Effect of some organic substances and foliar application of nano-Silica on physico-chemical soil properties and yield of wheat in salt affected soils

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 at Sakha Agricultural Research Station, Kafr El Sheikh, Egypt, were conducted to investigate the impact of soil organic substances and foliar application of nano-Silica on physico-chemical soil properties and yield of wheat in salt affected soils (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+KH, CT + KH, M+CT+KH and control treatment in main plots while sub plots had foliar application of (tab 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 (availability of Nitrogen, Phosphorus 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 Silica 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 of nano-Silica could be developed as an effective approach to restore and conserve the soil and increase wheat productivity in salt affected soils environment arid and semi-arid regions.

Key words:*physico-chemical soil properties, organic substances, Nano-Si, wheat yield*

1.INTRODUCTION

Wheat (*Triticumaestivum 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 yield of wheat/fed and effective plant nutrition and amending salt affected soils with organic substances can be used as a potential tools to achieve the goal of food and nutritional security**[2,3,4]**.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 **[6-7].** Humic substances (HS) are the major components of soil organic matter and impartmultiple 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**[11-12].**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 growthsweet 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 -16]**. Nano-Si mediates the synthesis of protein, amino acids, nutrient uptake and stimulates the antioxidant enzyme activity**[17-18]**. 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 **[2-20]**. 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**,**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]**.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.This work aimed to determine the effects of some organic substances and foliar application 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 application of nano-Si on some soil properties, wheat growth and its yield. Therefore, the T1: Check treatment, ii) T2: Molas(M),T3: Compost tea (CT), T4:K-humate(KH), T5:M+CT, T6:M+KH, T7:CT + KH and T8:M+CT+KH organic substances were considered as main plots in this study. While sub-plots were conducted with nano-fertilizer treatments viz.,t1 tab water without nano silca and t2: 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), K_2O (10), fulvic (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 m^2g^{-1}), pH (4.0-4.5), and mean diameter is (10 nm).Compost tea and K-humate (10% K_2O) 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 B_6 (5), thiamine or B1 (1.3), riboflavin or B_2 (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), propinic (0 – 0.2), and putyric (0.2). Compost tea, K-humate(10% K_2O) 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(300mg L^{-1}). Gypsum requirements (GR) were determined according to **[27]** to reduce the initial ESP for the soil matrix to 10% in the surface layer (0-30 cm) according to the following equation: GR = (ESPi – ESPf) x CEC x 1.72× (100/purity) Where: GR: gypsum requirement (Mg ha^{-1}) for upper 30 cm soil, ESP_i: initial soil ESP, ESP_f: The desired soil ESP and CEC: cation exchange capacity (cmolc kg^{-1}).

2.2. Wheat Experiment

In the winter seasons of 2017/18 and 2018/19, wheat seeds (*Triticumaestivum 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 agricultural 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% P_2O_5)and Potassium as Potassium, sulfate (48% K_2O) and fertilizers at rates of 15KgP_2O_5Fed.$^{-1}$ and 30K_2OFed.$^{-1}$were applied to the wheat plants before planting (at final tillage). 100% of gypsum requirements were added as soil application before soil 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 cm^2. 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**[28]**. Protein in grain of wheat was calculated according to Protein % = N% x 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**[28].** Particle size distribution of soil was measured using pipette method according to **[29].** Soil bulk density and total porosity were determined for each treatment according to **[30].** Field capacity and permanent wilting point were calculated from soil moisture tension curve **(31).**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 (cm)	pH	EC (dSm^{-1})	ESP (%)	CEC (cmole kg^{-1})	OM %	$CaCO_3$ %	N mgkg^{-1}	P mgkg^{-1}	K mgkg^{-1}
0-20	8.18	6.33	13.45	39.46	1.87	2.97	34	11.5	295
20-40	8.20	7.05	14.87	38.21	1.52	2.86	31	9.6	281
40-60	8.35	8.13	15.7	37.18	1.41	2.33	27	8.4	274

Physical characteristics of the experimental soil

Soil depth	Soil moisture characteristics	Particle size distribution

	F.C	W.P	A.W.	Bd.	Total porosity	Sand	Silt	Clay	Soil texture
cm	%			kg m^{-3}	%	%			
0-20	43.20	22.15	21.05	1.32	50.19	17.31	25.51	57.18	clay
20-40	40.60	20.46	20.14	1.35	49.06	18.85	24.76	56.39	clay
40-60	38.70	19.10	19.60	1.43	46.04	19.06	25.12	55.82	clay

Chemical composition of compost tea

Item	pH	EC	NO_3	NH_4,	P	K	Ca	Mg	Na	Fe	Mn	Zn
		(dSm^{-1})	mgl^{-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**[32].** 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 highly significant ($P \leq 0.01$) influenced by soil amendments applied individually or combined to each other.

