Environment, Biodiversity & Soil Security

http://jenvbs.journals.ekb.eg/

Effect of vinasse and foliar application of compost tea on improvement of some soil properties and yield of wheat in salt affected soil

Saher H. Rashed [1] and Said Hammad [2]

[1] *Soil Improvement and Conservation Research Dept., Soil, Water, Enviroenment Research Institute (SWERI), Agricultural Research Center*

[2] *Wheat Research Dept., Field Crop Research Institute, Agricultural Research Center*

WORLDWIDE, salinity significantly reduces the ability of soils to be used for agricultural productionespecially wheat crop. In order to improve this agricultural production process including soil properties and yield, the matter called for the use of some organic treatments, as soil additives i.e., vinasse at rates of 0, 30, 60, 90 and 120 L fed-1 (main plot), and foliar application with compost tea (60 L fed^{-1}, sub main), during seasons of 2020–2021 and 2021–2022 in field experiments at Sakha Agricultural Research Station, Kafr El Sheikh, Egypt. According to the experiment's findings, vinasse treatment (120 Lfed^{-1}), had a substantial impact on the soil's bulk density (BD), porosity (PO), cation exchange capacity (CEC), electrical conductivity (EC), exchangeable sodium percentage (ESP), and availability of N, P, and K. Also, the interaction effect between the studied treatments was still effective in terms of grain nitrogen and protein content as well as wheat production in both seasons and this was reflected significantly on wheat grain, straw, and yield characteristics. From our results, it can be concluded that the negative properties of the soil affected by salinity can be remedied through the joint application between vinasse treatment (120 Lfed^{-1}) and compost tea as a foliar application.

Keywords: Soil properties, Vinasse, Soil conservation, Wheat.

1. Introduction

In Egypt, the sugar Company and integrated industries (Hawamdyia) produce more than 2,000 cubic metersof vinasse. It represents the residues in the molasses fermentation processes. The large amount of vinasse can harm the environment, causing salinization and river Nile pollution. So, it was found useful to try to overcome the problem created by using it as soil amendments. It is composed to a large extent of water, organic matter and mineral elements. The results of such studies show that, when used correctly, vinasse contributes to the improvement of soil properties and agricultural productivity (Jiang et al., 2012;Omara et al. 2022).

The benefits of using vinasse in the agricultural system are that it can provide significant quantities of water and mineral nutrients, support soil quality and crop productivity, and finally, but no less importantly, can solve the environmental problem of the disposal of this agro-industrial residue (Prado et al. 2013).Vinasse have elevated levels of potassium, calcium and organic matter in its chemical composition as well as moderate quantities of nitrogen and other nutrients (Gloria 1985).Jiang et al. (2012) showed a significant decrease in bulk density and increase in porosity of the soils treated with vinasse, compared to the other treatments. Further, the no capillary porosity in vinasse treated soils also increased to a certain degree. Abou-Husssien et al., (2020) applied vinasse at rate 250Lfed^{-1} in sandy soil.

Application of compost tea could be economically used for production of wheat and maize under saline soil conditions (Amer et al. 2016),yield of rice (Amer et al., 2021) and maximizing productivity of cucumber (Farraga and Omara, 2022) as well as other some crops (Meshref et al, 2010; Amer et al., 2020). Productivity of wheat can be improved by successful management of soil and water, especially in salt-affected soils (estimated by 809371 ha) which

*Corresponding author e-mail:saharrashed64@gmail.com
Received: 18/01/2023;Accepted: 24/01/2023
DOI: 10.21608/JENVBS.2023.188267.1208

account for 35% of the total cultivated area in Egypt. Soil salinization is increasing globally as well as in Egypt, for many reasons including suboptimal irrigation, desertification and excessive fertilization. Worldwide, more than 800 million hectares of soil are affected by salt stress (Ramadoss et al. 2013). Salt stress can affect plants in different ways, including osmotic stress and ion homeostasis, affecting nutrient imbalance, increasing concentrations of Na^+ and Cl^-, and reducing plant growth and productivity (Shrivastava and Kumar 2015).

Salinity is one of the most brutal environmental factors limiting the productivity of crop plants (El-Ramady et al., 2022). Thus, there is an urgent need for environmentally friendly techniques to enhance growth and productivity of wheat.Irrigation of soil with vinasses, however, may induce physical, chemical and biochemical changes and affect crop yield and the recommended doses are necessary with the base of salt, phenols, organic material and cations K^+, Na^+, Ca^{++}, Mg^{++} contents. The objective of this study is to evaluate the effect of concentrated vinasse (Egyptian Sugar and Integrated Industries Company SAE) as soil amendments and compost tea as a foliar spray on physico-chemical soil properties and yield of wheat in salt affected soil of Egypt.

2. MATERIALS AND METHODS

Two field experiments were conducted on the Sakha Agricultural Research Station farm in Kafr El Sheikh, Egypt, over two winter growing seasons to study the effect of vinasse and foliar application of compost tea on some soil properties, wheat growth and its yield. The experiment was carried out in a split plot with three replicateshaving vinasse: without vinasse (V0), 30L fed^{-1} (V30), 60L fed^{-1}(V60), 90L fed^{-1} (V90) and 120L fed^{-1}(V120) treatment in main plots while sub plots had foliar application of (without compost tea (CT-) and with compost tea (CT+). The chemical composition of compost tea as shown (Table 1).Vinassewas added equally with 1^{st}irrigation and 2^{nd}irrigation via a soil application, while compost tea was added as twice at 25 and 50 days after sowing (DAS) as a foliar application(60Lfed^{-1}). Gypsum requirements (GR) were determined according to (FAO, IIASA (2000) GR was applied before soil tillage.

In the winter seasons of 2020/2021 and 2021/2022, wheat seeds (*Triticumaestivum*) were sown on November 20 and 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% P_2O_5) and Potassium as Potassium, sulphate (48% K_2O) and fertilizers at rates of 15 kg $P_2O_5$$fed^{-1}$ and 30 K_2O fed^{-1} were applied before sowing (at final tillage).

