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Original Article

Ameliorating the adverse effects of salinity on wheat plants using the bio-wastes (pomegranate peel extract and /or compost)

Melhorar os efeitos adversos da salinidade nas plantas de trigo usando os biorresíduos (extrato de casca de romã e/ou composto)

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Abstract

Climate changes and the related rise in the frequency of excessive weather proceedings have a strong influence on the physical, chemical, and hydrological processes in soils. Recently the investigators confirmed that the use of biological treatments and resources to overcome abiotic stress is fruitful. Thus, pomegranate peel extract (PPE) because of its high efficacy and/or compost application could improve soil characteristics, soil organic matter and nutrient status. This effect may be referred back to the enhancement in the plant antioxidative defense system against stress conditions. This experiment was done to study the influence of spraying wheat plants with pomegranate peel extract (PPE) with and/or without soil compost added under salt stress on some growth parameters and physiological aspects. Wheat plants were grown in the presence or absence of compost in the soil and foliar sprayed with PPE (600 and 1200 mg L^{-1}) under salt irrigation (3000 and 6000 mg L^{-1}). Growth and yield traits were decreased with salinity stress. High levels of PPE (1200 mg L^{-1}) induced the highest values of osmoprotectants (Total soluble sugars, total soluble protein, proline and free amino acids) in both unstressed or salinity-stressed plants presence or absence compost. Using compost in soil for cultivating wheat plants and PPE spraying treatments increased growth traits photosynthetic pigments and yield components. Moreover, these treatments increased the accumulation of minerals content (N, P, K and Ca) in plants. In general, the results of correlation coefficients showed a significant strong positive relationship among measured yield traits and other tested parameters. The correlation between 1000-grain Wt. and grain Wt./spike (r = 0.94**) was the highest. Meanwhile, a strong negative correlation coefficient between Na% and all yield parameters was recorded. Compost adding to soil and spraying pomegranate peel extract is a successful method for increasing wheat growth, yield and improving the nutritional value of the produced grains under salt stress.

Keywords: wheat, compost, pomegranate peel extract, compatible solutes, yield.

Resumo

As alterações climáticas e o aumento relacionado à frequência de processos climáticos excessivos têm uma forte influência nos processos físicos, químicos e hidrológicos dos solos. Recentemente, os investigadores confirmaram que o uso de tratamentos e recursos biológicos para superar o estresse abiótico é frutífero. Assim, o extrato de casca de romã (PPE), devido à sua alta eficácia e/ou aplicação de composto, poderia melhorar as características do solo, a matéria orgânica do solo e o *status* de nutrientes. Este efeito pode ser atribuído ao aprimoramento do sistema de defesa antioxidante da planta contra condições de estresse. Este experimento foi realizado para estudar a influência da pulverização de plantas de trigo com extrato de casca de romã (PPE) com e/ou sem composto de solo adicionado sob estresse salino em alguns parâmetros de crescimento e aspectos fisiológicos. Plantas de trigo foram cultivadas na presença ou ausência de composto no solo e pulverizadas foliarmente com EPI (600 e 1200 mg L-1) sob irrigação salina (3000 e 6000 mg L-1). As características de crescimento e rendimento diminuíram com o estresse salino. Altos níveis de PPE (1200 mg L-1) induziram os maiores valores de osmoprotetores (açúcares solúveis totais, proteínas solúveis totais, prolina e aminoácidos livres) em plantas não estressadas ou estressadas por salinidade, na presença ou ausência de composto. O uso de composto no solo para o cultivo de plantas de trigo e tratamentos de pulverização de EPI aumentaram as características de crescimento, pigmentos fotossintéticos e componentes de rendimento. Além disso, esses tratamentos aumentaram o acúmulo de minerais (N, P, K e Ca) nas plantas. Em geral, os resultados dos coeficientes de correlação mostraram uma relação positiva significativa e forte entre as características de rendimento medidas e outros parâmetros testados. A correlação entre peso de 1000 grãos e o peso do grão/espiga (r = 0,94**) foi o mais alto. Enquanto isso, foi registrado um forte coeficiente de correlação negativa entre Na% e todos os parâmetros de rendimento. A adição de composto ao solo e a pulverização de extrato de casca de romã é um método bem-sucedido para aumentar o crescimento e o rendimento do trigo e melhorar o valor nutricional dos grãos produzidos sob estresse salino.

Palavras-chave: trigo, composto, extrato de casca de romã, solutos compatíveis, rendimento.

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1. Introduction

Over the past twenty years, the world's climate showed dramatic changes. Climate changes are fueled by both natural and man-made sources. Sea levels have risen as a result of these variables altering the pattern of precipitation. Also, high evapotranspiration has an influence on soil salinization and agriculture production, causing to the problem of water and food safety. Salinity stress restricts plant growth by negatively impacting many physiological and biochemical processes, including photosynthesis, the balance of superoxide ions, antioxidant responses, the buildup of osmolytes and proline metabolism (Abdallah et al., 2020a). Salinity stress also is one of the most significant abiotic stresses that limits plant development and productivity leading to the overgeneration of reactive oxygen species "ROS" (Roussos et al., 2019**),** responsible for the oxidative damage of plants by interacting with biological components (Hasanuzzaman et al., 2013). Plants produce an antioxidant defense system (antioxidant chemicals or enzymes) to counteract these ROS (Hasanuzzaman et al., 2021**).**

The most important staple crops worldwide are wheat, rice and maize, which provide a large portion of the daily protein and calorie consumption (Kizilgeci et al., 2021**)**. Wheat is placed first among these important cereals due to the development of its role as the world's main crop for staple foods (Iqbal et al., 2021). It presently occupies the majority of arable land (38.8%), has a grain protein content (12–15%) that is higher than other cereals, but its productivity is still low (FAO, 2016).

The use of natural antioxidants and natural fertilizer is one tool of the most efficient ways to reduce the harmful effects of salinity stressors and induce salt tolerance in many crops. Between 25% and 30% of the goods manufactured by vegetables and some fruits are not edible. (Rifna et al., 2021). Fruit and vegetable by-products are made up of variously shaped and sized skins and seeds that are typically wasted or destroyed and have no further use **(**Ajila et al., 2007). Pomegranate (*Punica granatum* L., Punicaceae) is an olden fruit, greatly utilized in conventional medicine for its protective and therapeutic influences. Its peels have been used in folk medicine due to the presence of various useful compounds (Eghbali et al. 2021). Through the industrial dealings of pomegranate, a great quantity of waste is generated in the form of pomegranate peel as an inedible part of the fruit. The non-edible portions of fruit and trees, such as leaves, buds, barks, flowers and peels, serve a crucial role. Despite being seen as waste, these parts of fruits are far richer in nutrients and physiologically active substances than the fruit's edible portion (Prakash and Prakash, 2011**).** Pomegranate juice production leaves peel as a byproduct unfit for human consumption. The pomegranate peel extracts (PPE) qualitatively found to contain several phytochemicals like phenolics, flavonoids, alkaloids, saponins, tannins, steroids and terpenoids (El-Hamamsy and El-Khamissi, 2020). According to Mansour et al. (2013), the presence of phenolic compounds (ellagic acid, caffeic acid, *p*-coumaric acid, quercetin, and vanillic acid) is responsible for the pomegranate's peel antioxidant and antibacterial effects. Pomegranate peel extracts have the prospect of utilizing as natural antioxidant products (Varzakas et al., 2016**).**

The most effective method for handling agricultural waste is composting. Organic waste is a biological process where (plant and animal remains) is used under aerobic conditions to create a value-added product (organic and inorganic) that can be used safely for crop cultivation or livestock feed (Adugna, 2016). Using compost could ameliorate the ability to produce safe and cleanly green horticultural products and significantly improve the possibility of large-scale organic food production (Paulin and O'malley, 2008). The presence of organic matter in the soil is fundamental in maintaining soil fertility and decreasing nutrient losses (Toledo et al., 2018). It delivers nutrients to the soil, progresses its water-holding capacity, and supports the soil to maintain good tillage and that better aeration for germinating seeds and plant root development (Edwards and Hailu, 2011). It is also generally known that applying compost improves the properties of the soil. In addition, it offers in terms of increased crop output, soil fertility, sustainability and nutritionally-balanced plants (El Sebai et al., 2016**).**

Agricultural by-products are known to be one of the environmental problems unless they are used in making compost and used again as soil amendment. Since the most effective method for handling agricultural waste is composting, it can be used safely for crop cultivation or livestock feed. As well, fruit juice factories produce industrial by-products such as some fruit peels which characterized with its content of natural antioxidants that can play as a resisting agent against stress conditions (salt stress). Thus, the aim of this research was to investigate the effectiveness of using agricultural wastes (compost) and fruits peel produced resulted as industry wastes and not edible (pomegranate peel extract) either individual or in combination in improving soil structure and its reflection on wheat plant productivity and nutritional values of the yielded grains. The desired benefits from using the tested materials are to get rid of the agricultural waste as well as waste resulting from fruit juice factories in an environment safe way and benefiting them in improving the characteristics of treated plants.

