



SOIL SCIENCES

ASSESSING THE EFFECT OF COMPOST ON WHEAT UNDER SALINITY STRESS IN CLIMATIC ZONES OF VEHARI AND BAHAWALPUR PUNJAB PAKISTAN

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ABSTRACT

The study aimed to monitor the effect of diverse ratios of compost on physiological and biochemical responses of wheat grown under salinity stress. A field trial was conducted at farmer's field under natural saline soils in Chak No. 190 WB Vehari (3000'59"N, 7201'20" E) and Chak 6/BC Bahawalpur. The trial was organized in a completely randomized block design. There were two salinity levels with and without the addition of compost @ 10 and 20 t/ha. The two wheat varieties were tested in Faisalabad-2008 as tolerant while Sehar-2006 as sensitive. At harvest after 4 months, different parameters were recorded like shoot dry and fresh weight, relative water contents, membrane stability index, chlorophyll contents, potassium, sodium, nitrogen, phosphorous and biochemicals like SOD, POD and CAT from plant biomass. The data was analyzed using (Statistic 8.1) software. The experimental results indicated that the Faisalabad-2008 achieved the highest performance when cultivated in Vehari under challenging conditions of salinity stress in contrast Bahawalpur. The application of compost @ 20 tons per hectare further enhanced the growth and productivity. Sehar-2006 varieties showed significantly lower performance under the same conditions. This suggests that Faisalabad-2008 is more resilient and better suited for environments with high salinity, especially when supported with organic amendments like compost. These findings are very important for farmers in salinity-affected regions, as they highlight which crop variety and soil management practices are most effective for improving yields.

KEYWORDS: *Triticum aestivum*; compost; salinity; ionic parameters; biochemical parameters



INTRODUCTION

Salinity stress poses a important threat to agricultural output in arid and semiarid regions worldwide (Hussain *et al.*, 2010). This challenges are particularly prominent in Pakistan, where salinity, coupled with drought, creates adverse conditions for cropping system. Salts deposited in irrigation water, along with weathering and acid precipitation, contribute to increased salinity levels, affecting crop growth rates and production (Saifullah *et al.*, 2018). The impact of salt stress extends beyond agriculture, posing a major threat to environmental sustainability and public health by reducing crop output and restricting cropland utilization (Rolly *et al.*, 2020). Approximately 6% of the globally lands are saline, and currently, 20% of flooded lands face salt-related issues (Chen *et al.*, 2017). Some studies have reported abiotic stresses that can render plant growth and yield up to 50%, such as water stress and salt stress

(Hayat *et al.*, 2020). Soil salinization is a detrimental abiotic factor that affects about 800 mha of land globally (Munns and Tester, 2008). Around 20% of the world's cultivated area and 45 mha of irrigated area is salt pretentious worldwide and foundations a loss of US \$27.3 billion per year (Anschütz *et al.*, 2014). According to reports, the salt-affected area is increasing at 10% annually, and 50% of arable land will be converted to salt-affected by 2050 (Jamil *et al.*, 2011). The geographical area of Pakistan accounts for 80.5 m ha, out of which 20.36 m ha are under agricultural practices. According to (FAO, 2020), 10 m ha out of 20.36 m ha of agricultural land is affected by salinity or sodicity.

Soil salinity measures the concentration of soluble salts in soil water and is usually expressed as electrical conductivity (EC) (Mouhamad *et al.*, 2017). For 10,000 years, agricultural communities have been declining due to soil salinity, which is the second largest source

of land degradation after soil erosion (Muhammad *et al.*, 2018). More than 20% of agricultural land is already impacted by salinity, which is growing daily and already affecting almost 954 mha of the world's total land area. This is only one of the many abiotic stressors that pose a serious danger to agriculture. Around 831 million hectares of land are impacted by salt worldwide, of which, 397 million hectares are made up of saline soils and 434 million hectares are made up of sodic soil (Hasan uz zaman *et al.*, 2014). About 4.5 million hectares of Punjab, Pakistan, are damaged by salt (Aslam *et al.*, 2016). Plant growth is inhibited as a result, lowering crop output. Salinity affects plant development and decreases the absorption of vital minerals like calcium (Ca^{+2}) and potassium (K^{+}) due to the toxicity of Na^{+} . The photosynthetic system is harmed by osmotic and ionic stressors brought on by excessive salt concentrations. For instance, physiology shuts down the stomata and slows down the rate of leaf growth. (Carden *et al.*, 2013). The osmotic and ionic effects of salt stress (NaCl and/or Na_2SO_4) are the two key components. Because of its higher pH, salt stress (NaHCO_3 and/or Na_2CO_3) can impede ion uptake and alter plant cell equilibrium, causing more serious damage to plants than saline stress with a neutral pH (Zhang *et al.*, 2016).