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). At maturity, each plot was harvested, and grains were separated, dried at standard moisture of 14%, weighed, and calculated as Mg fed^{-1}. In addition, the straw yield was weighted and calculated as Mg fed^{-1} (Mg=1000kg)

Plant samples were taken at harvesting stage in each season, washed with distilled water. Nitrogen (%) was determined according to Jones et al. (1991) methods. and nitrogen was estimated using micro-Kjeldahl (Peters et al., 2003). Protein in grain of wheat was calculated according to protein (%) = N% × 6.25.Potassium and sodium, were measured by a Flame photometer (Cottenie, et al. 1982).

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 (Page et al.1982). Particle size distribution of soil was measured using pipette method according to (Gee and Bauder,1986). Soil bulk density and total porosity were determined for each treatment according to (Klute1986). Field capacity and permanent wilting point were calculated from soil moisture tension curve (Black,1965).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 2020/2021 and 2021/2022 as show in Table 2.

In this study organic amendments as concentrated vinasse (V) which taken from Egyptian Sugar and Integrated Industries Company SAE, Egypt. The used V was analyzed for some physical and chemical characters as well as its content of essential of plant nutrients according to the methods described by Klute (1986) and Page et al. (1982) and the obtained data are recorded in Table 3.

Table 1. Some Chemical and physical characteristics of the soil investigation.

Chemical characteristics of the soil investigation.									
Soil depth (cm)	pH	EC (dSm^{-1})	ESP (%)	CEC ($cmol_c\ kg^{-1}$)	OM %	$CaCO_3$ %	N $mg\ kg^{-1}$	P $mg\ kg^{-1}$	K $mg\ kg^{-1}$
0-20	8.01	6.30	13.05	39.46	1.87	2.97	34	11.5	295
20-40	8.03	6.85	14.14	38.21	1.52	2.86	31	9.6	281
40-60	8.05	7.68	15.24	37.18	1.41	2.33	27	8.4	274

Physical characteristics of the experimental soil									
Soil depth cm	Soil moisture characteristics			Bd	Total porosity	Particle size distribution			Soil texture
	FC	WP	AW	($kg\ m^{-3}$)	(%)	Sand	Silt	Clay	
		%					%		
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 (dSm^{-1})	NO_3	NH_4	P	K	Ca	Mg	Na	Fe	Mn	Zn
			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 2020/2021 and 2021/2022

Season	Month	T (C°)			RH (%)	WV km day^{-1}	PE (cm day^{-1})	Rain (mm)
		Max.	Min.	Mean				
2020/2021	**Nov.**	25.0	17.50	21.25	71.80	46.9	2.28	12.35
	Dec.	22.90	13.70	18.3	71.70	44.9	2.49	18.78
	Jan.	21.0	13.5	17.25	73.10	39.2	2.57	14.05
	Feb.	21.50	12.5	15.74	71.7	58.30	2.57	0.0
	Mars	23.8	12.50	18.15	66.8	83.40	3.56	5.4
	April	27.60	19.4	23.5	60.2	95.0	4.48	0.0
2021/2022	**Nov.**	26.63	18.84	22.74	72.15	66.33	4.19	12.70
	Dec.	20.58	12.21	16.40	74.48	62.35	4.00	20.7
	Jan.	17.82	9.88	13.85	75.47	62.35	3.91	50.35
	Feb.	19.3	10.76	15.03	70.77	81.32	3.54	25.25
	Mars	19.17	11.15	15.16	69.00	98.45	3.91	5.25
	April	27.64	19.75	23.69	60.95	138.69	5.45	0.0

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.

Table 3.Physical and chemical properties of vinasse (V).

Item	Units	Values
pH		4.1
Specific weight	g L^{-1}	1.11
Total dissolved solids (TDS)		20146.0
Dry matter	%	24.31
Total OC %		31.10
C:N Ratio		1:12.95
OM %		53.30
Ash		25.10
Reducing sugars		4.25
N		2.40
Total Ca		3.15
Total Mg		1.25
Total P		0.37
Total K		6.81
Total Mn	ppm	4.75
Total Fe		45.12
Total Zn		1.25

Statistical analyses

The data collected have been subjected to statistical analysis, the technique of variance analysis (ANOVA) in a split-plot design according. **(**Gomez and Gomez 1984)**.**Treatment averages were compared using the least significant differences (LSDs) at 5% and 1% in determining the level of significance.

3. Results and discussion

3.1 Soil chemical properties

The effect of different level of vinasse (V) on soil chemical properties are presented in (Fig.1). 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 byvinasse as soil amendments under different level of vinasse

The same data showed that soil salinity (Ece) was highly significant decreased with application of vinasse and recorded lowest values (4.65 and 4.21dSm^{-1}) for 1st season and 2nd season with application of V120 and foliar application of compost tea. Also, ESP took the same trend and recorded lowest values (10.15 and 10.11%) 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 (Amer et al., 2020 and Gaafar et al., 2019). Fig.(1) pointed out that CEC significantly ($P \leq 0.01$) increased with increasing application of vinasseand recorded highest values with V120.The combined effect of V120 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 vinasse on increasing the specific surface and thus increasing soil exchangeable capacity.

EC and ESP were non- significant ($P \leq 0.05$) with foliar application of compost tea as compared without application during two growing seasons. Fig. (1), pointed out that EC was significant decreased and recorded lowest values (10.15 and 10.11dSm^{-1}) for 1st season and 2nd season due to the interaction between V * CT. In the other hand ESP was non-significant affect due to the interaction between A*B. Also, CEC wassignificant decreased ($P \leq 0.01$) and recorded highest values (38.41 and 38.26 cmolckg^{-1}) for 1st season and 2nd season due to the interaction between V * CT.