2. Materials and Methods

2.1. Experimental procedure

Wheat (*Triticum aestivum* L., Cv. Gimeza 7) was obtained from the Agricultural Research Centre, Ministry of Agriculture, Giza, Egypt.

This experiment conducted for the evaluation the role of pomegranate peel extract (PPE) in the presence and/or absence of compost to alleviate the salinity stress on wheat plant. Growth, some physiological parameters, yield and chemical composition of the yielded grains of wheat plants under different salinity levels were tested. The compost used during this study was prepared by El Sebai et al. (2015) and its physico-chemical properties are presented in Table 1.

A pot experiment was done during winter (2019/2020) and (2020/2021) under greenhouse conditions at the National Research Centre, Dokki, Giza, Egypt.

The salt kind utilized in irrigation through this study was generally the chloride mixture suggested by Stroganov (1962). The salt compositions of the salt mixture are presented (Table 2).

2.2. Extraction of fruit peels

Pomegranate fruits (*Punica granatum* L., Cv. Manfalouty) were gathered at a local Cairo market, Egypt. Pomegranate peels were thoroughly cleaned with distilled water, allowed to dry at room temperature, and then ground into a fine powder. The resulting powder extracted with distilled water, centrifuged at 4500 rpm for 10 min and the residue re-extracted twice as described above. The crude aqueous extract concentrated using rotary evaporator under reduced pressure at 45°C.The concentrated extracts lyophilized and kept at -20°C. and after then prepared the used concentrations (600 and 1200 mg L^{-1}) Chemical composition, phytochemical screening and phenolic compounds identified using HPLC chromatogram in water extract of pomegranate peels according to El-Hamamsy and El-khamissi (2020) are listed in Table 3.

Table 1. Chemical analysis of compost used throughout this study.

Character	Value*
pH (1:10)	7.80
EC (1:10) dsm^{-1}	3.23
Total Nitrogen (%)	1.66
Total Phosphorus (P_2O_5%)	0.73
total Potassium (K_2O%)	1.38
Organic matter (%)	32.20%
Organic carbon(%)	18.70%
C:N ratio	11.20:1
Ash (%)	67.82%

*All analysis were supported on the basis of dry weight except for moisture content. Compost was applied during this experiment at rate 36 tons/ hectare =36 tons/ hectare.

2.3. Experimental procedure

The experimental soil has some physical and chemical properties: The soil texture had loam with coarse sand 9.3%, fine sand 25.9%, silt 47.4%, and clay 13.2%, EC 1.1 dS m^{-1}, pH 6.8, organic matter 1.32%, organic carbon 0.76%, and available N, P, and K accounting for 168.9, 11.70 and 423.20 mg kg-1, respectively. The method of analysis was described by Chapman and Pratt (1978).

The pots were split into two major sets; the first set was left as control and the second set was supplemented with compost. Every pot group was filled with about 9 kg clay soil /pot. Phosphorus fertilizer was added before sowing at the rate of 2.0 g triple phosphate (37% P_2O_5) per pot, while ammonium nitrate (33.5% N) was added as nitrogen fertilizer at the rate of 2.0 g/pot. Potassium sulfate (48-50% K_2O) was applied in the form of potassium fertilizer to the soil at the rate of 2.25 g/pot before sowing.

Table 2. The composition of the salt mixture utilized throughout this study is stated as a percentage of the total salt content.

$MgSO_4$	$CaSO_4$	NaCl	$MgCl_2$	$CaCO_3$
10.0	1.0	78.0	2.0	9.0

Anions and cations (% of total milli equivalents):

Na^+	Mg^{+2}	Ca^{+2}	SO^{-2}	Cl^-	CO_3^{-2}
38.0	6.0	6.0	5.0	40.0	5.0

Table 3. Chemical composition, phytochemical screening and phenolic compounds content of pomegranate peels.

Chemical composition	%
Fat	0.90
Ash	4.21
Moisture	6.94
Protein	9.00
Fiber	19.40
Total carbohydrates	59.61

Phytochemical analysis:

Total phenolics (mg GAE/g)	Total Flavonoids (mg Rutin/g)	Antioxidant Activity DPPH (IC50) (µg/ml)
126.0 ± 1	53.00 ± 1.35	27.6±2.9

Phenolic compounds content:

Item	Protocatechuic acid	Syringic acid	Ellagic acid	Iso-ferulic acid
Concentration (mg/ml)	2.02	5.22	25.33	12.36

Grains of wheat were chosen, which were the same size and color. Wheat grains were sterilized for nearly 2 min with 1% sodium hypochlorite after being gently washed with distilled water. Wheat grains were sown at the end of November using ten uniform wheat grains along a centre row in each pot at 30 mm depth. Every group was divided into three subsets according to irrigation with different levels of saline solutions by using Stroganov nutrient solutions (Table 2) at 0, 3000 and 6000 mg L^{-1} which equal to (EC of 0.03, 3.2 and 6.1 dSm^{-1}), respectively. Each of the previous subgroups were divided into three groups were sprayed twice with pomegranate peel extract at (0, 600 and 1200 mg L^{-1}). Every treatment contained five replicates dispensed in a completely randomized design system. Foliar applications of pomegranate peel extract (PPE) at 600 and 1200 mg L^{-1} were carried out twice after 30 and 37 days from sowing.

The seedlings were irrigated with equal volumes (one liter/pot) of various salt solutions three times, whereas tap water was utilized for the fourth one to keep the accumulation of salts about the root system. The seedlings were left under the following natural growth conditions: 12 h light period, 65-70% relative humidity, and day/night temperatures of 24/16°C.

2.4. Growth measurements

Plant samples were gathered after 75 days from sowing for measuring growth characters in terms of plant length (Cm), number of leaves / tiller, shoot fresh and dry weight (g), and biochemical analysis of photosynthetic pigments, total soluble sugars, proline, total free amino acids and total soluble protein.

2.5. Biochemical analysis

2.5.1. Photosynthetic pigments

The technique of Lichtenthaler and Buschmann (2001) was used to estimate the total amounts of chlorophyll a, b and carotenoids in the fresh leaves of wheat plants. Using 80% acetone, fresh tissue was ground filtrated. Using a spectrophotometer (Shimadzu UV- 1700, Tokyo, Japan), the optical density (OD) of the solution was measured at 662 and 645 for chlorophyll a and b and 470 nm for carotenoids. Photosynthetic pigment levels were given in mg/g FW.

2.5.2. Total Soluble Sugars (TSS)

Total Soluble Sugars were extracted according to Gomez et al. (2002). Weight 0.02 g of dry leaf tissue, extract it overnight period at 25°C with shaking in 10 ml of 80% (v/v) ethanol and centrifuge it. The supernatant was evaporated till completely dried then dissolved in a known volume of distilled water to be ready for determination of soluble carbohydrates. According to the method of Albalasmeh et al. (2013), TSS were calculated by combining 3.0 ml of freshly made anthrone (150 mg anthrone + 100 ml 72% H_2SO_4) with 0.1 ml of ethanolic extract in a boiling water bath for 10 minutes, and reading the cooled samples at 625 nm using a Spekol SpectrocololourimeterVEB Carl Zeiss.