Wheat (*Triticum aestivum* L.) belongs to the family Poaceae, and is considered the king of cereal crops. Generally called Granum and has been the primary source of food since ancient times. It is the capital source of staple food not only in Pakistan but also worldwide (Afridi *et al.*, 2018). In Pakistan, it gains an incredible place during the construction of its agriculture strategy. It is the second most growing crop after corn. Wheat crop is also a significant source of carbohydrates and protein. 40% of the land area is used for wheat cultivation in Pakistan (Shahzad *et al.*, 2014). Wheat contributes about 1.7% to gross domestic product and 1.9% to value-added in agriculture in Pakistan (ESP, 2017–2018). Wheat is grown on 6.97 million hectares of land in Punjab, Pakistan, accounting for 75% of total wheat production. Wheat has potential to grow in salt affected soil with amendments.

Treatment plan

The following treatment plant was applied. All the treatments and genotypes were replicated three times.

Vehari	Bahawalpur
T_1 = Control	T_1 = Control
T_2 = EC 6.46 d Sm^{-1} + Compost 10 tons/ha	T_2 = EC 7.23 d Sm^{-1} + Compost 10 tons/ha
T_3 = EC 6.46 d Sm^{-1} + Compost 20 tons/ha	T_3 = EC 7.23 d Sm^{-1} + Compost 20 tons/ha

It is grown on 1.15 million acres in Sindh, 12% of the total. KPK is grown on 0.73 million hectares, which are 8% of the total, and Baluchistan with 0.38 million hectares (4 percent of Pakistan's total wheat production) set aside for wheat production (Haider *et al.*, 2019). Wheat was grown on 8.73 million hectares in 2017–2018, yielding 25.50 million tons of grain with an ordinary yield of 2920 kg ha⁻¹ in Pakistan (Public Broadcasting Service, 2017–2018). Nonetheless, our national outcomes persist far below even in other countries such as the United States, China, and India (Ahmed, 2015). Late planting, weed infestation, water stress, imbalanced fertilizer use, and disease epidemics are major causes of low average yield (Hussain *et al.*, 2016). The objectives of the study are to assess the impact of compost on the growth and yield of wheat developed under salt stress conditions.

MATERIALS AND METHODS

Experimental site description: A field experiment was conducted at a farmer's field under natural saline soils in Vehari Chak No. 190 WB (3000'59"N, 7201'20"E) and Bahawalpur Chak 6/BC.

Seed source: There were 2 genotypes of wheat including Sehar-2006 and Faisalabad-2008. The seeds were collected from Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan.

Experimental outline: The field of this study was to examine the potential benefits of compost on the growth, physiology, biochemical and chemical properties of wheat cultivated in saline fields with deficit irrigations. The wheat crop was evaluated for physiological, morphological, biochemical, and chemical attributes in saline conditions, following a pre-analysis of the soil before experimentation. A randomized complete block design (RCBD) was used for the experiment with three replications and normal irrigation frequencies were applied, with no organic amendment in the control group, 4 irrigations along with 10 tons/ha of compost, and 4 irrigations with 20 tons/ha of compost after crop germination using a split-plot design. After soil preparation, the whole plot was uniformly watered, and wheat seeds were drilled at the field capacity level.

The wheat crop was sown on November 10 and 11, 2022, at both the locations, Vehari and Bahawalpur. All other suggested fertilizers (recommended) and cultural practices were followed.

The best-performing organic amendment (Compost) was made from a mix of “browns” and “greens.” Browns include materials like dry straw, leaves, and shredded paper, while greens include grass clippings, food scraps, and fresh leaves.