3.2 Soil physical properties

Remarkable reduction in the soil bulk density (Bd) was observed with different levels application of the vinasse and foliar application of compost tea (Fig.2). 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 levels of vinasse as soil amendments significantly decreased Bd, the application of V120 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 2, showed that total porosity (%) which was significantly increased with increasing level application of vinasse and the highest values were recorded with application 120 liter of vinasse. Also, the data revealed that foliar application of compost tea had no significant effect on the soil porosity (Fig.2).

This may be reflected the role of the vinasse as soil 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 (Amer et al., 2020 and Gaafar et al., 2019) 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 V120 and CT+. These results were supported by (Jiang et al., 2012 and Omara et al., 2022).

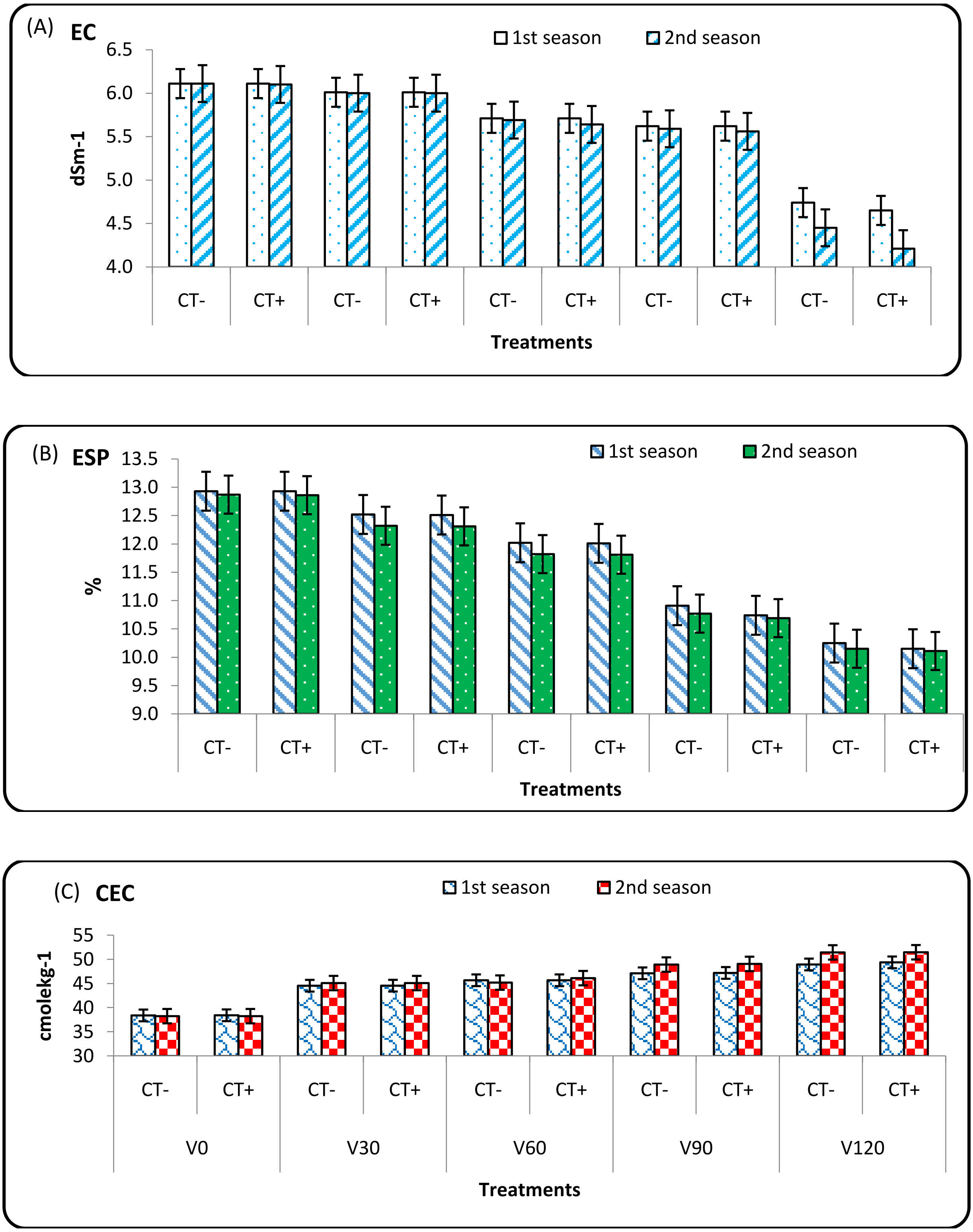

Fig. 1. Mean values of EC (dsm^{-1}), Exchangeable sodium percentage (ESP %) and Cation Exchange capacity (cmol$_c$kg^{-1}) as affected by thesoil application of vinasse (V) and foliar of compost teain 2020/2021 and 2021/2022seasons.