2.5.3. Indole acetic acid

Indole acetic acid (IAA) content was extracted and determined through the method of Gusmiaty and Payangan (2019). Fresh leaf of known weight was obtained and extracted three times at 0°C with 85% cold methanol (v/v). The mixed extracts were gathered and then cold methanol was used to dilute them to a known volume. Take 1 ml of the methanolic extract and 4 ml of the PDAB reagent (para-dimethylamino benzoic acid, 1 g dissolve in 50 ml HCl, 50 mL of ethanol 95%) and combine them. This mixture left for 60 minutes at 30-40°C. At a wavelength of 530 nm, the developing colour was spectrophotometrically recorded.

2.5.4. Proline

A known weight of fresh leaf was extracted according to the method described by Vartainan et al. (1992) for proline and free amino acids contents. The technique described by Bates et al. (1973) was used to measure proline. Proline extract, acid ninhydrin, and glacial acetic acid were each added in two milliliters. The mixture was then heated in a boiling water bath for one hour before being placed in an ice bath to complete the incubation process. Using a Spekol Spectrocolololourimeter VEB Carl Zeiss, the absorbance at 520 nm was measured. A known concentration of actual proline was used to create a standard curve.

2.5.5. Free amino acid

Tamayo and Bonjoch (2001) established a method for determining free amino acid using the ninhydrin reagent. 1.0 mL of free amino acid extraction, 1.0 ml of acetate buffer (pH 5.4) and 1.0 ml of chromogenic agent were added. Using water bath, the mixture was heated 15 min. After being cooled in tap water, 3 ml of ethanol (60% v/v) was added. Utilizing a Spekol-spectrophotometer VEB Carl Zeiss., the absorbance at 570 nm was then monitored.

2.5.6. Total phenol content

The amount of total phenol was measured as described by González et al. (2003). Using the IAA extraction from the previous extract, 0.5 mL of the extraction was added to 0.5 mL of Folin, shaken, and let to stand for 3 min. Each tube was then filled with distilled water, agitated, and one mL of saturated sodium carbonate before being left to stand for 60 minutes. Using a spectrophotometer, the optical density was measured at a wavelength of 725 nm.

2.5.7. Total soluble protein

Total soluble protein (TSP) was determined according to the methods of Bonjoch and Tamayo (2001).

2.5.8. Macro-element contents

The content of yielded grains from microelement contents was determined as stated by Chapman and Pratt (1978). Phosphorus was determined using a Spekol spectrocolorimeter (VEB Carl Zeiss; Jena, Germany, while, estimation of K+ contents was done utilizing a flame photometer.

2.6. Yield and yield component

At harvest, the following characters were recorded on random samples of 10 plants: Plant height (Cm), spike weight (g), No. of spikelet/spike and 1000-grains weight (g) in addition to the nutritive value of the grains yield, i.e. total carbohydrates, protein, nitrogen, phosphorus, potassium, sodium and calcium contents (%).

2.7. Statistical analysis

The experiment was conducted in a completely randomized design (CRD) with 5 replicates. The MSTAT-C statistical analysis program (MSTAT-C, 1988) was used to analyse the data using traditional methods of analysis of variance. Least Significant Difference (LSD) test was used to compare means at a 5% confidence level. Data were subjected to pearson correlation coefficient according to Payne (2009) using Genstat Pro software version 20th edition.

3. Results and Discussion

3.1. Changes in plant growth

The vegetative growth (Table 4) of wheat plants (Shoot length, number of leaves/tiller, tillers fresh and dry weight, and root dry weight) were significantly ($P<0.05$) decreased in response to 6000 mg L^{-1} compared to the corresponding control, while low salinity level (3000 mg/L) increased all the studied growth parameters. Foliar application of PPE significantly ($P<0.05$) increased all the above mentioned growth criteria in plants grown under saline or normal condition. Application of PPE (1200 mg L^{-1}) recorded the maximum increases in all growth criteria. While progressive increases were observed for the plants cultivated in the presence of compost compared to the corresponding treatment plants cultivated without compost.

The inhibitory effect of salinity stress on plant vegetative growth (Table 4) may be because of the poisonous influence of Na and Cl ions excessive accumulation around the root system and hence in plant cells. Salinity reduced photosynthetic pigments (Figure 1) which led to limiting the equipping of carbohydrate required for growth. According to Kosová et al. (2011) the higher osmotic pressure of the soil solution caused by these ions caused a decrease in the amount of water that plants were able to absorb. The plants reduced the rate of photosynthesis, improved stomata closure and modified the osmotic pressure to counteract the damaging effects of salt. Also, Abdallah et al. (2016) and Sassine et al. (2022) found that salinity has negative effects on growth of rice and tomato respectively.

The role of compost in improving wheat growth parameters (Table 4) might be through increasing photosynthetic pigments (Figure 1), increased nutrient availability N, P, K, Ca and endogenous growth bioregulators produced by mutant *Penicillium* which improve the mobilization of nutrient to the buds via enhancing cell divisions. El Sebai et al. (2016) observed that progressive enhances in growth parameters of quinoa plants cultivated in the presence of compost compared to the corresponding treatment plants cultivated without compost. They added that compost addition to the agricultural soils improved quality through the presence of a variety of microorganisms that are essential for increasing nutrient availability (Phosphorus, sulfur, manganese and micronutrients) which increasing soil fertility and quality.

Several authors found that PPE contains large amount of antioxidants (Karthikeyan and Vidya, 2019**;** Fischer et al., 2011; Sorrenti et al., 2019**)**. According to Aviram et al. (2002), liquid extracts of pomegranate peel have bioactive compounds such as ascorbic acid and phenolic (tannins, flavonoids, and pro-anthocyanides) and phenolic acids (hydroxylcinnamic acid and hydrobenzoic acid). These phenolics play protective roles in the regulation of the phenylpropanoid pathway which are essential for the growth and development of plants (Salum and Erra-Balsells, 2013). Moreover, phenolic compounds are antioxidant substances that play a role as free radical scavengers which in turn could improve stress tolerance in plants (Trchounian et al., 2016**)**. In addition, Mercy et al. (2014) added that the fruit peels contain potassium, vitamins, minerals and some essential elements which mitigate the adverse effects of salt stress on plant growth parameters.

Table 4. Effect of different concentrations of pomegranate peel extract (PPE600 & 1200 mg L^{-1}) on morphological criteria of wheat plants in absence (-) and presence (+) of compost under various levels of saline solution (at 75 days from sowing).

Salinity (mg L^{-1})	Treatment (mg L^{-1})	Plant height		No of leaves/tiller		Tiller fresh wt (g)		Tiller dry wt (g)	
		-	+	-	+	-	+	-	+
0	Control	38.66^{h}	40.50^{fgh}	4.85^{g}	5.02^{f}	1.09^{m}	1.27^{l}	0.16^{i}	0.18^{gh}
	PPE (600)	44.17^{cde}	44.47^{cde}	5.35^{f}	6.45^{b}	1.74^{j}	2.26^{f}	0.21^{fg}	0.24^{f}
	PPE (1200)	45.91^{abc}	46.52^{a}	5.50^{e}	6.50^{b}	1.92^{h}	2.51^{d}	0.28^{e}	0.35^{bc}
3000	Control	38.98^{gh}	41.54^{f}	5.30^{e}	5.75^{d}	1.51^{k}	2.03^{g}	0.24^{f}	0.33^{cd}
	PPE (600)	43.65^{e}	45.73^{b}	6.24^{c}	6.45^{b}	1.81^{i}	2.89^{b}	0.27^{e}	0.38^{b}
	PPE (1200)	45.67^{bcd}	46.28^{a}	5.80^{d}	6.81^{a}	2.43^{e}	2.92^{a}	0.28^{e}	0.43^{a}
6000	Control	34.52^{i}	35.26^{i}	4.47^{h}	4.85^{g}	1.06^{m}	1.84^{i}	0.17^{hi}	0.19^{ghi}
	PPE (600)	39.95^{fgh}	40.61^{fg}	4.99^{g}	5.44^{e}	1.72^{j}	2.58^{cd}	0.27^{e}	0.30^{de}
	PPE (1200)	43.94^{de}	44.88^{bcde}	5.40^{e}	5.88^{d}	2.03^{g}	2.61^{c}	0.34^{c}	0.38^{b}

$^{a-m}$: Means in the same column with different letter are significantly differed at $P<0.05$.