Soil analysis: Pre- sowing soil analysis is given in Table 1. The underground tubewell water was used in the experiment and it was analyzed by procedures described by U.S Salinity Lab. Staff (1954) Table 2.

Wheat crop harvesting, data recording and plant biochemical analysis: On April 12 and 13, 2023 the crop was harvested when it reached full maturity. At that time, the plant growth parameters like shoot fresh and dry weight were recorded. With a Konica-Minolta SPAD-502 meter, Japan, greenness of leaves, or SPAD values, were measured on fully extended green

leaves between 9 and 11 am. To measure the relative water index, membrane stability index, antioxidant enzyme activity (POD, SOD, CAT, fully grown fresh green leaves were collected. The relative water content of fresh leaves was ascertained using the method by Weatherley (1951), and the MSI was considered by the procedure outlined by Sairam *et al.* (2002). The SOD activity was resolute using the technique described by Beauchamp and Fridovich (1971), as modified by Giannopolitis and Ries (1977). The POD and CAT activity were measured by using the method described by Castillo *et al.* (1984) and Aebi (1984), respectively. The CAT activity was measured by decomposing H₂O₂.

RESULTS AND DISCUSSION

Effect of organic amendment on growth parameters of wheat under salinity stress: The different abiotic stress significantly reduced plant growth and production. The result of our experiment showed the

Table 1. Pre- planting soil analysis

Characteristics	Units	Vehari	Bahawalpur
pH	-	8.03	8.15
EC _e	dS m ⁻¹	6.46	7.23
Ca ²⁺ + Mg ²⁺	me L ⁻¹	14.57	20.3
Na ⁺	ppm	29.8	25.3
SAR	-	1.96	1.46
Texture		Silt clay loam	Sandy clay loam

Table 2. Analysis of water used for irrigation

Characteristics	Units	Vehari	Bahawalpur
pH	-	7.43	8.14
EC _{iw}	dS m ⁻¹	1.54	2.23
Ca ²⁺ + Mg ²⁺	me L ⁻¹	09	10.7
CO ₃ ⁻	me L ⁻¹	1.07	1.46
HCO ₃ ⁻	me L ⁻¹	11	12.67
RSC	me L ⁻¹	1.87	3.54

detrimental effect of salinity, as compared to control conditions. These stresses significantly decreased the development parameters as compared to the control condition while the shoot fresh weight, shoot dry weight and yield data was considered as the major attribute of morphological aspects. The different genotypes have different potentials and perform differently to relieve the toxic effect of this stress. The results are presented in Table 3 and Fig. 1. Under saline stress and controlled conditions, the shoot fresh weight, shoot dry weight and yield data of Faisalabad -2008 in Vehari dropped by 14.7 g/plant, 3.07 g/plant and 3836 kg/ha and in sehar-2006 were measured 11.27 g/plant, 2.27 g/plant and 3507 kg/ha respectively. And the shoot fresh weight, shoot dry weight and yield data of Faisalabad -2008 in Bahawalpur were measured 13.47 g/plant, 2.83 g/plant, and 3178 kg/ha and in sehar-2006 were measured 20.83 g/plant, 6.27 g/plant and 2740 kg/ha, respectively. In third treatment compost (20 t/ha was used to decrease the injurious impacts of abiotic stresses, so in T₃, the shoot fresh weight, shoot dry weight and yield data of Faisalabad -2008 in Vehari dropped by 24.67 g/plant, 7.08 g/plant and 4712 kg/ha and in sehar-2006 were measured 18.67 g/plant, 4.83 g/plant and 4164 kg/ha, respectively. And the shoot fresh weight, shoot dry weight and yield data of Faisalabad -2008 in Bahawalpur were measured

20.83 g/plant, 6.27 g/plant and 4274 kg/ha and in sehar-2006 were measured 15.83 g/plant, 4.4 g/plant and 3836 kg/ha, respectively. Salinity stresses resulted in a tremendous decline in all the wheat varieties. Each level of the applied stress resulted in a considerable reduction in wheat growth parameters (shoot fresh weight, shoot dry weight and yield data). However, it was also observed that increasing the stress level caused a gradual decline in the plant growth attributes (Fahad *et al.*, 2016). Similar trends were described by (Nadeem *et al.*, 2022; Akram *et al.*, 2007).