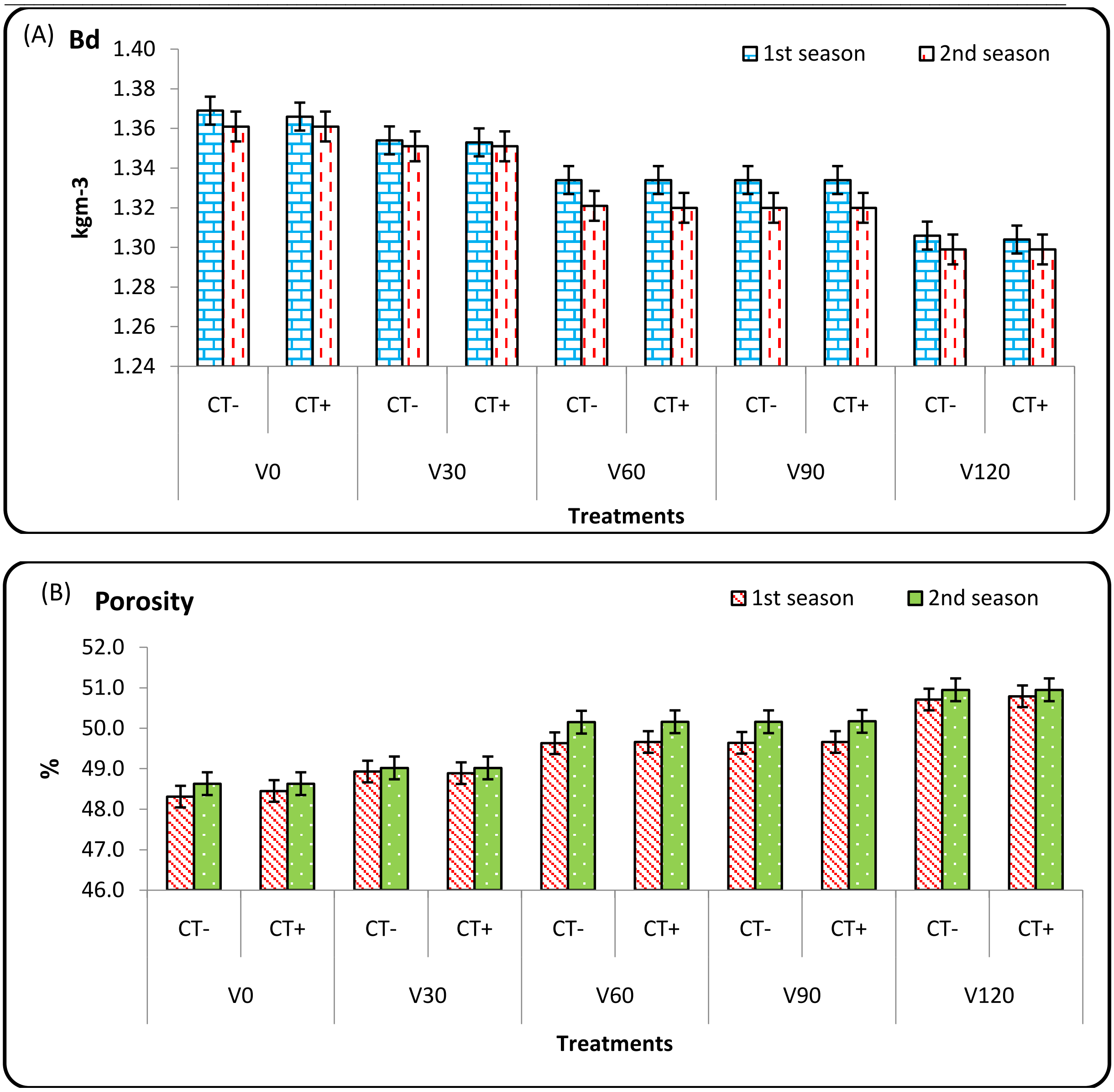

Fig. 2.Mean values of bulk density (kgm^{-3}) and soil porosity (%) as affected by the soil application of vinasse (V) and foliar of compost tea in 2020/2021 and 2021/2022 seasons.

3.3. Soil fertility

The data in Fig.3 showed that available of Nitrogen was significant increased with application of vinasse as soil amendments and recorded highest values (42.74 and 43.42mgkg^{-1}) for 1st season and 2nd season with increasing level of vinasse up to 120L/fed. Also Available of 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 available of K was increased with increasing of vinasse and recorded highest values up to 120L/fed. The same data showed that N, P and K were non- significantly affected with foliar of compost tea as compared without treatment.

Fig.3 Showed that the Nitrogen was highly significant increased with increasing application of vinasse and recorded highest values (42.96 and 43.70) due to the interaction between of V* CT for both of two growing seasons. Where both of Phosphorus and Potassium was significant increased due to the same previous treatment and recorded highest values due to the interaction between of V and CT. Fig.3 Showed that the effect of level of vinasse on soil available of N, P and K. The results revealed that the N, P and K were highly significantly ($P \leq 0.01$) influenced by different level of vinasse as soil amendments. These results were supported by (Gloria 1985 and Prado et al., 2013).

