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PROMOTING SALT TOLERANCE IN WHEAT SEEDLINGS BY APPLICATION OF NITROGEN FERTILIZER

MUHI ELDEEN HUSSIEN IBRAHIM[1, 2], XINKAI ZHU*[3], GUISHENG ZHOU*[1], ADAM YOUSIF ADAM ALI[1,4], IRSHAD AHMAD[1], ABOAGLA MOHAMMED IBRAHIM ELSIDDIG[1], GUANGLONG ZHU[1] AND NIMIR ELTYB AHMED NIMIR[5]

[1]*Joint International Research Laboratory of Agriculture and Agri-Product Safety of the Ministry of Education of China, Yangzhou University, Yangzhou 225009, China*

[2]*Department of Agronomy, College of Agricultural Studies, Sudan University of Science and Technology, Khartoum 13311, Sudan.*

[3]*Jiangsu Key Laboratory of Crop Genetics and Physiology/Co-Innovation Center for Modern Production Technology of Grain Crops, Yangzhou University, Yangzhou 225009, China.*

[4]*Department of Agronomy, College of Agricultural and Environmental Science, University of Gadarif*

[5]*University of Khartoum, Khartoum 11115, Sudan*

**Corresponding author's email: xkzhu@yzu.edu.cn; gszhou@yzu.edu.cn*

Abstract

Salinity is one of the primary abiotic stresses limiting crop production, especially in arid and semi-arid areas. This study was conducted to examine if nitrogen fertilizer could alleviate the adverse impacts of salinity on wheat (*Triticum aestivum* L.) seedling emergence, seedling growth characteristic and physiological responses. Two wheat varieties (Xumai30 and Elnilein) were sown into soil treated with NaCl at levels of 1.4, 2.5, 4.2, and 7.6 dS m^{-1}. The saline soil was fertilized with three nitrogen levels as urea fertilizer (0, 86, and 210 kg N ha^{-1}). The emergence percentage, root and shoot length, and total dry weight were significantly affected by the interaction among the varieties, nitrogen, and salinity. The interaction between nitrogen and salinity was impacted the seedling vigor index (SVI). Superoxide dismutase (SOD) and protein were increased with increasing nitrogen level and decreased in salt-stressed plants. The antioxidant enzymes of peroxidase (POD) and catalase (CAT), were increased with increasing salinity level. This study revealed that nitrogen was successful for alleviating the adverse effects of NaCl. Furthermore, 86 and 210 kg Nha^{-1} had similar effects on wheat seedling emergence, seedling growth and physiological responses. Moreover, results revealed that nitrogen fertilizer at moderate salinity exerted a positive affect on wheat plants while at high salt concentration had negative affect or remained ineffective. Therefore, fertilizers management is required in the salt-affected areas to sustain yield and to decrease the degradation of soil.

Key words: Abiotic stresses, Antioxidative enzymes, Physiological attributes, Seedling growth.

Introduction

Worldwide, the growing salinity problem is linked to lousy quality irrigation water in irrigated systems and the transport of subsurface salts to the surface soil through capillary action or seeps in dryland systems. (Wassmann *et al*., 2009). Presently, around 20% of the whole agricultural areas are influenced by salinity (Anon., 2007). Salt stress usually decrease plant growth through osmotic impact, ion toxicity, and their interactions (Munns, 2002).

Nitrogen (N) is an essential fertilizer in agricultural production, and its practical use to enhance crop production is important than others fertilizers (Ibrahim *et al*., 2016 a). Salinity stress causes the ion imbalance in the soil, resulting in decreased absorption of nitrogen, phosphorus, potassium in the root.

Plants developing in saline condition are usually N deficient. The lack of nitrogen is particularly common in crops and causes inhibition of plant growth whether plants are growing under salinity stress or natural conditions. Addition of nitrogen to nitrogen deficient soils at moderate salinity enhanced growth and yield of crops. In most cases, total N uptake declines, but N concentration increases under optimal N conditions (Machado & Serralheiro, 2017; Ibrahim *et al*. 2018b).