Effect of organic amendment on physiological parameters of wheat under salinity stress: The different abiotic stress significantly reduced plant growth and total production. These stresses caused drastic effects and a tendency to a major injury in plant metabolism. The outcome of our trial showed the detrimental effect of salinity, as compared to control conditions. These stresses significantly decreased the physiological parameters as compared to the control condition while the membrane stability Index, SPAD value and relative water content was considered as the major attribute of morphological aspects. The different genotypes have different potentials and perform differently to relieve the toxic effect of these stresses. The results were presented in Fig. 2, 3 & 4. Under saline stress under controlled conditions, the

Table 3. Effect of organic amendment on growth parameters of wheat under salinity stress

Shoot fresh weight (g/plant)				Shoot dry weight (g/plant)		
Treatments	Vehari	Bahawalpur	Mean	Vehari	Bahawalpur	Mean
Faisalabad-2008						
T ₁	14.7±0.15	13.47±0.61	14.08 b	3.07±0.074	2.83±0.177	2.94 c
T ₂	18.17±0.22	16.6±0.66	17.38 ab	4.8±0.25	4.33±0.22	4.57 b
T ₃	24.67±1.45	20.83±0.84	22.75 a	7.08±0.36	6.27±0.26	6.68 a
Mean	19.18 A	16.97 B		4.98 A	4.48 B	
Sehar-2006						
T ₁	11.27±0.44	10.6±0.74	10.93 b	2.27±0.044	1.83±0.203	2.05 c
T ₂	15.2±0.306	12.9±0.32	14.05 b	3.25±0.132	3.03±0.146	3.142 c
T ₃	18.67±0.883	15.83±0.88	17.25 ab	4.83±0.203	4.4±0.265	4.62 b
Mean	15.04 C	13.11 D		3.45 C	3.09 D	