3.2. Photosynthetic pigments

Wheat plants irrigated with saline water (3000 and 6000 mg L^{-1}) induced a gradual decreases in chlorophyll a, chlorophyll b, carotenoids and total pigments as contrast to the corresponding untreated plant (Figure 1). The results in the same figure also showed that significant (P<0.05) increments in photosynthetic pigment with respect to the treatment with PPE and compost under normal or salinity stress conditions compared to the corresponding control. The presence of compost significantly (P<0.05) increased the photosynthetic pigments compared to treated plants without compost at all different levels of salinity. Foliar application with PPE at 1200 mg L^{-1} and amended with compost induced the maximum increments in photosynthetic pigments at all salinity levels. The inhibitory influence of salinity stress to the photosynthetic pigments of wheat plants might be because of the inhibitory influence of photosynthetic enzymes which induces an increase in the free radicals in the chloroplasts and devastation of chlorophyll molecules via ROS, leading to the decrease of photosynthesis and growth (Desingh and Kanagaraj, 2007).

Moreover, according to the explanation of Parida and Das (2005) that the photosynthetic process, including photosynthetic pigments, stomatal function, gaseous exchange characteristics, the structure and function of the thylakoid membrane, electron transport and enzyme activities, is hindered by the presence of salt (Na and Cl) around the root zone. In addition, chlorophyll breakdown is caused by the production of proteolytic enzymes like chlorophyllase (Yildirim et al., 2008).

Soil amended with compost, increased the photosynthetic pigments of wheat plants in salt stress and non-stressed conditions as compared with corresponding control.

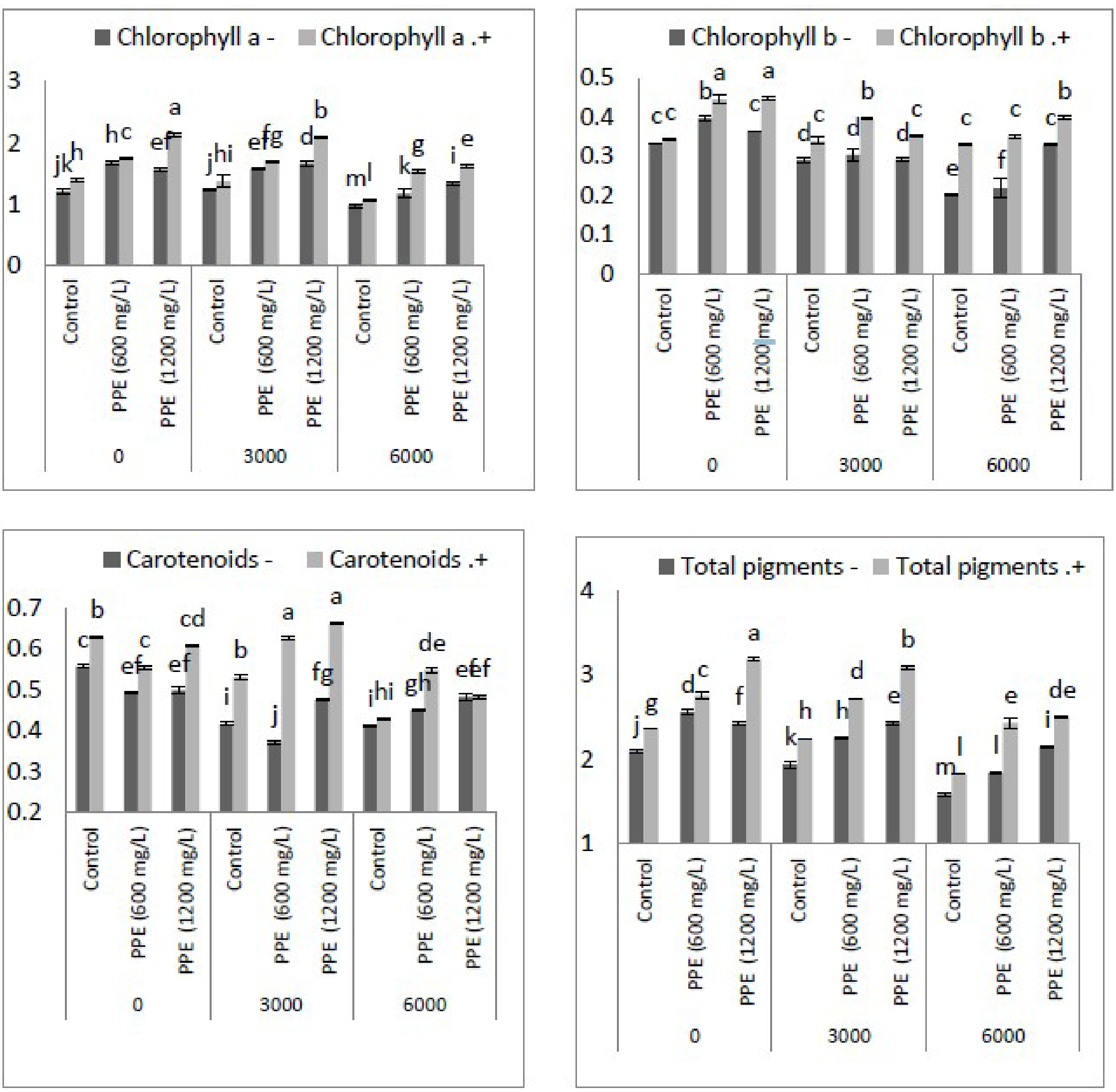

Figure 1. Effect of different concentrations of pomegranate peel extract (PPE) on photosynthetic pigments (chlorophyll a chlorophyll b carotenoids total chlorophylls) mg/g fresh weight on wheat plant at 75 days from sowing with different levels of saline solution in absence (-) and presence (+) compost. The different letters (a-m) show statistical significance at $p < 0.05$; vertical bars indicate ± SE.

This study indicated that all photosynthetic pigments of wheat plants responded better in soil with compost than that in soil without compost. Fernendez-Luqueno et al. (2010) investigated the impact of organic fertilizer enhanced the synthesis as well as the amount of chlorophyll and increased the rate of photosynthesis. Addition of compost to the soil improves soil fertility and increase mineralization of nutrients as biological cycles within the soil. Compost found to increase the content of Mg and Fe which are the two important nutrients involved in chlorophyll synthesis (Libutti et al., 2020). According to Kumar et al. (2010) and Sharma et al. (2012), iron (Fe) is a crucial metal activator (Co-factor) of many antioxidant enzymes that aids in controlling plant life-sustaining processes like photosynthesis and chloroplast production. It is important to note that wheat plants treated with compost along with various salt concentrations had much higher levels of carotenoids than plants treated similarly without compost. Carotenoids might play a function as a free radical scavenger. Thus, enhancing the amount of carotenoids in wheat with soil that has been modified with compost could improve their ability to diminish the harm done by ROS, which in turn enhanced the level of chlorophyll.

Exogenous application of PPE increased all photosynthetic pigments in wheat plants grown under normal and salinity stress conditions. The influence of PPE on the biosynthesis of chlorophyll might be due to either its potential for natural antioxidants such as flavonoids, phenols and pro-anthocyanides (Varzakas et al., 2016) or to the improvement in activities of key antioxidant and thereby their free radical scavenging (Saparbekova et al., 2023).

3.3. Changes in phenol and IAA content

It is obvious from Figure 2 that IAA increased significantly (P<0.05) under low salinity level (3000 mg/L), but it decreased in response to the highest concentration (6000 mg L^{-1}). Meanwhile, phenols content was increased significantly (P<0.05) in response to all salinity levels, but IAA decreased significantly (P<0.05) with salinity stressed wheat plants. In both unstressed and salinity stressed plants, PPE at the two tested levels and compost addition increased significantly (P<0.05) the contents of both phenols and IAA in wheat leaves.