Bread wheat (*Triticum aestivum* L.) is an essential source of food and livelihood for over one billion people in both developing and developed countries. It is reckoned among the "big three cereal crops (Metwali *et al*., 2011). China is one of the world's largest wheat-producing countries. However, Chinese wheat yield is among the highest in the world, and its estimated production put it in second place after the European Union (Anon., 2014, Anon., 2014). Wheat has become an important staple food in Sudan; it is one of the most important cereal crops in Sudan. Wheat cultivated areas in Sudan occur in irrigation schemes such as Gezira, Rahad, and New Halfa schemes (Anon., 2015). Salinity is the most critical factor limiting wheat production in Sudan particularly in the Northern States of the country (Elahmadi & Hamza, 2015). In this study, we hypothesize that adverse impacts of salt stress might be alleviated by the use of fertilizer. This investigation aims to explore the probability of mitigating salt stress by nitrogen fertilization.

Plants growing in saline soils are often N deficient. The lack of nitrogen is very common in crops and induces inhibition of plant development whether plants are growing under salinity stress or normal conditions. Addition of nitrogen to nitrogen deficient soils at moderate salt stress increased growth and yield of crops. In most cases, total N uptake declines, but N concentration increases under optimal N conditions (Ibrahim *et al*., 2018a).

Materials and Methods

Plant material: In this study, two wheat varieties, Elnilein (Provided by Agricultural Research Corporation, Sudan) and Xumai 30, routinely grown on saline soils in Sudan and China were selected as model varieties (Ibrahim *et al*., 2016a). All seeds were less than 18-month old. The seeds were treated with 2.5% Sodium hypochlorite for 5-7 min to sterilizing, then washed with distilled water three times and then air-dried. So within each variety, the seeds of uniform color, size, and shape were selected.

Soil preparation: The soil used in this study was the 0-20 cm layer of a Typic fluvaquents Entisols. It was collected from the surface of sandy loam soil (0-20 cm) of the Experimental Farm of Yangzhou University (32°30'N, 119°25'E), Jiangsu Province, China. The soil was dried and sieved with a 7 mm sieve. Then the soil was spread at a thickness of about 50 mm over a piece of polyethylene sheet. Soil suspension was prepared in deionized water at a ratio of 1:2 (soil: water) (Sonneveld & Van Den Ende, 1971). The suspension was moved and allowed to stand overnight. The soil samples were analyzed for EC with an EC meter (TZS-EC-I, Zhejiang Top Instrument Co., Ltd., Hangzhou, China), pH (1:1 in water) using a pH meter (Bench Top pH-meter by 3B Scientific - U33100 - 1011690 - pH meter), The determination of soil organic carbon is based on the Walkley-Black method. (Nelson & Sommers, 1996), nitrogen (N) was measured following the Kjeldahl method described by Labconco (1998), available phosphorus (P) was determined following Micro-Vanadate-Molybdate method Olson (1954), available potassium (K) determined following neutral ammonium acetate extract method determined by the flame photometer (Chapman & Pratt, 1962). The soil was tested containing, EC 0.26 dSm^{-1} 1.22 % organic matter, 1.0 g kg^{-1} total N, 14.1 mg kg-1 P, and 77.3 mg kg^{-1} soil test K with pH 7.1. Water added to each treatment was 3.44 L/94.3 cm^2 (pot surface area) to promote germination. Tap water (EC of 0.4 dS m^{-1}) was the water source in this experiment. The pots were weighted every 2 or 3 days to maintain the soil water content at 80% of field capacity. Each container was without holes at the bottom to avoid drainage or leaching through the pots.

Experimental design: The experiment was done on the Experimental Farm of Yangzhou University during two wheat growing seasons of winter of 2014 and 2015. The study was designed as a factorial experiment arranged in a randomized complete block design (RCBD) with three replications. The experimental factors included variety; nitrogen fertilizer (0, 86, and 210 kg N ha^{-1}), and salinity (1.4, 2.5, 4.2, and 7.6 dS m^{-1}). The saline soils were made by adding NaCl into the non-saline soil and mixed. The control treatment of soil was prepared by adding tap water. Each pot (30 cm in diameter × 32 cm in depth) was filled with 12 kg dry soil. Twenty seeds were sown at the seeding depth of 1.5 cm. All the pots were placed in the open field. The seeding dates were October 20th and 25th in 2014 and 2015 respectively.