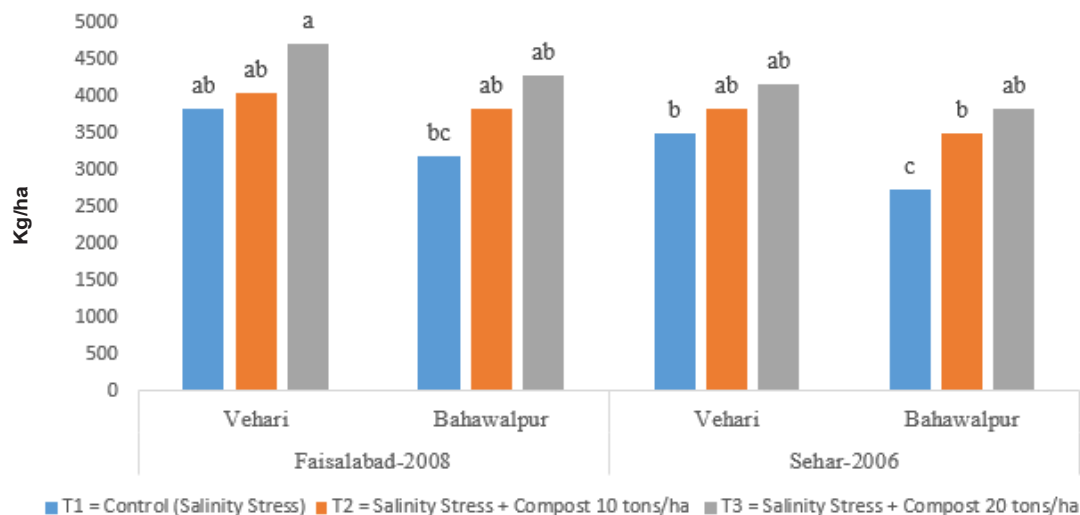


Fig. 1. Yield data of wheat under salinity stress

SPAD value, membrane stability index and relative water content of Faisalabad -2008 in Vehari dropped by 46.4, 64%, and 68.67% and in sehar-2006 were measured 36.6, 54.03%, and 47.33% respectively. And the SPAD value, Membrane Stability Index and Relative Water Content of Faisalabad -2008 in Bahawalpur were measured 39.73, 57.33%, and 63.67% and in sehar-2006 were measured 30.93, 47.37%, and 40.67% plant respectively. In third treatment Compost (20t/ha), an organic amendment, was used to decrease the harmful impacts of abiotic stresses. So in T₃ the SPAD value, Membrane Stability Index and Relative Water Content of Faisalabad -2008 in Vehari dropped by 59.67, 91.1%, and 88.57% and in sehar-2006 were measured 51.67, 79.9%, and 73.33% respectively. And the SPAD value, Membrane Stability Index and Relative Water Content of Faisalabad -2008 in Bahawalpur were measured 52.33, 84.43%, and 85.23% and in sehar-2006 were measured 46.33, 73.33%, and 66.67% respectively. We observed a correlative effect between abiotic stresses (drought, and salinity) and plant physiological attributes such as SPAD value and relative water contents. As with an increase in the extent of these stresses, plant physiology proved to be negatively affected. Less impact of these applied stresses was observed on the wheat physiological parameters (SPAD and relative water contents) (Ullah *et al.*, 2021). With an increase in the levels of these stresses, a considerable decline in these attributes was pragmatic. Several researchers have shown evidence regarding the adverse impacts of temperature, drought, and salinity stress on the plant chlorophyll contents (SPAD value) as well as relative water contents (Zhu, 2020).

Effect of organic amendment on ionic parameters of wheat under salinity stress:

The different abiotic stress significantly reduced plant growth and total production. These stresses caused drastic effects and a tendency to a major injury in plant metabolism. The outcome of our trial showed the detrimental effect of salinity, as compared to control conditions. These stresses significantly decreased the ionic parameters as compared to the control condition while the sodium, potassium, nitrogen and phosphorous was considered as the major attribute of morphological aspects. The different genotypes have different potentials and perform differently to relieve the toxic effect of these stresses. The results were presented in Table: 4 and 5. Under saline stress under controlled conditions, the sodium, potassium, nitrogen and phosphorous of Faisalabad -2008 in Vehari dropped by 55.67 ppm, 44.67 ppm, 0.177 % and 0.180 ppm and in sehar-2006 were measured 36.6 ppm, 31.33 ppm, 0.098 % and 0.104 ppm, respectively. The sodium, potassium, nitrogen and phosphorous of Faisalabad -2008 in Bahawalpur were measured 46.33 ppm, 42.67 ppm, 0.150 % and 0.182 ppm and in sehar-2006 were measured 30.93 ppm, 24.67 ppm, 0.094 % and 0.104 ppm plant, respectively.

In third treatment, Compost (20 t/ha), an organic amendment, was used to decrease the harmful impacts of abiotic stresses. So, in T₃ the sodium, potassium, nitrogen and phosphorous of Faisalabad -2008 in Vehari dropped by 29 ppm, 74 ppm, 0.290 % and 0.220 ppm and in sehar-2006 were measured 51.67 ppm, 57 ppm, 0.150 % and 0.147 ppm, respectively. The sodium, potassium, nitrogen and phosphorous of Faisalabad -2008 in Bahawalpur were measured