The ameliorative effects of PPE and/or compost addition on the contents of total phenolics and IAA contents of wheat plants are in line with Aminifard et al. (2013) who found that treatment of sweet pepper with compost (5, 10 and 15 tons ha^{-1}) positively affected fruit antioxidant compounds (antioxidant activity, total phenolic and total flavonoid). The highest total phenolic in plants treated obtained with the highest level of compost (15 tons ha^{-1}). Also, Vernieri et al. (2006) added that organic fertilizers (Compost) act as precursors or activators of phytohormones, growth substances and secondary compounds in the treated plants. Moreover, Khalil et al. (2023) found that foliar application of pea plants with 0.25 and 0.50% natural antioxidants increased total phenols and IAA contents. An increase in phenolic compounds may improve stress tolerance which act as ROS scavengers and enhancing oxidative damage tolerance (Gill and Tuteja, 2010).

3.4. Changes in compatible solutes

The data in Figure 3 demonstrated that the compatible solutes (proline, free AA, TSP, and TSS) in the studied plants increased significantly (P<0.05) as salinity increased. There is a significant (P<0.05) gradual increase in these parameters with increasing salinity concentration. Treatment of wheat plants with PPE at 600 and 1200 mg L^{-1}stimulated these increases compared to the corresponding control. Addition of compost to the soil contained the stressed and unstressed plants also increased these tested compounds. Generally, the most significant increase was observed with the highest concentration of both PPE and compost in both stressed and unstressed plants.

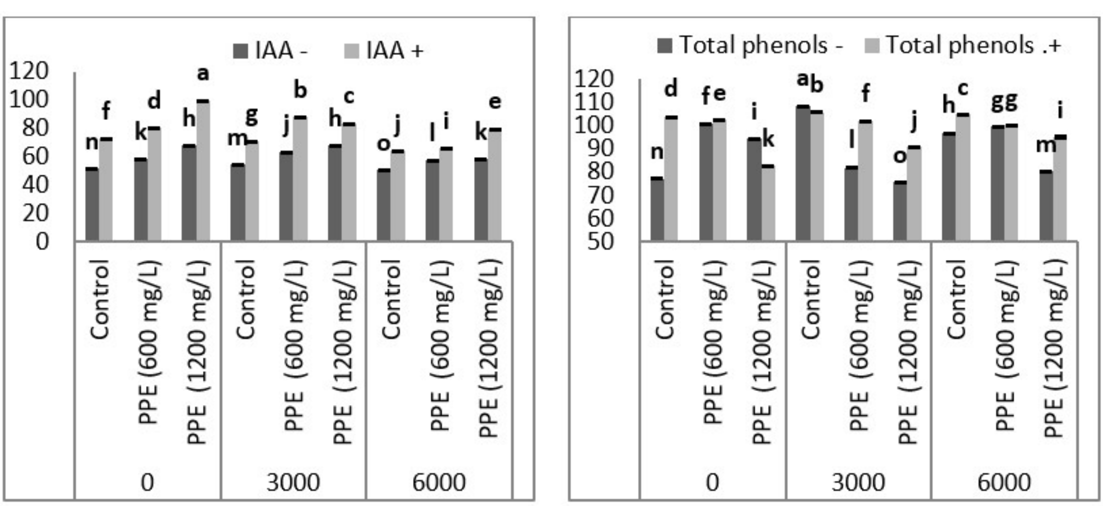

Figure 2. Effect of different concentrations of pomegranate peel extract (PPE) on indol acetic acid (IAA) and total phenols (mg/100g fresh weight) on wheat plant at 75 days from sowing with different levels of saline solution in absence (-) and presence (+) compost. The different letters (a–o) show statistical significance at $p < 0.05$; vertical bars indicate ± SE.

The increase in compatible solutes due to salinity stress are in harmony with the results obtained by Tawfik et al. (2017) and Ramadan et al. (2019) *Spartina patens* and sunflower respectively. Proline and TSS may regulate the osmotic potential and increase the absorption and translocation of plant water content (Oraki et al., 2012). Proline also is essential for protecting enzymes, proteins and membranes from the harmful effects of salinity stress as well as for osmotic adjustment and stabilization (Meena et al., 2019)

Figures (2 and 3) showed that also that foliar application of wheat plants with PPE (600 and 1200 mg L^{-1}) with amended compost enhanced all the previous parameters in leaves. The increases in osmoprotectants due to PPE may be due to its content of antioxidant substances as mentioned previously by Karthikeyan and Vidya (2019). Pomegranate peels are a rich source of polyphenol and flavonoid components, which are natural antioxidants that contribute to the antioxidant index (Konsoula, 2016).

Regarding the positive effect of compost on wheat plant osmoprotectants, the obtained results were in good agreement with the results obtained by Abdallah et al. (2020b) who found that compost addition to the soil positively enhanced the content of proline, free amino acids and TSS in quinoa plants with rising salinity stress level compared to untreated ones (compost-free) under stress and unstressed conditions. Also, El-Sebai et al. (2016) on quinoa showed an increase in TSS which caused changes in the osmotic balance and improved chlorophyll levels, which speed up photosynthesis and carbohydrate synthesis.

From the data in the same Figure 3 increasing the tested osmoprotectants protect the plants from harmful effect of salinity which adjust osmotic pressure of cytoplasm, stabilization of proteins and membranes, buffering cellular redox potential and scavenging reactive oxygen (Semida et al., 2020).

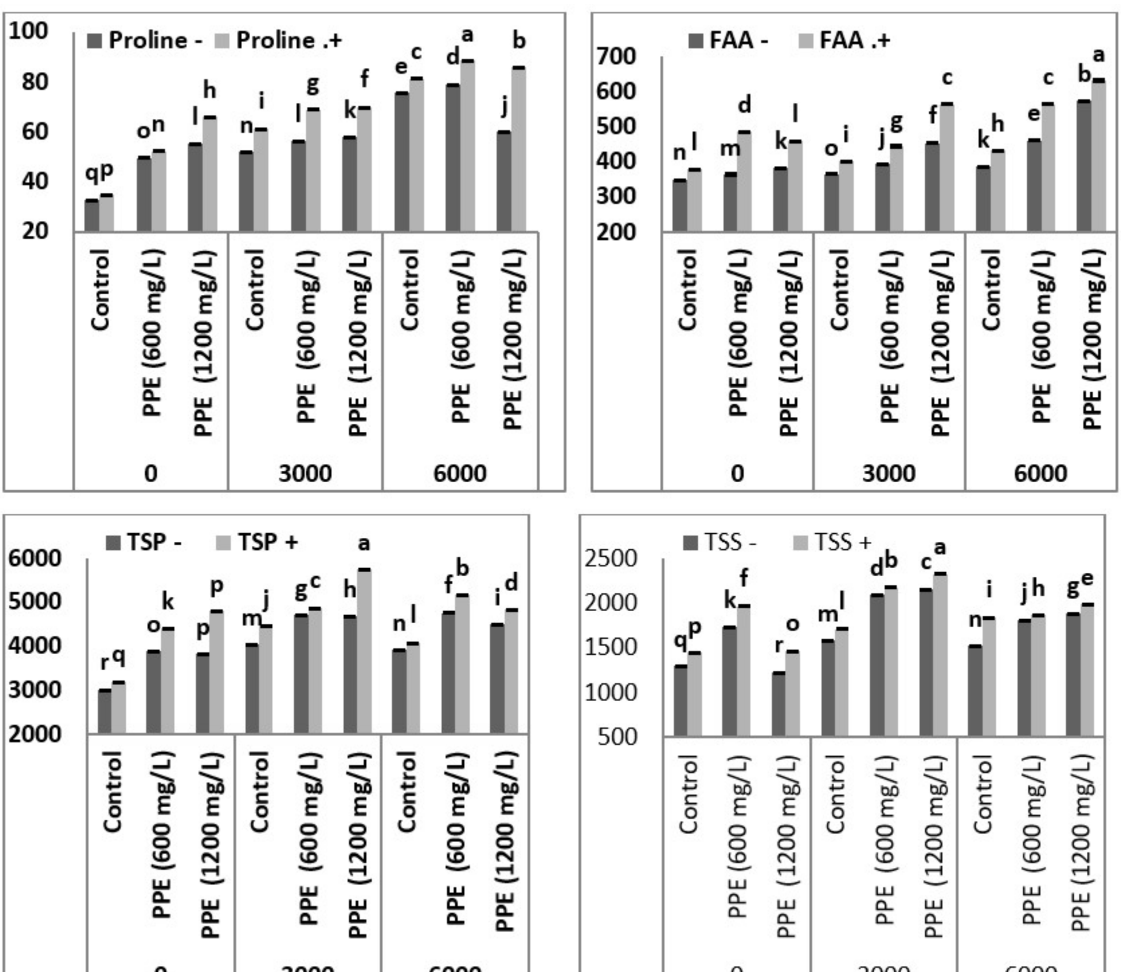

Figure 3. Effect of different concentrations of pomegranate peel extract (PPE) on proline, free amino acid (FAA), total soluble protein (TSP) and total soluble sugar (TSS) as mg/100g dry weight on wheat plant at 75 days from sowing with different levels of saline solution in absence (-) and presence (+) compost. The different letters (a-r) show statistical significance at $p < 0.05$; vertical bars indicate ± SE.