Observations and measurements

Seedling growth measurements: The emerged seedlings were counted on a daily basis. Ten days after sowing the total emergence (%) was determined with the following formula:

$$\text{Emergence (\%)} = (\text{Emerged seeds}/\text{Total seeds}) \times 100$$

One month after seeding, five seedlings per pot were collected randomly for seedling growth measurements including seedling shoot and root length. For dry weight five plants were selected from each pot and drying at 85°C for two days to constant weight. Moreover, seedling vigor index (SVI) was calculated following (Ibrahim *et al.,* 2016 a):

$$\text{SVI} = (\text{Emergence \%} \times \text{Seedling length})/ 100$$

Physiological parameters: Leaves of three plants from each treatment were sampled and immersed in liquid nitrogen for 30 min and then stored at -75°C for the determination of physiological parameters, including soluble protein, and enzymatic activity of, peroxides (POD), catalase (CAT), and superoxide dismutase (SOD). The content of soluble protein was determined by following (Bradford, 1976) around 0.5 g of leaf sample was used, and samples were homogenized at 4ºC in 5 ml Na-phosphate buffer (pH 7.2) and then centrifuged at 4°C. The supernatants were placed on ice for analysis. The content of soluble protein was measured using the Coomassie blue dye-binding assay (Bradford, 1976). Absorbance readings were converted into protein content using bovine serum albumin (BSA) as the standard curve. Supernatants and dye were pipetted in spectrophotometer cuvettes, and absorbance was determined with a spectrometer (Model 721, Shanghai Mapada Instruments Co. Ltd, Shanghai) at 595 nm.

For enzyme extraction, frozen (–75ºC) leaves samples of wheat plant (0.5 g) were collected and powdered to the fine powder in liquid nitrogen with mortar and pestle, and then homogenized at 4ºC in 5 ml extraction buffer of 50 mM PBS, pH 7.8, 0.1 mM EDTA, 0.3% TritonX-100, 4% poly vinyl poly pyrroidone (PVP), and centrifuge at 4ºC, 10,500rpm, for 20 min, the supernatant was collected and placed on ice and used for antioxidant enzymes activities analysis. The activity of POD measured by following the method of (Xu and Ye, 1989). While SOD was determined according to the method described by Koch *et al*., (2007).

Data analysis

This study was performed in two different seasons, and there were no significant differences in all factors between the two seasons. So, the mean of each variable of the two seasons was applied for statistical analysis. The data were analyzed following the method of (Gomez & Gomez, 1984) with the statistical package of Mstat-C (Freed *et al*., 1991). Means compared by the Tukey's range test when F values were significant ($p \leq 0.05$) by an ANOVA-protected test.

Results

Emergence percentage was significantly affected by variety, nitrogen, and salinity (Table 1). Emergence percentage was increased by increasing nitrogen level, compared to the control (0 kg N ha-1), 210 kg N ha-1 increased emergence percentage by 16.1 %. However, there were no significant differences between 86 and 210 kg N ha^{-1} (Fig. 1a). The average of emergence percentage was decreased from 99.61 % at the control to 81.77%, 74.73% and 65.24% as the soil salinity was increased from 1.4 dS m^{-1} to 2.5 dSm^{-1}, 4.2 dSm^{-1}, and 7.6 dS m^{-1} respectively (Fig. 1b). Elnilein had the highest emergence percentage overall salinity and nitrogen levels as compared with Xumai 30 (Fig. 1c).