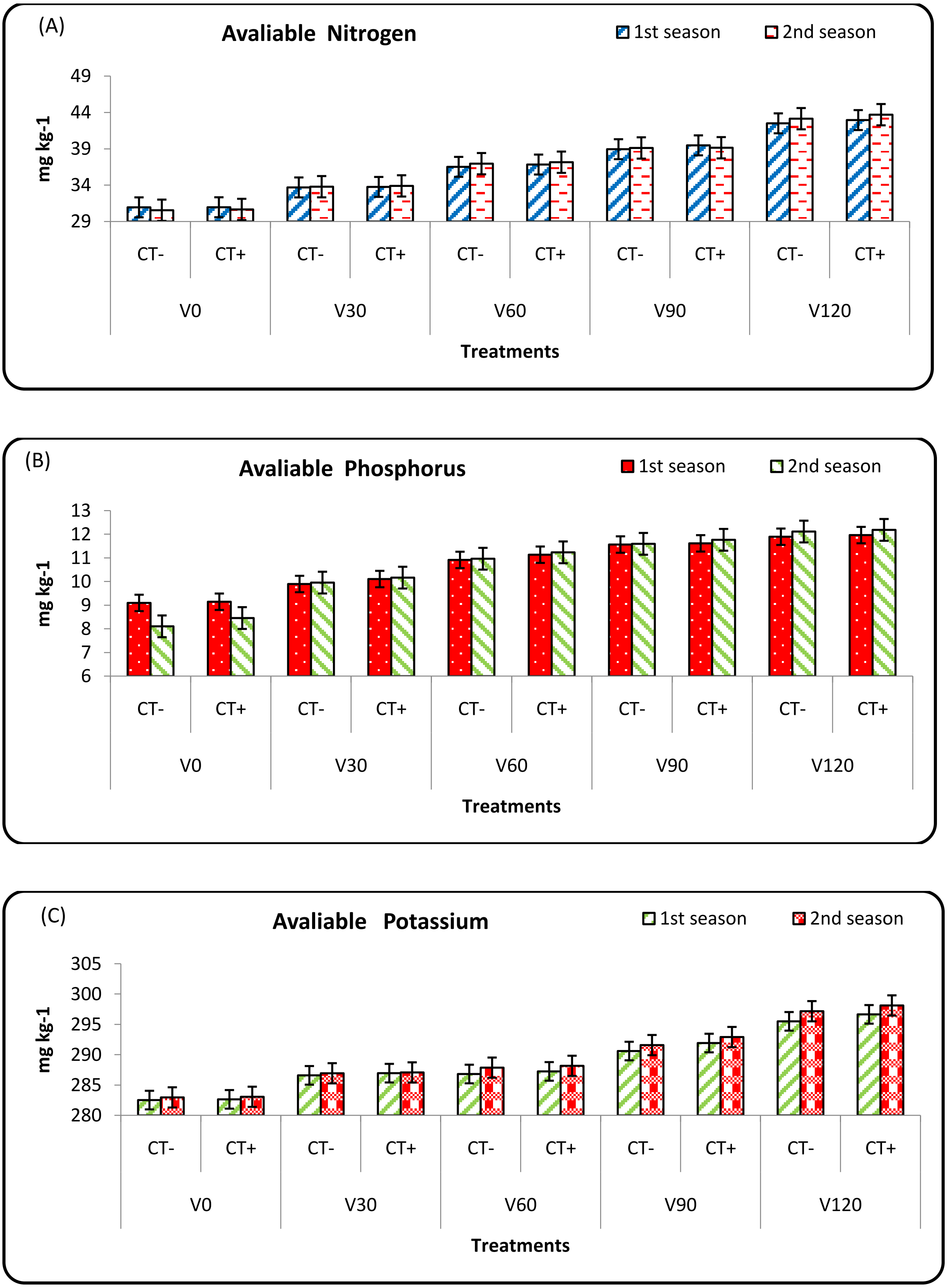

Fig. 3.Mean values soil available of Nitrogen, Phosphorus and Potassium (mgkg^{-1}) as affected by soil application of vinasse (V) and foliar of compost tea in 2020/2021 and 2021/2022 seasons.

3.4. Growth attributes

The data illustrated in Table 4 indicated that the flag leaf area (cm^2), chlorophyll and1000-GW (g) of wheat were increased highly significant ($p < 0.01$) by vinasse additions. The data showed that flag leaf area (cm^2) was highly significant increased ($p < 0.01$) with application of vinasse and recorded highest values (37.17 and 39.28 cm^2) for 1st season and 2^{nd} season with increasing application of vinasse up to V120. 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 V120. The foliar application of compost tea also highly significantly ($p < 0.01$) increased 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 compost tea, thereby improving the tolerance of plants to abiotic stress. These results are supported by (Meshref et al., 2010).

Table 4 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 V*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 V and CT.Data in Table 5 pointed out that K^+ and K^+/Na^+ percentage in the leaves of wheat at 70 days post seed sowing during two growing seasons were highly significant increased with application of vinasse up to V120 and recorded highest values due to the interaction between V120and CT+

3.5. Grain and straw yield of wheat

The data illustrated in Table6indicated that the grain and straw yield of wheat were highly significantly ($p < 0.01$) increased by vinasse as soil amendments. The data showed that grain was highly significant increased ($p < 0.01$) with application of vinasse and recorded highest values (2.721 and 3.188 Mg Fed^{-1}) for 1st season and 2^{nd} season with increasing level of vinasse up to 120L/fed. Also, straw yield of wheat took the same trend and recorded highest values (3.713 and 4.178 Mg Fed^{-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 2^{nd} season with foliar application of compost tea (60L fed^{-1}). Also, the straw yield of wheat was highly significantly increased up to (3.514 and 3.981 Mg Fed^{-1}) for both of two growing seasons with foliar application of compost tea.

Table 6 showed that grain yield of wheat was highly significant increased and recorded highest values (2.883 and 3.280Mg Fed^{-1}) due to the interaction between of V*CT for both of two growing seasons. Where straw yield of wheat took the same trend and recorded (3.850 and 4.391 Mg Fed^{-1}) Table 6 showed that application of different level of vinasse, had significant effect on 1000-grain weight along with grain and straw yields of wheat. The highest values were recorded for V120 while, the lowest values were obtained from the control treatment. Similar results were obtained by (Abou-Husssien et al., 2020).Also, data presented in Table 6 show that the weight of 1000-grain, grain and straw yield of wheat were affected significantly using foliar application of compost tea in both seasons. The highest values of 1000-grain weight, grain and straw yield of wheat were obtained by the foliar spraying of compost tea compared with the other treatments. These results are compatible with those observed by (Meshref et al., 2010 and Amer, 2016).The interaction effect between vinasse as soil amendments treatment and foliar spraying of compost tea showed highly significance according to the grain and straw yield of wheat during the two growing seasons and the highest values were recorded with treatment of V120 combined with CT application. These results were supported byGaafar et al.(2019). 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.

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

Data in Fig. (3.a) Nitrogen content in grain yield of wheat was significant increased by application of different level of vinasse 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 V120. With regard to the treatment of foliar CT, nitrogen content in grain yield of wheat was significant increased due the previous treatment as compared with control. Thesis results are superseded by Gaafar et al., (2019).Nitrogen content in grain yield of wheat was significant increased (2.23 and 2.27%) due to the interaction between

V120 and CT. 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 V120 and CT(Fig. 3.b).These results may be due to the positive effect of the vinasse in improving the properties of the soil and increasing the availability of thenutrients, as well as the effective role of spraying with CT in reducing and mitigating the adverse effect of salinity on the plant growth. These results are supported by (Gaafar et al.2019).

Table 4. Mean values of flag leaf area, total chlorophyll content (SPAD) and1000-GW (g) as affected by soil application of vinasse (V) and foliar of compost tea and its interaction in2020/2021 and 2021/2022 seasons.