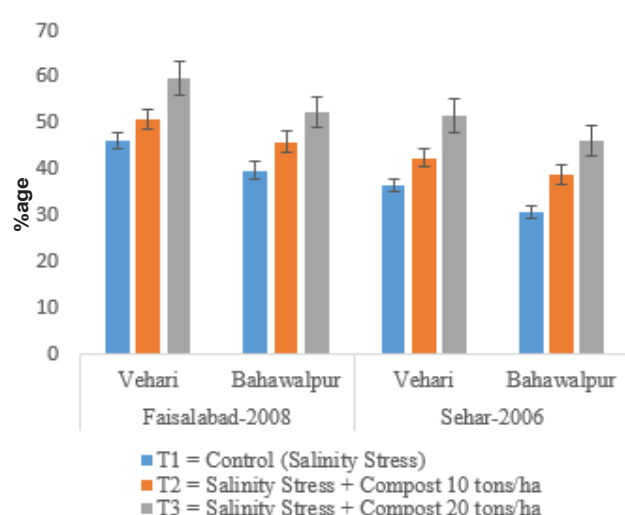


Fig. 2. Chlorophyll contents

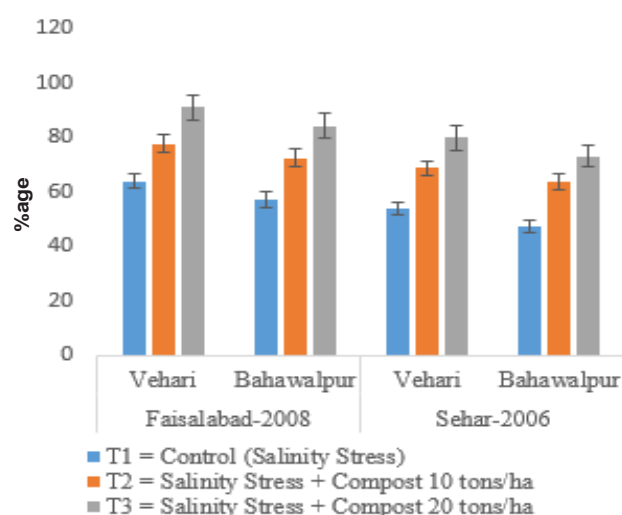
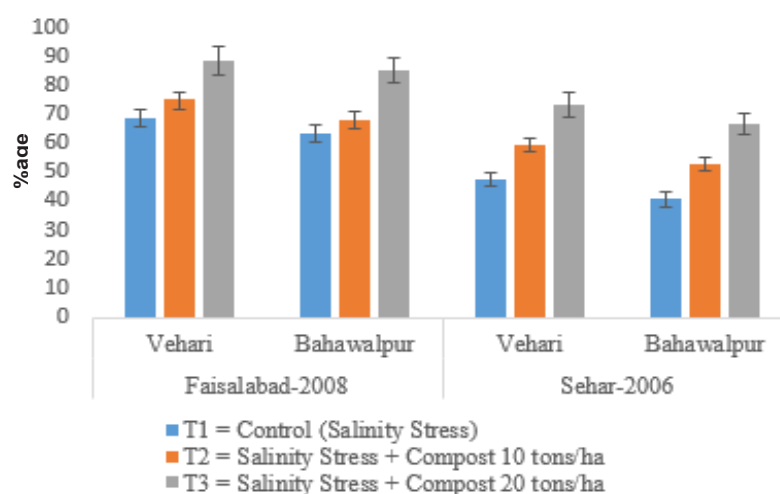


Fig. 3. Memberane stability index



Figs. 2, 3 and 4. Effect of organic amendment on physiological parameters of wheat under salinity stress

20.67 ppm, 70 ppm, 0.280 % and 0.200 ppm and in sehar-2006 were measured 46.33 ppm, 52 ppm, 0.130 % and 0.143 ppm, respectively.

Excessive uptake of Na⁺ under salt stress leads to a decline in the uptake of essential minerals particularly K⁺ and hence, beneficial functions of K⁺ are compromised under salt stress. Several researchers have already documented the negative impacts of salinity, drought, and temperature stress on uptake of vital nutrients by plants (Khan *et al.*, 2016). Salinity stresses also affected wheat nutrient profile and interfered with the uptake of necessary plant nutrients i.e., nitrogen (N), phosphorous (P), calcium (Ca), and

potassium (K). Moreover, salinity stress also increased the relative concentrations of sodium (Na⁺), which also suppressed K⁺ entry within plant cells (Akram *et al.*, 2007).

Effect of organic amendment on biochemical parameters of wheat under salinity stress: The salinity stress significantly reduced plant growth and total production. This stress causes drastic effects and a tendency to a major injury in plant metabolism. The result of our experiment showed the detrimental effect of salinity, as compared to control conditions. These stresses significantly decreased the biochemical parameters as compared to the control condition,

Table 4. Effect of compost on ionic parameters of wheat under salinity stress

sodium (Na ⁺) ppm				potassium (K ⁺) ppm		
Treatments	Vehari	Bahawalpur	Mean	Vehari	Bahawalpur	Mean
Faisalabad-2008						
T ₁	55.67±2.19	46.33±4.10	51 bc	44.67±0.33	42.67±1.45	43.67 b
T ₂	39.33±2.34	33.33±1.77	36.33 cd	56.00±0.58	52.33±1.86	54.17 b
T ₃	29.00±2.08	20.67±0.67	24.83 d	74.00±0.57	70.00±2.08	72.00 a
Mean	41.33 C	33.44 D		58.22 A	55 B	
Sehar-2006						
T ₁	36.6±1.388	30.93±1.32	33.77 b	31.33±2.33	24.67±1.45	28.00 c
T ₂	42.53±1.36	38.87±0.781	40.7 ab	46.33±1.76	40.33±1.47	43.33 b
T ₃	51.67±3.91	46.33±1.31	49 ab	57.00±2.08	52.00±2.08	54.50 b
Mean	43.6 C	38.71 D		44.89 C	39.00 D	

