 2.548efefg | 3.520g | 3.140e | 3.960f |
| K-Humat (KH) | tab water | 2.519g | 3.107m | 2.913i | 3.406n |
| | Nano Si | 2.559de | 3.234j | 3.124f | 3.538k |
| M + CT | tab water | 2.558de | 3.424h | 3.034h | 3.774g |
| | Nano Si | 2.596c | 3.460g | 3.281a | 4.456a |
| M + KH | tab water | 2.554def | 3.610d | 3.033h | 3.747i |
| | Nano Si | 2.578cd | 4.108a | 3.256b | 4.347c |
| CT + KH | tab water | 2.536ef | 3.549f | 3.125f | 3.761h |
| | Nano Si | 2.663b | 3.884b | 3.198c | 4.172d |
| M + CT + KH | tab water | 2.56de | 3.577e | 3.096g | 3.966e |
| | Nano Si | 2.883a | 3.850c | 3.280a | 4.391b |
| LSD _{0.05} | | 0.024 | 0.003 | 0.003 | 0.002 |

Means of each factor followed by the same letter are not significantly different at 5 % level according to Duncan's multiple range test.* and ns indicate p < 0.05 and not significant.

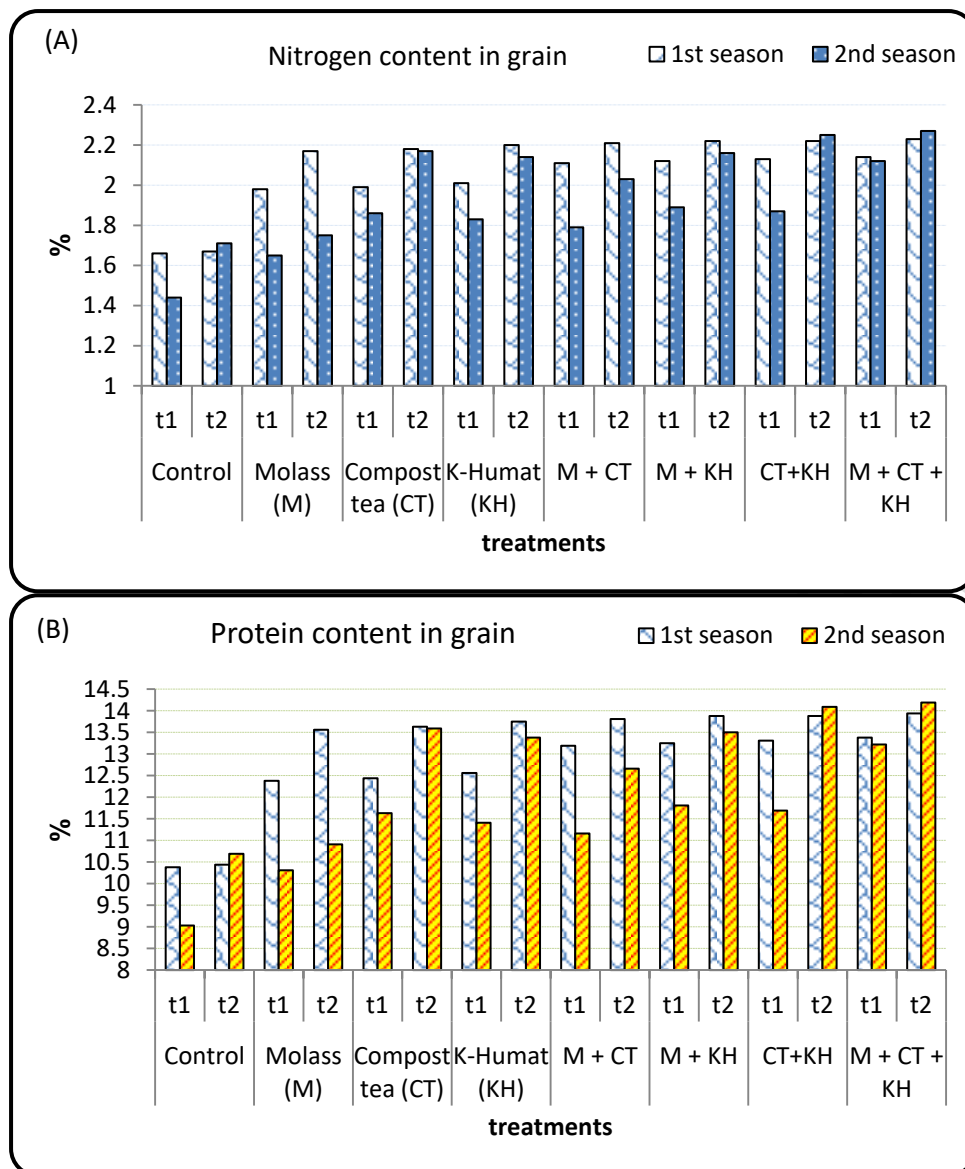


Fig.(1). Nitrogen content (%) and protein contents (%) in grain of wheat as affected by the interaction between soil and foliar application of Nano-Si in 2017/18 and 2018/19 seasons. Notice: (t1:Foliar with tab water and t2 :foliar with Nano-Si)

Conclusions

It was hypothesized that organic substances applied solely or in conjunction with each other and exogenous application of nano -Si have the potential to improve both of soil physico-chemical characteristics and soil fertility as well as boost wheat grain yield under saline environment. Our results were in line with the postulated hypothesis as co-application of Molas+ K-humate+compost tea outperformed other treatments in terms of improved bulk density, soil porosity, electrical conductivity, cation exchange capacity, N content and protein in grain etc. Moreover, foliage applied silicon remained superior in terms of better yield attributes and grain yield of wheat under saline environment. However, further studies are needed to optimize dose of these nutrients and these findings may serve as base line to evaluate the impact of other organic substances and trace elements for alleviating the adverse effects of salinity on wheat crop under changing climate.

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