Statistical analysis showed that the seedling growth measurements were significantly affected by variety, nitrogen, salinity, and their interactions (Table 1). In the interaction between the three experimental factors (variety, nitrogen, and salinity), shoot and root length was decreased with soil salinity increased under the same nitrogen level. At the 7.6 dS m^{-1} salinity level 210 kg N ha^{-1} nitrogen treatment increased shoot length by 26.6 and 14.6 % in Elnilein and Xumai 30 respectively. However, for Xumai 30 there no significant difference between 86 and 210 kg N ha^{-1}. Root length was significantly affected by nitrogen under salinity. At 7.6 dS m^{-1} salinity level, the highest root length was 6.6 and 8.09 cm recorded at 86 kg N ha^{-1} nitrogen level in Elnilein and Xumai 30 respectively (Tables 2, 3).

In the interaction among the three-experimental factor, at 7.6 dS m^{-1} salinity level, the highest value of dry weight was 0.67g, recorded in Xumai 30 at 86 kg N ha^{-1} nitrogen level (Table 4).

Results showed that variety, nitrogen, salinity, and the interaction between salinity and nitrogen were significantly impacted SVI (Table 1). The SVI was decreased with increase in salinity level and increased with nitrogen rate increase. At the 7.6 dS m^{-1} NaCl, 86 kg N ha^{-1} treatment increased SVI by 29.2% as compared to the control. However, there was no significant difference between 86and 210 kg N ha^{-1} (Fig. 2).

The leaf soluble protein was significantly affected by nitrogen, salinity, and the interactions between variety and nitrogen and the interaction between variety and salinity (Table 1). Of the interaction between variety and nitrogen, at 210 kg N ha-1 nitrogen level, soluble protein content increased by 35.9 % and 42.3% as compared to the control in Elnilein and Xumai 30 respectively (Fig. 3a). In the interaction between salinity and variety, at 7.6 dS m^{-1} NaCl, the highest value of soluble protein was 122 mg g-1 Fw recorded in Xumai 30. However, at low (2.5 dS m^{-1}) and medium (7.6 dS m^{-1}) salinity level, Elnilein had the high values of soluble protein content (Fig. 3b).

In the interaction between nitrogen and salinity treatments, SOD decreased with increase in salinity level. Moreover, SOD at all salinity levels. At the control (1.4 dS m^{-1}) and low (2.5 dS m^{-1}) salinity level, 86 kg N ha^{-1} more effective than 210 kg N ha^{-1} (Fig. 4a).

The POD was significantly affected by nitrogen, salinity, and the interaction of salinity and variety (Table 1). Of nitrogen treatment, the POD was increased with increasing nitrogen level. At 210 kg N ha^{-1}, POD increased by 31.8% as compared to the control (Fig. 4b) In the interaction between salinity and variety, at the control (1.4 dS m^{-1}) and medium salinity (4.2 dS m^{-1}) Xumai 30 had the highest value of POD, however, at the low (2.5 dS m^{-1}) and high salinity levels (7.6 dS m^{-1}) Elnilein had the highest value of POD (Fig. 4c). The CAT was significantly affected by salinity. By increasing, salinity level CAT was increased. 7.6 dS $^{m-1}$ salinity level increased CAT by 76.3% as compared to the control (Fig. 4d).