Table 5. Effect of compost on ionic parameters of wheat under salinity stress

nitrogen (N) %age				phosphorous (P) ppm		
Treatments	Vehari	Bahawalpur	Mean	Vehari	Bahawalpur	Mean
Faisalabad-2008						
T ₁	0.177±0.0067	0.150±0.02	0.017 c	0.18±0.0017	0.182±0.00173	0.182 b
T ₂	0.232±0.010	0.22±0.016	0.023 b	0.21±0.0043	0.197±0.0012	0.199 ab
T ₃	0.290±0.0097	0.280±0.14	0.029 a	0.22±0.0032	0.200±0.0012	0.208 a
Mean	0.024 A	0.021 B		0.20 A	0.193 B	
Sehar-2006						
T ₁	0.098±0.002	0.094±0.00029	0.0096 d	0.104±0.0026	0.104±0.00261	0.104 d
T ₂	0.130±0.008	0.0113±0.00035	0.0118 d	0.127±0.0012	0.127±0.0012	0.127 c
T ₃	0.150±0.007	0.013±0.00012	0.014 cd	0.147±0.0012	0.143±0.0022	0.145 c
Mean	0.012 C	0.0111 D		0.126 C	0.125 D	

while the SOD, POD & CAT was considered as the major attribute of morphological aspects. The different genotypes have different potentials and perform differently to relieve the toxic effect of these stresses. The results were presented in Fig. 5, 6 & 7.

Under saline stress under controlled conditions, the SOD, POD & CAT of Faisalabad -2008 in Vehari dropped by 113.33, 352 and 160 (Unit g⁻¹ FW) and in Sehar-2006 were measured 103.33, 273.67 and 121 (Unit g⁻¹ FW), respectively. The SOD, POD & CAT of Faisalabad -2008 in Bahawalpur were measured 107.67, 328.67 and 228.67 (Unit g⁻¹ FW) and in sehar-2006 were measured 98.67, 233.33 and 187.33 (Unit g⁻¹ FW) plant, respectively.

In the third treatment Compost (20 t/ha), an organic amendment, was used to decrease the harmful impacts of abiotic stresses. So, in T3, the SOD, POD

& CAT of Faisalabad -2008 in Vehari dropped by 178, 481.67 and 278.67 (Unit g⁻¹ FW) and in Sehar-2006 were measured 150.33, 422.67 and 221.67 (Unit g⁻¹ FW), respectively. The SOD, POD & CAT of Faisalabad -2008 in Bahawalpur were measured 156.33, 463.33 and 363.33 (Unit g⁻¹ FW) and in Sehar-2006 were measured 144.33, 406 and 306 (Unit g⁻¹ FW), respectively. Abiotic stresses result in the production of reactive oxygen species (ROS), which not only impose oxidative stress on the plants but also lead to a considerable decline in membrane integrity. Moreover, the photosynthetic efficiency of the plant system is also distressed (Liu *et al.*, 2016). To tackle these circumstances, plants produce different antioxidants such as catalase (CAT), peroxidase (POS), superoxide dismutase (SOD), and ascorbate peroxidase (APA), etc., which not only scavenge these toxic species but

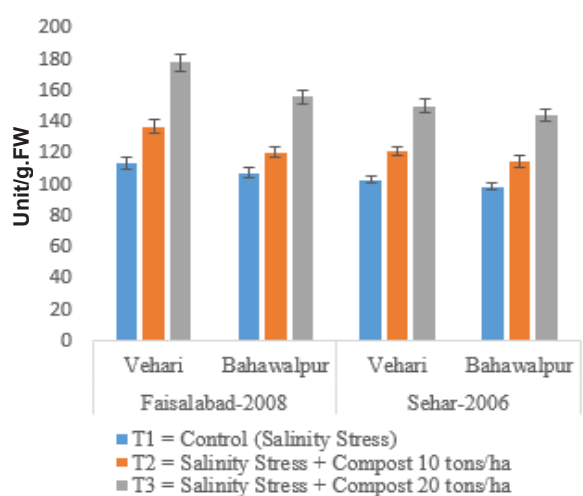


Fig. 5. Superoxide dismutase (SOD)