The same data showed that soil salinity (EC_e) was highly 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 2ndseason. 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**[33]**

EC and ESP were non- significant ($P \leq 0.05$) with foliar application of nano-Si as compared without application during two growing seasons .Table (3) pointed out that EC was significantly 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 x nano-Si. In the other hand ESP was insignificant affect due to the interaction between A x B in the second season. Also CEC was significant decreased ($P \leq 0.01$) 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	**1st season**	**2nd season**

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.

		EC (dSm^{-1})	**ESP** (%)	**CEC** (cmolekg^{-1})	**EC** (dSm^{-1})	**ESP** (%)	**CEC** (cmolekg^{-1})
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
F$_{test}$		**	**	**	**	**	**
LSD $_{0.05}$		0.015	0.007	0.030	0.020	0.006	0.029
LSD$_{0.01}$		0.036	0.0107	0.041	0.027	0.008	0.040
Nano-Si(B)							
tab water without nano-Si		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
F$_{test}$		ns	ns	ns	ns	ns	ns
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
Molas (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
F$_{test}$		*	**	**	**	ns	**
LSD$_{0.05}$		0.013	-	0.029	0.021	-	0.025
LSD$_{0.01}$		-	0.014	0.040	0.027	-	0.027

Means of each factor followed by the same letter are not significantly different at 5 % level according to Duncan's multiple range test.*indicate significant $p < 0.05$,** indicate significant $p < 0.01$ and ns indicate 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 Kgm^{-3} before to setup the experiments, while their corresponding values ranged from 1.299 to 1.369 Kgm^{-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 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**[34],** who opined that the organic amendments improved soil physical characteristics including soil porosity and bulk density. Also BD was significantly 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

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.*indicate significant $p < 0.05$,** indicate significant $p < 0.01$ and ns indicate not significant. (Mg=1000kg)

Treatments		**1st season**		**2nd season**	
		Bd (kgm^{-3})	**Porosity** (%)	**Bd** (kgm^{-3})	**Porosity** (%)
Organic substances (A)					
Control		1.367a	48.38g	1.361a	48.63g
Molas (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
F_{test}		**	**	**	**
$LSD_{0.05}$		0.0009	0.037	0.0010	0.042
$LSD_{0.01}$		0.0013	0.051	0.0015	0.058
Nano-Si(B)					
tab water		1.339	49.50	1.329	49.83
nano-Si		1.338	49.56	1.329	49.83
F_{test}		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
Molas (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
F_{test}		**	**	ns	ns
$LSD_{0.05}$		0.001	0.046	-	-
$LSD_{0.01}$		0.002	0.049	-	-

3.3. Soil fertility:

The data in Table 5 showed that availability of Nitrogen was significantly 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 phosphorus 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 insignificant affected with foliar of nano -Si as compared without treatment.

Table 5 showed that the Nitrogen was high significant increased and recorded highest values (42.96 and 43.70) due to the interaction between of Si x M + CT for both of two growing seasons. Where both of Phosphorus and Potassium was highly 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 availability of Nitrogen, Phosphorus and Potassium. The results revealed that the N, P and K were highly significant ($P \leq 0.01$) influenced by soil amendments applied individually or combined to each other.

Table (5). Mean values soil available of Nitrogen, Phosphorus 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.

Means of each factor followed by the same letter are not significantly different at 5 % level according to Duncan's multiple range test.*indicate significant $p < 0.05$,** indicate significant $p < 0.01$ and ns indicate not significant.