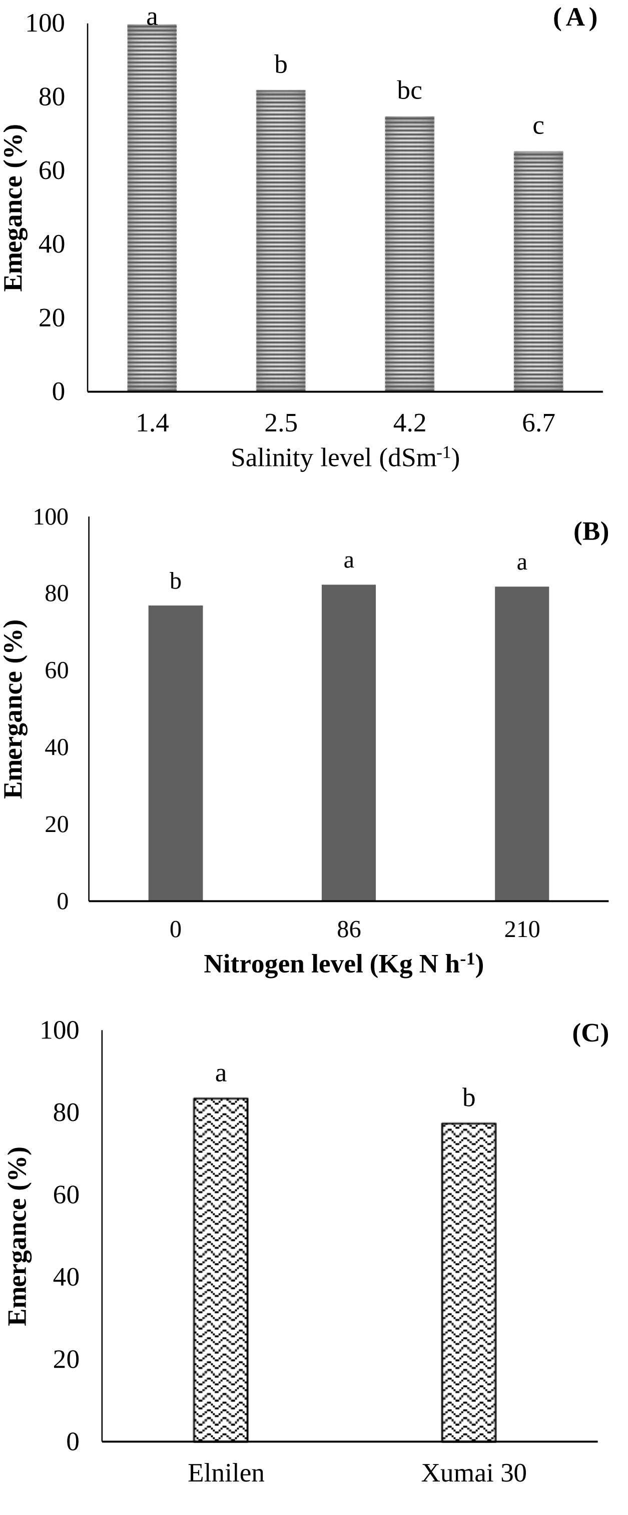

Fig. 1. Effects of salinity (A) nitrogen (B) and variety (C) on emergence % of wheat plants of Elnilein and Xumai 30. Bars with the same letter are not different at the 0.05 probability level. Means separated by the Tukey's range test.

Table 1. Analysis of variance for investigation traits.

SOV	d.f	Emergence %	Shoot length	Root length	Dry weight	SVI	Protein content	SOD	POD	CAT
Variety (A)	1	*	**	*	ns	**	ns	ns	ns	ns
Nitrogen(B)	2	*	**	**	**	**	**	**	**	ns
Salinity(C)	3	**	**	**	**	**	**	**	**	**
AB	2	ns	**	**	ns	ns	**	ns	Ns	ns
AC	3	ns	*	**	*	ns	**	ns	**	ns
BC	6	ns	**	**	**	**	ns	**	ns	ns
ABC	6	ns	**	**	**	ns	ns	ns	ns	ns
EMS	36	97.42	0.29	0.013	0.001	3.76	92.7	251.5	101	211.1
CV (%)		12.3	2.8	1.2	4.5	12.2	17.9	16.3	24.6	14.1

*Significant the difference at $p\leq0.05$; **Significant difference at $p\leq0.01$
ns = No significant difference

Table 2. Effect of interaction among the variety, N, and salinity on Shoot length of wheat plants.

Salinity (dSm^{-1})	Nitrogen (kg N ha^{-1})					
	Elnilein			Xumai 30		
	0	86	210	0	86	210
1.4	26.70^{a}	24.60^{c}	26.70^{a}	18.96^{i}	23.20^{d}	26.37^{b}
2.5	20.10^{gh}	20.00^{gh}	21.86^{e}	17.96^{k}	20.26^{g}	21.27^{f}
4.2	18.58^{j}	17.28^{l}	19.90^{h}	14.78^{n}	17.04^{l}	18.03^{k}
6.7	13.20^{p}	17.20^{l}	17.98^{k}	13.53^{o}	15.75^{m}	15.84^{m}

Different letters at the same line and column show significant differences at 0.05 level

Table 3. Effect of interaction among the variety, N, and salinity on, root length of wheat seedling.