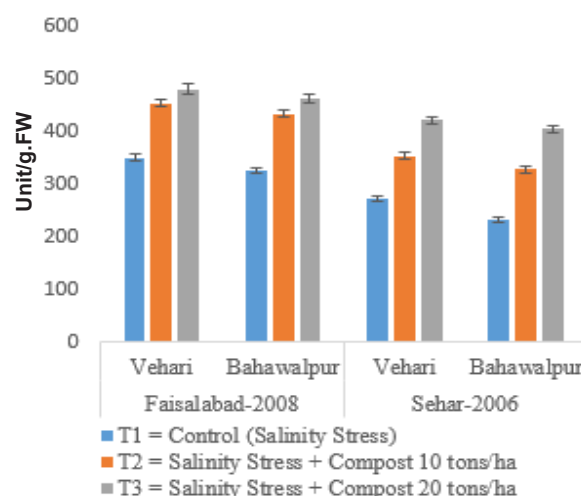


Fig. 6. Peroxidase (POD)

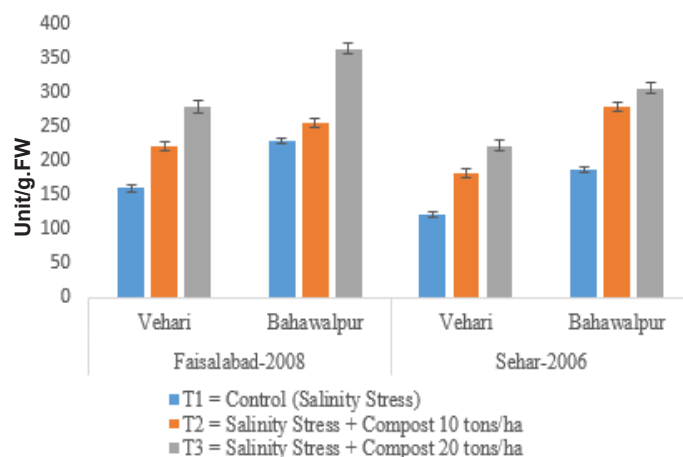


Fig. 7. Catalase (CAT)

Figs. 5-7. Effect of organic amendment on biochemical parameters of wheat under salinity stress

also act as a plant defense mechanism against them (Wang *et al.*, 2019).

CONCLUSION

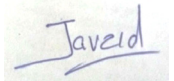
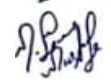
The salinity has deteriorated effect on wheat metabolic activities and significantly reduced the plant growth, physiological parameters, ionic concentration, and antioxidant enzymatic activity. However, the different varieties have different potential against stress conditions. The wheat variety Faisalabad-2008 exhibited more significant results under abiotic stresses so, it is considered a tolerant variety while the Sehar-2006 was sensitive variety by its results. The deteriorated impact of abiotic stresses and saline irrigation water was mitigated by using compost as an amendment. The compost enhanced the capacity of soil to conserve more water as compared to others and improved wheat growth under stress conditions. The finding of our experiments revealed that the addition of compost maintained the ionic homeostasis in soil which leads to enhancing the plant defense system against stresses. Wheat variety Faisalabad-2008 which we screened out from our previous experiments when the compost was applied to the field in the salinity stress conditions gives better result. At both the locations Vehari and Bahawalpur the natural saline soil and water deficit irrigation conditions when the compost was applied @ 20 ton/ha the wheat crop strengthen itself against salinity stress damages.

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2.	Javaid Akhtar	Team member of project	
3.	Muhammad Aftab	Analysed the samples and wrote-up the manuscript	
4.	Muhammad Arif	Analysed the data statistically	
5.	Muhammad Usama Mustafa	Collected the data	
6.	Muhammad Tayyab Mehmood	Helped in sample collection	
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