3.5. Yield quantity and quality

Results of yield parameters (Table 5 and 6) showed that the influence of the foliar application of PPE (600 &1200 mg L^{-1}) in the presence and absence of compost on wheat plant grown under various levels of salinity (0, 3000 and 6000 mg L^{-1}) on yield traits (Shoot length, spike length, spike Wt., number of spikelets/spike, number of grains/spike, grain Wt./spike, weight of 1000-grain, carbohydrates and Protein %). Data clearly showed that, the salinity level (6000 mg L^{-1}) only caused a significant ($P<0.05$) reduction in all yield parameters compared with the control plants, while a low salinity level (3000 mg/L) increased it. The results showed a significant ($P<0.05$) increase in all yield components in response to inoculation with compost. Spraying wheat plants with PPE significantly ($P<0.05$) raised yield traits of wheat as contrast with the corresponding salinity levels, especially when the soil supplemented with compost. Generally, the maximum increment was detected with PPE (1200 mg L^{-1}) under both unstressed and stressed conditions.

Salinity stress at high concentration resulted in extreme inhibition in the studied yield traits of wheat plants. These results were in harmony Ramadan et al. (2019) on sunflower and Zörb et al. (2019) on cotton, barley and sugar beet. Pastuszak et al. (2022) found that salt treatments induced a negative impact on yield traits of three durum wheat genotypes. The reduction in yield traits might be referred to the inhibitory effect of salinity on vegetative growth (Table 4) and the physiological disturbance caused by the increase in osmotic stress, consequently affecting the yield traits. Additionally, the adverse effects of salt on growth and the disruption in mineral uptake (Figure 4) may contribute to the decreased wheat yield/plant. In this concern, Farooq et al. (2017) stated that the decrease in grain yield because of salinity can be referred to decrease pollen viability, stigma receptivity and the provision of photo-assimilates during grain filling.

The stimulatory effect of PPE on wheat yield are in harmony with those recorded by Dayarathna and Karunarathna (2021) who concluded that the improvement in yield traits (Number of fruit/plant, fruit length and girth,

Table 5. Effect of different concentrations of pomegranate peel extract (PPE) on yield components of wheat plants irrigated with different levels of saline solution in absence (-) and presence (+) compost (combined analysis of two seasons).

Salinity (mg L^{-1})	Treatment (mg L^{-1})	Plant height (Cm)		Spike Length (Cm)		Spike Wt. (g)		Number of spikelet/Spike		Number of grain/Spike	
		-	.+	-	.+	-	.+	-	.+	-	+
0	Control	44.12^{j}	55.15^{b}	8.5^{j}	9.60^{f}	2.18^{i}	2.21^{hi}	14.59^{h}	15.50^{fg}	$39. 39^{j}$	43.31^{e}
	PPE (600)	46.95^{h}	53.63^{c}	9.58^{fg}	9.77^{f}	2.34^{g}	2.94^{b}	15.83^{efg}	16.50^{cd}	41.20^{h}	44.92^{d}
	PPE (1200)	48.77^{f}	54.63^{b}	9.50^{fg}	10.30^{e}	2.69^{e}	2.99^{a}	16.72^{bc}	18.72^{a}	42.30^{fg}	46.54^{b}
3000	Control	50.35^{de}	54.15^{b}	9.00^{hi}	11.04^{d}	2.23^{h}	2.34^{g}	15.45^{g}	17.08^{b}	39.90^{i}	44.98^{d}
	PPE (600)	47.96^{g}	59.50^{a}	10.08^{e}	11.98^{b}	2.60^{f}	2.99^{a}	16.20^{de}	18.62^{a}	41.99^{g}	45.39^{c}
	PPE (1200)	49.99^{e}	59.00^{a}	10.34^{e}	13.42^{a}	2.78^{d}	2.89^{c}	16.55^{cd}	18.41^{a}	42.62^{f}	47.65^{a}
6000	Control	42.39^{k}	47.50^{gh}	8.50^{j}	8.99^{i}	1.52^{m}	1.66^{k}	12.51^{i}	12.55^{i}	32.00^{o}	37.83^{i}
	PPE (600)	45.64^{i}	50.88^{d}	9.55	10.88^{d}	1.60^{l}	1.95^{i}	14.61^{h}	15.62^{fg}	35.54^{n}	38.52^{k}
	PPE (1200)	46.15^{e}	49.75^{e}	9.30^{gh}	11.55^{c}	1.65^{k}	1.99^{j}	14.73^{h}	15.94^{ef}	36.24^{m}	39.21^{j}

$^{a-o}$: Means in the same column with different letter are significantly differed at P<0.05.

Table 6. Effect of different concentrations of pomegranate peel extract (PPE) on yield components of wheat plants irrigated with various levels of saline solution in absence (-) and presence (+) compost (combined analysis of two seasons).

Salinity (mg L^{-1})	Treatment (mg L^{-1})	Grain wt/ Spike (g)		Weight of 1000 grain (g)		Carbohydrates %		Protein %	
		-	+	-	+	-	+	-	+
0	Control	1.41^{hi}	1.68^{ef}	38.37^{m}	41.14^{h}	45.40^{m}	56.34^{d}	13.72^{jk}	16.23^{e}
	PPE (600)	1.73^{f}	1.93^{cd}	40.33^{ij}	45.33^{c}	55.35^{f}	58.68^{b}	16.21^{e}	17.73^{b}
	PPE (1200)	1.85^{d}	2.27^{a}	43.75^{d}	45.93^{b}	56.69^{c}	58.45^{b}	16.56^{d}	18.16^{a}
3000	Control	1.52^{gh}	2.25^{ab}	41.08^{h}	42.37^{f}	50.93^{j}	56.68c	14.20^{i}	16.56^{d}
	PPE (600	2.02^{c}	2.21^{ab}	43.12^{e}	46.67^{a}	54.31^{h}	59.95^{a}	14.73^{fg}	18.18^{a}
	PPE(1200)	2.15^{b}	2.27^{a}	45.63^{bc}	46.46^{a}	54.74^{g}	55.47^{ef}	14.56^{gh}	16.86^{c}
6000	Control	1.15^{j}	1.42^{hi}	38.83^{l}	39.81^{k}	42.12^{o}	49.67^{k}	11.70^{m}	12.60^{l}
	PPE (600)	1.35^{i}	1.58^{fg}	39.50	40.02^{jk}	43.21^{n}	55.76^{e}	13.54^{k}	13.85^{j}
	PPE(1200)	1.41^{hi}	1.63^{efg}	40.15	40.53^{i}	49.06^{lg}	51.86^{i}	14.38^{hi}	14.86^{f}

$^{a-o}$: Means in the same column with different letter are significantly differed at P<0.05.

fresh and dry weights/fruit and number of seeds/fruit)) of okra at 1st, 2nd, 3rd and 4th picking are via adding the fruit peel powder (pomegranate peel, orange and Banana) into the soil. They explained that increasing the yield due to fruit peel powder addition because of its contents from important quantities of macronutrients particularly potassium content which are necessary for plant growth and yield. According to Colpan et al. (2013), tomato plants treated with potassium produced the largest fruit diameter whereas the control plant had the smallest ones. Islam et al. (2004) observed that the bush-bean plant treated with potassium led to improved pod dry weight as compared to the untreated plant.