Salinity (dSm^{-1})	Nitrogen (kg N ha^{-1})					
	Elnilein			Xumai 30		
	0	86	210	0	86	210
1.4	9.7^{j}	10.90^{f}	16.12^{a}	10.56^{g}	11.03^{e}	12.08^{c}
2.5	8.66^{m}	10.00^{i}	12.36^{b}	9.64^{jk}	10.10^{h}	11.26^{d}
4.2	6.8^{r}	8.460^{n}	9.62^{k}	8.94^{l}	9.70^{j}	7.92^{p}
6.7	4.8^{v}	6.60^{s}	6.38^{t}	7.44^{q}	8.09^{o}	5.64^{u}

Different letters at the same line and column show significant differences at 0.05 level

Table 4. Effect of interaction among the variety, N, and salinity on and dry weight (g/plan^{-1}) of wheat plants.

Salinity (dSm^{-1})	Nitrogen (kg N ha^{-1})					
	Elnilein			Xumai 30		
	0	86	210	0	86	210
1.4	0.80^{f}	1.18^{c}	1.39^{be}	0.82^{f}	1.12^{d}	1.41^{a}
2.5	0.71^{h}	0.94^{e}	1.12^{d}	0.70^{h}	0.94^{e}	1.12^{d}
4.2	0.66^{ij}	0.70^{h}	0.79^{g}	0.59^{l}	0.93^{e}	0.83^{f}
6.7	0.51^{m}	0.61^{kl}	0.65^{j}	0.52^{m}	0.67^{i}	0.63^{k}

Different letters at the same line and column show significant differences at 0.05 level

Discussion

Understanding the interactions between salinity and fertilizer are of high economic value and various studies have been carried to determine the effect of fertilizer on plant growth under saline conditions (Chen *et al*., 2010; Ibrahim *et al*., 2018b). Our study showed that seedling growth was significantly affected by salinity treatments. Also, the results indicate that wheat was sensitive to salinity during seedling emergence and early seedling growth stage. In this study emergence percentage was decreased gradually with increasing salinity level. Our finding also matched with those (Ibrahim *et al*., 2016a) who summarized that the delay in emergence by salinity principally occurred from the altered water relations induced by salinity in the intercellular areas. Also, high uptake of sodium and chloride ions during seed germination can make cell toxicity that eventually decrease the germination rate and therefore reduces the final emergence percentage. Additionally, the deterioration in final emergence percentage under salt conditions it was associated to the complex impact of osmosis and toxicity of salts or due to the influence of added Cl^- ion that yielded rise to osmotic stress (Moud & Maghsoudi, 2008). On the other hand, in this study results indicate that applied of nitrogen fertilizer has a positive affect on seedling emergence, but there are no significant differences between 86 kg N ha $^{-1}$ and 210 kg N ha^{-1} nitrogen level. Our findings were in agreement with results of (Xiong *et al*., 2013; Ibrahim *et al*., 2019) who reported that N significantly enhanced the germination percentage.