Treatments		1st season			2nd season		
		leaf area (cm^2)	Chlorophyll	1000-GW(g)	leaf area (cm^2)	Chlorophyll	1000-GW(g)
Vinasse ((A)							
V0		30.62e	32.88e	40.54e	30.18e	33.17e	41.27e
V30		32.28d	34.85d	40.72d	33.10d	34.94d	41.52d
V60		35.04c	35.97c	41.48c	36.08c	36.30c	41.89c
V90		35.61b	36.20b	41.48b	36.78b	36.52b	41.97b
V120		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
$LSD_{0.01}$		0.024	0.015	0.010	0.028	0.011	0.020
Compost tea (B)							
CT-		32.87	35.15	40.70	33.73	35.32	41.22
CT+		35.90	36.44	41.85	37.15	36.77	42.40
F_{test}		**	**	**	**	**	**
$LSD_{0.05}$		0.003	0.008	0.009	0.006	0.014	0.009
$LSD_{0.01}$		0.005	0.010	0.010	0.008	0.016	0.010
Interaction(A x B)							
V0	**CT-**	30.09j	31.51i	40.22j	30.15j	31.68j	41.10i
	CT+	31.15i	34.25g	40.87h	30.22i	34.66i	41.45e
V30	**CT-**	31.92h	33.61h	40.27i	31.11h	33.68h	41.11i
	CT+	32.64g	36.1d	41.17d	35.09f	36.20e	41.92d
V60	**CT-**	33.15f	35.83e	40.88f	34.13g	35.96f	41.23h
	CT+	36.93c	36.11d	41.85c	38.03c	36.64d	42.56c
V90	**CT-**	33.64e	34.61f	40.90e	35.15e	34.79g	41.28f
	CT+	37.58b	37.79b	42.06b	38.42b	38.25b	42.66b
V120	**CT-**	34.88d	37.61c	41.02g	37.47d	37.69c	41.41g
	CT+	39.46a	41.13a	42.88a	41.08a	41.58a	43.19a
F_{test}		**	**	**	**	**	**
$LSD_{0.05}$		0.015	0.018	0.011	0.032	0.012	0.034
$LSD_{0.01}$		0.018	0.020	0.014	0.034	0.015	0.036

V0: without vinasse, V30: 30L fed^{-1}, V60: 60L fed^{-1}, V90:90L fed^{-1} and V120:120L fed^{-1}, CT-: without compost and CT+ foliar application of compost.

Means of the same growing season designated with different letters indicate significant differences among treatments according to the Duncan's test (P<0.01).

Table 5. Effect of vinasse as soil amendments, foliar application of compost tea, and their interaction on Na^+, K^+ and K^+/Na^+ percentage in the leaves of wheat at 70 days post seed sowing during two growing season 2020/2021 and 2021/2022.

Treatments		1st season			2nd season		
		K%	Na%	K/Na	K%	Na%	K/Na
Vinasse (**(A)**							
V0		2.68e	2.41a	1.11e	2.69e	2.40a	1.12e
V30		2.83d	2.39b	1.19d	2.84d	2.38b	1.20d
V60		2.88c	2.37c	1.22c	2.88c	2.3c6	1.22c
V90		2.92b	2.29d	1.28b	2.92b	2.27d	1.29b
V120		2.96a	2.20e	1.35a	2.96a	2.18e	1.36a
F_{test}		**	**	**	**	**	**
Compost tea (B)							
CT-		2.82	2.36	1.20	2.82	2.35	1.20
CT+		2.88	2.30	1.26	2.89	2.28	1.27
F_{test}		**	**	**	**	**	**
Interaction (A x B)							
V0	**CT-**	2.67f	2.41a	1.11i	2.68i	2.40a	1.12i
	CT+	2.68f	2.40b	1.12h	2.69h	2.39b	1.13h
V30	**CT-**	2.81e	2.39c	1.18g	2.82g	2.38c	1.18g
	CT+	2.85d	2.38d	1.20f	2.86f	2.37cd	1.21f
V60	**CT-**	2.86d	2.38d	1.20f	2.86f	2.37cd	1.21f
	CT+	2.89c	2.35e	1.23d	2.90c	2.34ef	1.24d
V90	**CT-**	2.88c	2.36f	1.22e	2.88d	2.35e	1.23e
	CT+	2.95b	2.21g	1.33b	2.96b	2.19h	1.35b
V120	**CT-**	2.88c	2.25h	1.28c	2.87e	2.23g	1.29c
	CT+	3.04a	2.15i	1.41a	3.05a	2.12i	1.44a
F. Test		**	**	**	**	**	**

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 $p < 0.05$, $P<0.01$ and not significant. Vinasse: V0: without vinasse, V30: 30 L fed^{-1}, V60: 60 L fed^{-1}, V90:90 L fed^{-1} and V120: 120 L fed^{-1}, CT-: without compost and CT+ foliar application of compost CT, N, nitrogen; Na^+, sodium; K^+, potassium; K^+/Na^+, potassium/sodium ratio.

Table 6. Grain and straw yield of wheat as affected by soil application of vinasse (V) and foliar of compost tea and its interaction in2020/2021 and 2021/2022seasons.

Treatments		1st season		2nd season	
		Grain	Straw	Grain	Straw
		Mgfed^{-1}			
Vinasse (A)					
V0		2.495d	2.809e	2.703e	3.142e
V30		2.523c	3.182d	2.990d	3.488d
V60		2.566b	3.442c	3.157b	4.115b
V90		2.577b	3.859a	3.144c	4.047c
V120		2.721a	3.713b	3.188a	4.178a
F_{test}		**	**	**	**
$LSD_{0.05}$		0.017	0.002	0.0016	0.0021
$LSD_{0.01}$		0.019	0.004	0.0019	0.0024
Compost tea (B)					
CT-		2.53	3.309	2.939	3.576
CT+		2.60	3.514	3.145	3.981
F_{test}		**	**	**	**
$LSD_{0.05}$		0.017	0.001	0.003	0.002
$LSD_{0.01}$		0.019	0.003	0.005	0.004
Interaction(A x B)					
V0	**CT-**	2.476h	2.759j	2.693h	2.841j
	CT^+	2.514g	2.859i	2.713g	3.444i
V30	**CT-**	2.518g	3.171h	2.811f	3.440h
	CT^+	2.529fg	3.194g	3.170c	3.537g
V60	**CT-**	2.558de	3.424f	3.034e	3.774e
	CT^+	2.596b	3.460e	3.281a	4.456a
V90	**CT-**	2.554de	3.610c	3.033e	3.747f
	CT^+	2.578c	4.108a	3.256b	4.347c
V120	**CT-**	2.560d	3.577d	3.096d	3.966d
	CT^+	2.883a	3.850b	3.280a	4.391b
F_{test}		**	**	**	**
$LSD_{0.05}$		0.024	0.003	0.003	0.002
$LSD_{0.01}$		0.026	0.005	0.004	0.004