Treatments		**1st season**			**2nd season**		
		N	**P**	**K**	**N**	**P**	**K**
		mgkg^{-1}					
Organic substances (A)							
Control		30.95h	9.12h	282.59h	30.61h	8.28h	283.02h
Molas (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
F_{test}		**	**	**	**	**	**
$LSD_{0.05}$		0.015	0.009	0.193	0.014	0.021	0.056
$LSD_{0.01}$		0.021	0.012	0.268	0.019	0.029	0.78
Nano-Si(B)							
tab water		35.78	10.47	288.95	36.03	10.43	289.77
nano-Si		36.04	10.58	289.53	36.25	10.64	290.33
F_{test}		ns	ns	ns	ns	ns	ns
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
Molas (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
F_{test}		**	**	**	**	**	**
$LSD_{0.05}$		0.015	0.007	0.297	0.019	0.017	0.081
$LSD_{0.01}$		0.019	0.009	0.301	0.021	0.019	0.092

3.4. Growth attributes

The data illustrated in Table 6 indicated that the flag leaf area (cm^2), chlorophyll and1000-GW (g) of wheat were highly significant increased ($p < 0.01$) by organic substances additions. The data showed that flag leaf area (cm^2) was highly significant increased ($p < 0.01$) 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 highly significant increased ($p < 0.01$) these parameters compared without application. The significant increases of leaf area index, flag leaf area (cm^2), chlorophyll content and1000-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 highly significant increased and recorded highest values (39.46 and 41.08) due to the interaction between of Si x M + CT for both of two growing seasons. Where both of chlorophyll and 1000-GW (g) of wheat was highly 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) and1000-GW (g) as affected by soil and foliar application of nano-Si and its interaction in 2017/18 and 2018/19 seasons

Treatments		**1st season**			**2nd season**		
		leaf area (cm^2)	**Chlorophyll**	**1000-GW(g)**	**leaf area (cm^2)**	**Chlorophyll**	**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
F_{test}		**	**	**	**	**	**
$LSD_{0.05}$		0.022	0.013	0.009	0.026	0.010	0.018
$LSD_{0.01}$		0.031	0.018	0.012	0.037	0.033	0.025
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
F_{test}		**	**	**	**	**	**
$LSD_{0.05}$		0.003	0.018	0.009	0.006	0.014	0.009
$LSD_{0.01}$		0.007	0.019	0.023	0.014	0.014	0.023
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
Molas (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
F_{test}		**	**	**	**	**	**
$LSD_{0.05}$		0.015	0.018	0.011	0.032	0.012	0.034
$LSD_{0.01}$		0.019	0.021	0.014	0.038	0.015	0.036

Means of each factor followed by the same letter are not significantly different at 5 % level according to Duncan's multiple range test.*indicate significant $p < 0.05$,** indicate significant $p < 0.01$ and ns indicate not significant.

3.5. Yield of wheat

The data illustrated in Table7 indicated that the grain and straw yield of wheat were highly significant increased ($p < 0.01$) by organic substances additions. The data showed that grain was highly significant increased ($p < 0.01$) with application of M, CT, KH and recorded highest values (2.721 and 3.188MgFed^{-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 (3.713and 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 highly 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 highly significant increased and recorded highest values (2.883 and 3.280MgFed^{-1}) due to the interaction between of Si x 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 7 showed that application of molas, 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**[10-14]**, 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 **[10-19].** 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 +KH 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 -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 highly significant increased due the previous treatment as compared with control. Thesis results are superseded by **[17-18]**.Nitrogen content in grain yield of wheat was highly 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 Silica (Fig. 1.b). This results may be due to the positive effect of the molas, compost tea and potassium humate in improving the properties of the soil and increasing the availability of the nutrients, as well as the effective role of application with nano-Silica in reducing and mitigating the adverse effect of salinity on the plant growth. These results are supported to those obtained by **[7-26]**

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		**1st season**		**2nd season**	
		Grain	**Straw**	**Grain**	**Straw**
		Mgfed.$^{-1}$			
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
F_{test}		**	**	**	**
$LSD_{0.05}$		0.017	0.002	0.0016	0.0021
$LSD_{0.01}$		0.039	0.0022	0.0020	0.003
Nano-Si(B)					
tab water		2.53	3.309	2.939	3.576
nano-Si		2.60	3.514	3.145	3.981
F_{test}		**	**	**	**
$LSD_{0.05}$		0.017	0.001	0.003	0.002
$LSD_{0.01}$		0.023	0.0023	0.006	0.005
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	2.548efg	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
F_{test}		**	**	**	**
$LSD_{0.05}$		0.024	0.003	0.003	0.002
$LSD_{0.01}$		0.026	0.004	0.005	0.012

Means of each factor followed by the same letter are not significantly different at 5 % level according to Duncan's multiple range test.*indicate significant $p < 0.05$,** indicate significant $p < 0.01$ and ns indicate not significant.