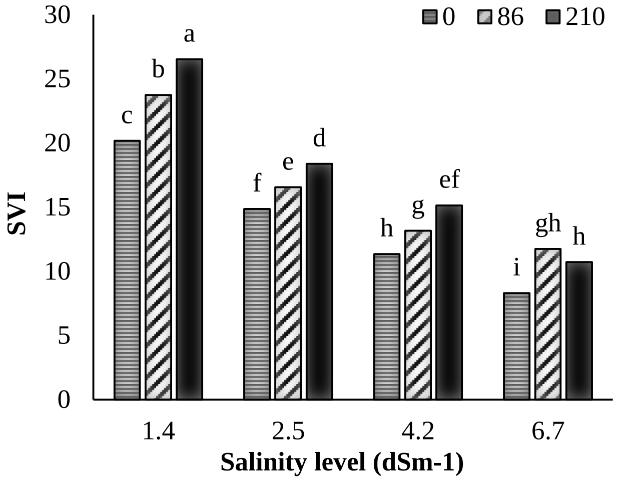

Fig. 2. Effects of the interaction between nitrogen (N kg h-1) and salinity on seedling vigor index (SVI) of wheat leaves. Bars with the same letter are not different at the 0.05 probability level. Means separated by the Tukey's range test.

The most critical parameter for salinity stress is root length because its closeness to the soil, absorbs and transfer water to the others part of the plant. Also shoot length considered the critical parameter, because it provides water to the other plant parts, for this logic, root and shoot length presents essential evidence to the response of plants to salinity stress (Sozharajan & Natarajan, 2014). In the present study, salinity inhibited the seedling growth in term of root and shoot length, and dry weight, moreover, at the 6.7dS m^{-1} salinity treatment, the root length was more affected than the shoots. Inhibition of plant development by salt may be due to the harmful impact of Na and Cl ions. The decrease in seedling growth may be due to the toxic influences of the NaCl applied. Moreover, high salt concentrations may inhibit plant growth due to the lower water absorption by the root system due to osmotic pressure. Our findings are in agreement with previous studies Ibrahim *et al*., (2016b) and Nimir *et al*., (2014) showed that there is a negative relationship between salt concentration and vegetative growth parameters. Ibrahim *et al*., (2016b) mentioned that Salinity decreased root length and shoot length as the concentration of NaCl increased; nevertheless, the reduction of the root length was more noticeable as associated with shoot length. On the other hand, nitrogen treatment enhanced plant growth in term of shoot and root length, and dry weight. In the present study, results showed that the impact of nitrogen treatments on the seedling growth parameters was positive.

Moreover, in the combination of salinity and nitrogen, results revealed that nitrogen treatments at moderate salinity exert a positive and effective influence on these parameters while at high salt concentration was harmful or ineffective. These findings were in agreement with those of (Fallahi & Khajeh-Hosseini, 2011, Ibrahim *et al*., 2018b). Furthermore, saline soil can change the role of nitrogen in plants metabolism, and there is a possibility that the application of N fertilizers can alleviate harmful impacts of moderate salinity and assist in increasing the plant growth. (Murtaza *et al*., 2013).

The damaging impacts of the salt stress on plants could be recognized at all plant growth stages as the death of plants and reductions in production. High salinity, affects plant growth by changing the physiological processes (Muscolo *et al*., 2003). In this study, results indicated that salinity stress inhibited physiological parameter in term of soluble protein and antioxidant enzymes compared with non-saline conditions.

In this investigation, leave soluble protein content was significantly affected by salt stresses. Moreover, protein content was increased when the salinity and nitrogen levels were increased. These findings agree with results reported by (Mahboobeh & Akbar, 2013). Also, in agreement with those who stated that, the soluble protein was considerably higher than that in non-saline treatment (Nimir *et al*., 2015; Ibrahim *et al*., 2018a), and disagreed with those who reported that salinity stress significantly reduced protein contents in plant (Ebrahimian & Bybordi, 2012, Gautam & Singh, 2011).

To cope with oxidative harm under salinity stress, crop plants have developed an antioxidant defense system (Foyer & Noctor, 2005, Kala, 2015). In the present investigation, the highest SOD activity was observed at the control and low (1.4 dS $m^{-1)}$ salinity level with the nitrogen level (210 kg N ha^{-1}), but at the medium (4.2 dS m^{-1}) and high salinity levels (6.7 dS m^{-1}), 1N had the highest value of SOD activity. Many researchers have also reported the increased activity of SOD under salt stress in canola (*Brassica napus* L.) (Ebrahimian & Bybordi, 2012), and wheat (Kahrizi *et al*., 2012).