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 $p < 0.05$, $P<0.01$ and not significant.

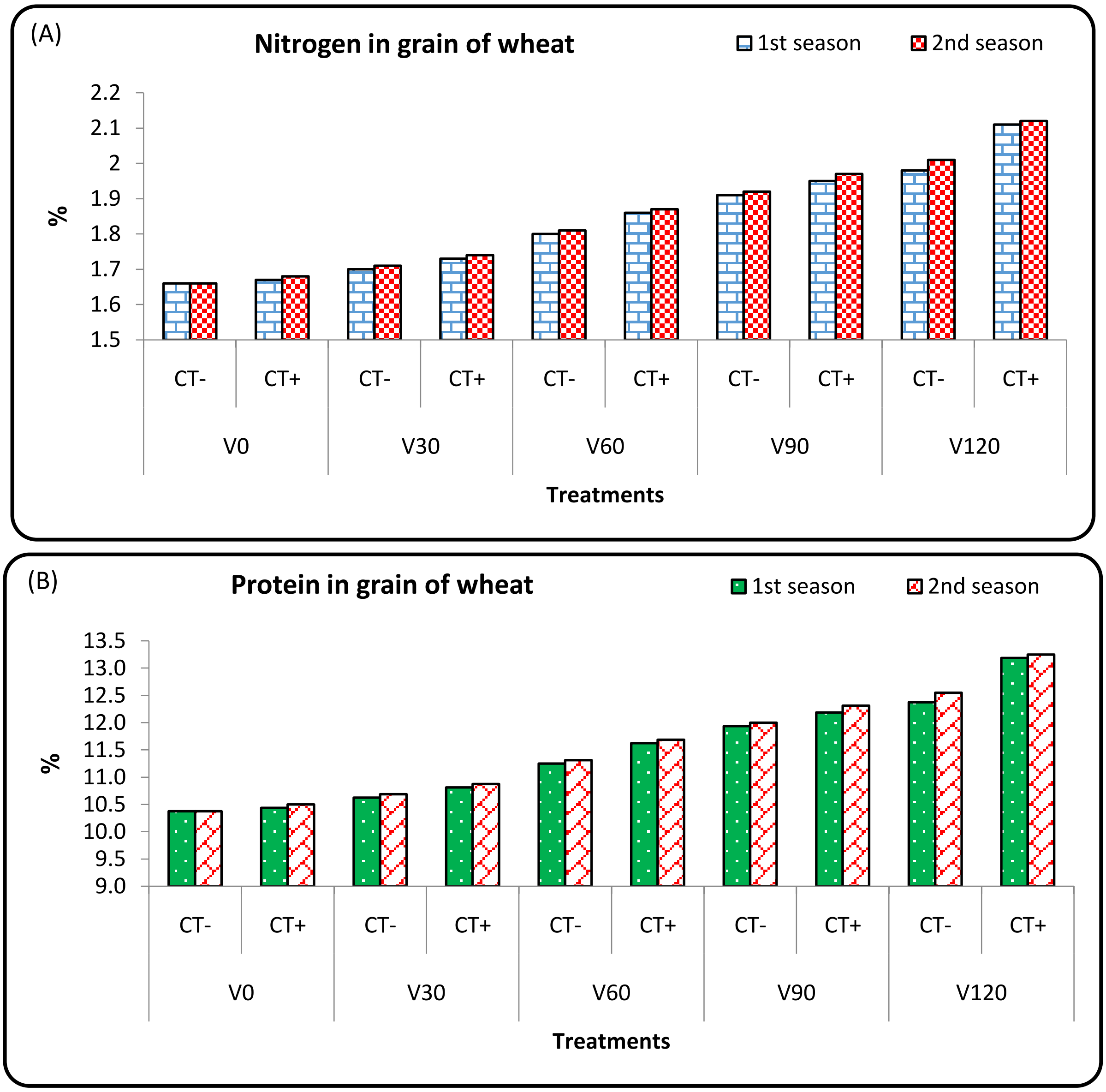

Fig. 3. Nitrogen content (%) and protein contents (%) in grain yield of wheat as affected by the interaction between vinasse as soil amendments and foliar application of compost tea (CT) in 2020/21 and 2021/22 seasons. Notice: (CT-: foliar with tab water and CT+:foliar with CT).

Conclusions

Our results were in line with the postulated hypothesis as optimized dose application of vinasse (V120) 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 compost tea(60Lfed^{-1}) remained superior in terms of better yield attributes and grain yield of wheat under saline environment for alleviating the adverse effects of salinity on wheat crop under changing climate.

Ethics approval and consent to participate:

This article does not contain any studies with human participants or animals performed by any of the authors.

Consent for publication:

All authors declare their consent for publication.

Conflicts of Interest:

The authors declare no conflicts of interest.

Contribution of Authors:

All authors shared in writing, editing, revising, and approving the manuscript for publication.