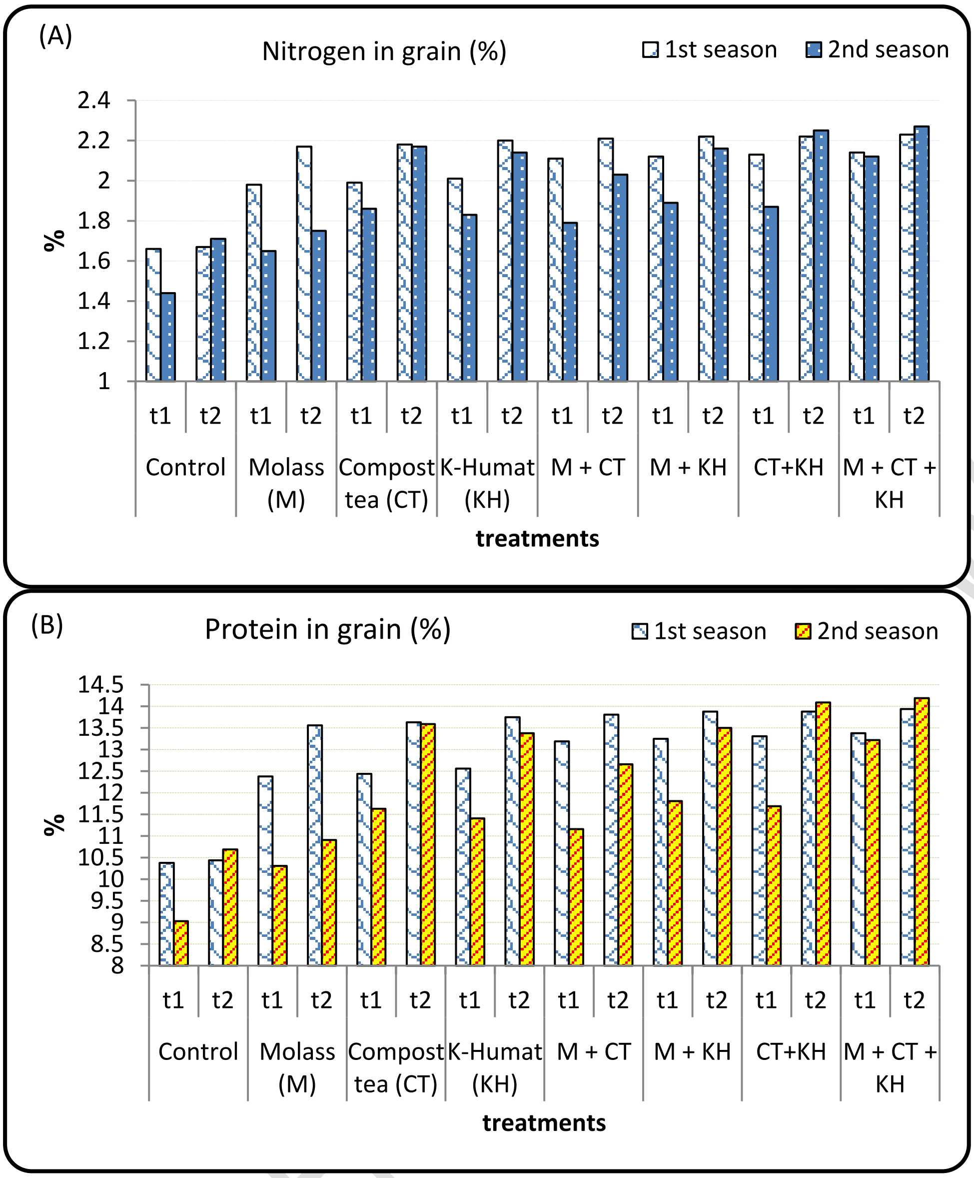

Fig.(1). Nitrogen content (%) and protein contents (%) in grain yield of wheat as affected by the interaction between soil and foliar application of nano-Si in 2017/18 and 2018/19 seasons. Notice: (t1:foliar with tab water and t2 :foliar with nano-Si)

CONCLUSIONS

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 nano-silica remained superior in terms of better yield attributes and grain yield of wheat under saline environment. But insignificant effect on the studied soil properties

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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