Figure 4. Effect of different concentrations of pomegranate peel extract (PPE) on minerals percentage of wheat plants irrigated with different levels of saline solution in absence (-) and presence (+) compost. The different letters (a-m) show statistical significance at $p < 0.05$; vertical bars indicate ± SE.

The promotive effect of pomegranate peel extracts on yield production and its attributes may be due to its content of bioactive antioxidant substances which induced a protective role on all plant cells, (Karthikeyan and Vidya, 2019). Antioxidant activity of the pomegranate peel extracts (PPE) qualitatively found to contain several phytochemicals like phenolics, flavonoids, alkaloids, saponins, tannins, steroids and terpenoids (El-Hamamsy and El-khamissi, 2020**)** which reflected on the quantity and quality of grain yield under salinity stress.

The utilization of compost could be a perfect occasion to minimize the unfavorable influence of abiotic factors, like salinity on crop yield. Kelbesa (2021), Kołodziejczyk (2021) and Ho et al. (2022) reported that compost participates in the stability and increment of crops quantity and quality, which may be due to the improvement in physical, chemical, and biological properties of soil. In this concern, Gomaa et al. (2015) and El Sebai et al. (2016) observed that the soil supplemented with compost improved the yield traits of maize and quinoa plants under water stress. Compost provides nutrients to the soil which raises its water holding capacity and assists the soil to preserve good tillage consequently preferable aeration for germinating seeds and plant root development and consequently improved yield component and consequently improved yield component (Edwards and Hailu, 2011).

According to Abdel-Rahman (2009) and Purnawanto & Ahadiyat, (2022), application of compost improved the quality of corn and maize crop in terms of seed protein. The improvement in wheat yield (Table 6) may be due to the increase in macro-element content (Figure 4), especially Ca content, as the result of PPE and compost. These results confirmed by Rashedy et al. (2022) who showed that increasing Ca content increased fruit weight, fruit number and pulp/peel ratio of pomegranate trees. Calcium plays an important role to alleviate salinity stress by promoting tissue growth. These influences might be resulting from the function of Ca in plant cell elongation and division, permeability of cell membrane, nitrogen metabolism and carbohydrate transport (White, 2000).

Some macro-elements (N, P, K, Na, and Ca) content of wheat plants resulted from foliar application of PPE (600 and 1200 mg L^{-1}) and/or compost amended to the soil are listed in Figure 4. The findings demonstrated definitely that salinity significantly ($P<0.05$) decreased all measured elements, with the exception of Na%, which significantly increased with rising salt levels.While PPE alone or in combination with compost treatments considerably reduced Na levels in the examined plants, the same treatments significantly ($P<0.05$) improved N, P, K, and Ca levels. In general, the greatest values of these examined elements were obtained with stressed and unstressed plants as well as with compost present or absent after PPE treatment at a dosage of 1200 mg L^{-1}). Compost was a more effective addition since it had the highest elemental concentration.

As reviewed by Ramadan et al. (2019) discovered that under salt stress, the amount of essential mineral ions (N, P, K, Ca and Mg) of sunflower plants was drastically reduced while the detrimental ion (Na^+) rose. Also, Farooq et al. (2017) indicated that salt stress interferes with nutrition availability, absorption by competitors and transfer to the above-ground plant sections. Because Na and Cl ions interfere with other elements, the presence of high quantities of these ions in the soil will lead to an unbalanced nutrition in legumes. Such findings can be opposed by others on the basis that greater NaCl concentrations, the predominant salt in the soil, have osmotic and ionic impacts on plants because they reduce the soil's osmotic potential, which reduces the availability of water and nutrients to root cells (Sharif et al., 2019**)**. Increased salinity led to oxidative stress in plants which was led to a decline in physio-chemical activity, having deleterious consequences on cell membranes (Rasool et al., 2013).

The significant increase in minerals content in yielded grains as the result of PPE treatment (Figure 4) may be because of the content of PPE from antioxidants especially polyphenols which encourage the absorption and transportation of nutrients and consequently increase the content of macro-elements. These findings are in line with those of Singh et al. (2018) who discovered that, in comparison to other pomegranate parts, the peel is a appreciated source of bioactive substances like phenolic acids (hydroxycinnamic and hydrobenzoic), hydrolyzable tannins (ellagi-tannins, gallo-tannins and gallagylesters) and flavonoids. Trans-cinnamic acid is a direct precursor of salicylic acid (Raskin, 1992**)**. In this respect, Abdallah et al (2020a) on wheat plant and Hadi et al. (2016) on summer squash fruit found that application of salicylic acid (SA) induced significant increases in N, P, K and Ca, while Na ion contents reduced as compared to control plants. Salicylic acid initiates the antioxidant reactions and encouraged Ca uptake that protect the plant from the oxidative injury (El-Tayeb, 2005**)**. Calcium ions (Ca) play a crucial role in controlling the preferential transport of K^+ over Na^+ and preserving the integrity of cell membranes (Orlov et al., 2005; Wu and Wang, 2012; Cheng et al,, 2015). Jini and Joseph (2017) discovered that by lowering Na and increasing K content, SA treatment increased salinity tolerance of rice varieties.

Composting is an excellent way to mitigate the harmful effects of salinity stress through increasing the macro-element absorption. According to research by Abdallah et al. (2020b) on quinoa plants, adding compost to soil increased its total N, K, and readily available P contents relative to the control by enhancing its physical characteristics and promoting biological activity. The same finding was obtained by El-Naggar (2010) and El Sebai et al. (2016) on *Narcissus Tazetta, L* and quinoa, respectively.

3.6. Correlation coefficient among yield and its components and the morphology and physiology traits

The result of correlation analysis (Table 7) revealed that yield parameters (Spike length, spike Wt., No. of spikelets/spike, No. of grains/spike, grain Wt./spike, weight of 1000-grains) exhibit a significant positive correlation with both morphological and physiological traits. It is observed that the highest significantly ($P<0.01$) strong positive correlation (more than 0.50) were found between morphological (Plant height, No. of leaves/tiller and tiller fresh & dry weights) and yield parameters.

Table 7. Correlation coefficient among mophological, physiological parameters, yield and its components characteristics for combined data of two studied seasons of wheat.