References

Abou-Husssien EA., El-Zemrany HM., Hammad MB. (2020). Effect of Vinasses, Molasses and Mineral Fertilization on Nodulation and Growth of Common Bean (Phaseolus Vulgaris L.) Grown in Sandy Reclaimed Soils. Menoufia J. Soil Sci., Vol. 5: 1 – 17

Amer MM. (2016) Effect of Biochar, Compost Tea and Magnetic Iron Ore Application on some Soil Properties and Productivity of Some Field Crops under Saline

Soils Conditions at North Nile Delta. Egypt. J. Soil Sci.Vol.56, No.1, pp.169-186

Amer MM., Aabd-Allah YA. M., Kasem AA., Omara A. El-Dein (2021). Saline-Sodic Soils Treated with Some Soil Amendments and Foliar Application with Compost Tea and Proline for Improvement Some Soil Properties and Yield-Water Productivity of Rice. International Journal of Plant & Soil Science 33(1): 1-15DOI: 10.9734/IJPSS/2021/v33i130402

Amer MM., Gazia EAE., Aboelsoud HM., Rashed SH(2020) Management of Irrigation Water and Organic Matter Application Contribution in Improving Some Soil Properties and Yields – Water Productivity of Sugar Beet and Cotton in Salt Affected Soil. Env. Biodiv. Soil Security, 4, 7 – 18.DOI: 10.21608/jenvbs.2020.24121.1082

Black, CA. (1965).Methods of soil analysis. Amer. Soc.Agro. Inc., Madison, Wisconsin, U.S.A.

Cottenie, A., Verloo, M., Kiekens, L., Velghe, G., Camerlynck, R. (1982). Chemical Analysis of Plants and Soils; Laboratory of Analytical and Agrochemistry, State University: Ghent, Belgium, pp. 14–24.

El-Ramady H., Faizy SE-D, Amer MM, Elsakhawy T., Omara A, Eid Y, Eric C. Brevik (2022). Management of Salt-Affected Soils: A Photographic Mini-Review. Env. Biodiv. Soil Security, Vol. 6, pp: 61 – 79.DOI: 10.21608/jenvbs.2022.131286.1172

FAO, IIASA (2000). Diagnosis and Improvement of Saline and Alkali Soils, USDA Handbook No 60, U.S. Salinity Lab. Staff (1954), Washington.

Farraga DK., Omara A (2022) Productivity Maximizing of Cucumber (*Cucumissativus* L.) Through Optimized Use of compost and compost tea under Different rates of Mineral Fertilizers. Env. Biodiv. Soil Security, Vol. 6, pp: 181 - 189. DOI: 10.21608/JENVBS.2022.145574.1179

Gaafar S. Mona, NMM. EL-Shimi, Helmy MM. (2019).Effect Of Foliar And Soil Application Of Some Residuals Of Sugar Cane Products (Molasses And Vinasses) With Mineral Fertilizer Levels On Growth, Yield And Quality Of Sweet Pepper. Menoufia J. Plant Prod. (4): 353 – 373

Gee, GW., Bauder JW. (1986) Particle-size Analysis. P. 383 - 411. In A.L. Page (ed.). Methods of soil analysis, Part 1, physical and mineralogical methods.DOI: 10.12691/env-3-5-3

Gloria, N. (1985). Environmental aspects in ethanol production related to vinasse disposal and groundwater, 31. Piracicaba: ESALQ

Gomez, KA., Gomez AA. (1984) Statistical procedures for agricultural research, 2ndedition.John Wiley and Sons, New York, 680.

Jiang Ze-Pu, Yang-Rui Li, Guang-Po Wei, Qing Liao, Tian-Ming Su, Yan-Cheng Meng, Hai-Ying Zhang, Chang-Yan Lu (2012). Effect of Long-Term Vinasse Application on Physico-chemical Properties of Sugarcane Field Soils. Sugar Tech 14(4):412–417.DOI 10.1007/s12355-012-0174-9

Jones, J., Wolf, BJB., Mills, HA. (1991). A practical sampling, preparation, analysis, and interpretative guide. In Plant Analysis Handbook; Micro-Macro Publishing: Athens, Greece.

Klute, A. (1986) Methods of Soil Analysis, Part 1, Physical and Mineralogical properties, Amer., Society, Agronomy, Monograph 9, 2nd ed. Madison, Wisc., USA.

Meshref, HA., Rabie MH., El-Ghamry AM., A. El-Agamy M.(2010). Maximizing utilization of compost addition using foliar compost extract and humic substances in alluvial soil. J. Soil. Sci. and Agric. Engineering. Mansoura. Univ.2010, 1 (9): 957- 971.

Omara A. El-Dein, Aiad M., Abo-Elela EG., El-Ramady H, Amer MM (2022). Significant Use of Molasses and Foliar Application of $Ca(NO_3)_2$ on Improving of Some Soil Properties and Yield of Rice under Salt Affected Soils. Env. Biodiv. Soil Security, Vol. 6, pp: 285 – 297.DOI: 10.21608/JENVBS.2022.170499.1197

Page, AL., Miller RH., Keeny DR(1982). Methods of Soil Analysis II. Chemical and Microbiological Properties. Soil Sci. Soc. Amer. Madison, Wisconsin.

Peters, J., Combs, S., Hoskins, B., Jarman, J., Kovar, J., Watson, M., Wolf, A., Wolf, N. (2003).

Recommended Methods of Manure Analysis; University of Wisconsin CooperativePrado, RDM., G. Caione, Campos CNS. (2013). Filter cake and vinasse as fertilizers contributing to conservation agriculture. Applied and Environmental Soil Science. https://doi.org/10.1155/2013/581984 article ID 581984, 8p

Ramadoss, D., Lakkineni, VK., Bose, P., Ali, S., Annapurna, K. (2013). Mitigation of salt stress in wheat seedlings by halotolerant bacteria isolated from saline habitats, Springer plus;2:6.

Shrivastava, P., Kumar, R. (2015). Soil salinity: A serious environmental issue and plant growth promoting bacteria as one of the tools for its alleviation. Saudi J. Biol. Sci., 22, 123–131, doi:10.1016/j.sjbs.2014.12.001.