	Shoot length	L. No. Ti.	T.F. Wt.	T.D. Wt.	Ch. A	Ch. B	Carot.	T. pig.	IAA	Phenols	Proline	FAA	T.S.P	TSS	Sh. L.	Sp. L.	Sp. Wt.	Sp. N	No. of gr.	Gr. Wt./sp.	1000 gr. wt.	Carb.	Prot. %	N %	P %	K%	Na %	K/Na	Ca %
Shoot length	--																												
L. No. Ti	0.74**	--																											
T.F. WT	0.69**	0.81**	--																										
T.D. Wt.	0.60**	0.74**	0.83**	--																									
Ch. A	0.59**	0.61**	0.51**	0.30*	--																								
Ch..B	0.20^{NS}	0.18^{NS}	0.13**	0.10^{NS}	-0.02^{NS}	--																							
Carot.	0.31*	0.35**	0.33**	0.23^{NS}	0.37**	0.53**	--																						
T. pig.	0.77**	0.77**	0.70**	0.50**	0.65**	0.59**	0.63**	--																					
IAA	0.73**	0.80**	0.81**	0.72**	0.44**	0.40**	0.59**	0.77**	--																				
Phenols	-0.11^{NS}	-0.06^{NS}	-0.04^{NS}	0.09^{NS}	-0.29**	0.09^{NS}	0.06^{NS}	-0.01^{NS}	0.15^{NS}	--																			
Proline	-0.04^{NS}	0.09^{NS}	0.48**	0.44**	-0.23^{NS}	-0.06^{NS}	-0.23^{NS}	-0.07^{NS}	0.16^{NS}	0.04^{NS}	--																		
FAA	0.35**	0.50**	0.74**	0.68**	0.19^{NS}	-0.02^{NS}	0.02^{NS}	0.32*	0.60**	-0.19^{NS}	0.68**	--																	
T.S.P	0.39**	0.66**	0.82**	0.79**	0.26^{NS}	-0.02^{NS}	0.07^{NS}	0.40**	0.53**	-0.13^{NS}	0.71**	0.79**	--																
TSS	0.35**	0.60**	0.67**	0.51**	0.47**	-0.13^{NS}	-0.08^{NS}	0.31*	0.40**	-0.27*	0.40**	0.63**	074**	--															
Sh. L.	0.48**	0.71**	0.66**	0.55**	0.46**	0.35*	0.63**	0.68**	0.75**	0.35**	0.05^{NS}	0.25^{NS}	0.44**	0.30*	--														
Sp. L.	0.64**	0.78**	0.86**	0.79**	0.54**	0.26^{NS}	0.34*	0.72**	0.71**	-0.03^{NS}	0.37**	0.56**	0.78**	0.62**	0.74**	--													
Sp. wt.	0.73**	0.79**	0.55**	0.36**	0.64**	0.29*	0.55**	0.79**	0.63**	-0.06^{NS}	-0.31*	0.01^{NS}	0.23^{NS}	0.26^{NS}	0.69**	0.55**	--												
Sp. N.	0.79**	0.86**	0.73**	0.66**	0.60**	0.47*	0.51**	0.81**	0.75**	0.05^{NS}	-0.04^{NS}	0.23^{NS}	0.45**	0.32*	0.78**	0.78**	0.88**	--											
No. of gr.	0.61**	0.76**	0.53**	0.41**	0.58**	0.44*	0.69**	0.80**	0.70**	0.11^{NS}	-0.29*	0.01^{NS}	0.21^{NS}	0.18^{NS}	0.83**	0.61**	0.92**	0.88**	--										
Gr. wt./Sp.	0.70**	0.79**	0.67**	0.54**	0.62**	0.27*	0.51**	0.77**	0.70**	0.05^{NS}	-0.11^{NS}	0.15^{NS}	0.39**	0.35**	0.78**	0.75**	0.89**	0.92**	0.93**	--									
1000 gr. Wt.	0.78**	0.79**	0.80**	0.67**	0.62**	0.18^{NS}	0.43**	0.77**	0.79**	-0.07^{NS}	0.08^{NS}	0.39**	0.58**	0.49**	0.79**	0.78**	0.85**	0.89**	0.82**	0.94**	--								
Carb.	0.67**	0.79**	0.57**	0.41**	0.54**	0.29*	0.65**	0.75**	0.73**	0.23^{NS}	-0.15^{NS}	0.10^{NS}	0.22^{NS}	0.11^{NS}	0.82**	0.60**	0.81**	0.83**	0.83**	0.80**	0.78**	--							
Protein	0.78**	0.79**	0.60**	0.55**	0.59**	0.41**	0.63**	0.83**	0.82**	0.18^{NS}	0.23^{NS}	0.15^{NS}	0.25^{NS}	0.18^{NS}	0.77**	0.63**	0.86**	0.90**	0.89**	0.86**	0.82**	0.89*	--						
N %	0.74**	0.79**	0.60**	0.53**	0.57**	0.43**	0.62**	0.83**	0.80**	0.22^{NS}	0.18^{NS}	0.14^{NS}	0.26^{NS}	0.19^{NS}	0.80**	0.65**	0.86**	0.90**	0.91**	0.88**	0.82**	0.90**	0.98**	--					
P %	0.59**	0.79**	0.66**	0.42**	0.51**	0.51**	0.36**	0.64**	0.61**	0.05^{NS}	0.04^{NS}	0.22^{NS}	0.40**	0.37**	0.66**	0.56**	0.82**	0.80**	0.78**	0.85**	0.82**	0.70**	0.70**	0.76**	--				
K %	0.38**	0.79**	0.50**	0.56**	0.39**	0.14^{NS}	0.44**	0.52**	0.53**	0.12^{NS}	0.06^{NS}	0.37**	0.45**	0.22^{NS}	0.55**	0.57**	0.38**	0.58**	0.48**	0.51**	0.49**	0.53**	0.59**	0.58**	0.40**	-			
Na %	-0.53**	0.79**	-0.29**	-0.12**	-0.52**	-0.40**	-0.64**	-0.69**	-0.34*	0.25^{NS}	0.34*	0.10^{NS}	0.06^{NS}	0.07^{NS}	-0.25^{NS}	-0.26^{NS}	-0.60**	-0.47**	-0.53**	-0.43**	-0.35*	-0.52**	-0.55**	-0.52**	-0.33*	-0.13^{NS}	-		
k/Na	0.66**	0.53**	0.45**	0.25^{NS}	0.72**	0.53**	0.82**	0.87**	0.65**	-0.12^{NS}	-0.26^{NS}	0.13^{NS}	0.14^{NS}	0.04^{NS}	0.63**	0.48**	0.73**	0.66**	0.76**	0.64**	0.61**	0.80**	0.78**	0.77**	0.51**	0.47**	-0.77**	-	
Ca %	0.46**	0.53**	0.80**	0.60**	0.34**	-0.06^{NS}	0.12^{NS}	0.34^{NS}	0.51**	0.11^{NS}	0.61**	0.67**	078**	0.78**	0.46**	0.71**	0.27*	0.42**	0.27*	0.45**	0.55**	0.27*	0.21^{NS}	023^{NS}.	0.47**.	0.18**	-0.04^{NS}	0.15^{NS}	-

* Significant at P<0.05. ** Significant at P<0.01. ^{NS}: Not significant.

The highest correlation values were observed between tiller fresh Wt. and both 1000-grains weight and spike length (r= 0.80** & 0.86**). Also from the same table, it can be concluded that the endogenous chemical analysis (Total pigments, IAA, phenols, proline, FAA, TSP and TSS) exhibits the significant correlation with yield and yield attributes. A positive correlation was also observed in the same mentioned physiological parameters, except proline with spike Wt., No. of spikes, No. of grains/spike and grain Wt./Spike which induced a significant and non-significant negative correlation (-0.31*, -0.04^{NS}, -0.29* and -0.11^{NS}, respectively). The highly significant (P<0.01) positive correlation coefficient was observed in total pigments (0.68**, 0.72**, 0.79**, 0.81**, 0.80**, 0.77** and 0.77**) and IAA (0.75**, 0.71**, 0.63**, 0.75**, 0.70**, 0.70** and 0.79**) and with all yield parameters, respectively. It is worthy to mentioned that there is a strong positive correlation near r=1 between No. of grains/spike and spike Wt. (r= 0.92**). Also, grains Wt./spike correlated positively with No. of grains/spike and No. of grains/spike and spike wt. (r= 0.89**, 0.92** and 0.93**, respectively). Spike Wt. (r = 0.85**), No. of spike (0.92**), No. of grains (0.82**) and grains wt./spike (0.89**) induced a significant positive correlation with 1000-grains wt. In this regard, Moosavi et al. (2015) discovered that grain yield shows the highest significantly positive correlation with panicle number (r = 0.55**) and harvest index (r = 0.37*). Numerous researchers, including Rajeshwari and Nandrajan (2004) for the number of filled grains per panicle and Chakraborty et al. (2010) for the weight of 100 seeds, supported the found positive connection of grain yield with various traits. Also, Azarpour (2013) stated that rice grain yield had significant and positive correlation with panicle weight (r = 0.96) and biological yield (r = 0.71). Arafat et al. (2022) found on rice plants there is a strong positive correlation between grain yield and other yield parameters (panicle length, number of spikelets/panicle, harvest index and biological yield). The highest degree of significant positive connection was observed between the grain yield and biological yield (r = 0.730*).

4. Conclusion

Considering PPE as non-chemical (Natural) by-product of the pomegranate industry, it can preserve as safe by-product for overcoming salinity stress conditions, sine it may be integrated in soil enriched with compost. Using compost improved the capacity of plants productivity through increasing the soil fertility, decreasing nutrient losses and improves its water holding capacity. The most effective concentration of PPE was the highest one (1200 mg/L) in combination with compost since it increased photosynthetic pigments, plant osmoprotectants (Proline, free AA, TSP and TSS), endogenous IAA and total phenols and finally yield components. Such kind of treatments introduce economic and environmentally-friend alternative to chemical products that harm the environment and human health.

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