In this study, we observed a significant increase in CAT and POD activity in leaves with increasing salinity and nitrogen level. Approximate increase in CAT activity under salinity has been observed in wheat (Ibrahim *et al*., 2018a). An increase in the Antioxidative enzymes under salt stress could be suggestive of an increased. The result of ROS and improvement of a protective mechanism to decrease oxidative harm triggered by stress in plants. Catalase in peroxisomes breaks down H_2O_2. Peroxidase in cytosol and chloroplast can correctly scavenge H_2O_2. An increase of peroxidase activity by salt treatment in plants has also been reported by (Kahrizi *et al*., 2012). Our finding revealed that antioxidant enzymes (POD and SOD) activity increased slightly at all of the nitrogen treatments. The related result has been observed by (Rios-Gonzalez *et al*., 2002), and CAT initially increased with increasing nitrogen rate. Associated increases in the CAT has been followed by (Huang *et al*., 2004).

Fertilization with N may add to soil salinization and enhance the adverse impacts of salinity on plant production (Ibrahim *et al*., 2018b). Also, the potential for NO_3 leaching may improve where moderate to high quantities of salts are already in the soils because plants under salinity stress cannot absorb and use the utilized N efficiently. Subsequently, careful fertilizer management is crucial in salt-affected soils to provide yields and to reduce the degradation of soil (Chen *et al*., 2010). Nevertheless, the interactions between N fertilization and salinity and nitrogen metabolism in pants is a highly complicated system.

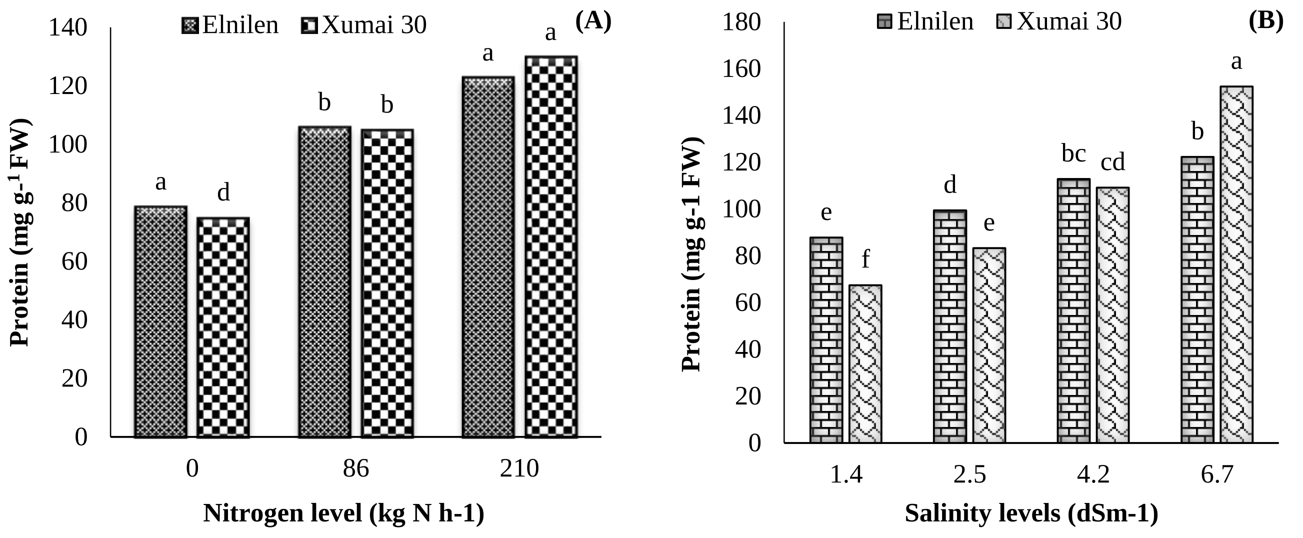

Fig. 3. Effects of (A) the interaction between varieties and nitrogen and (B) the interaction between varieties and salinity on the Protein ($mg^{-1}g$ -1 FW) of wheat plants of Elnilein and Xumai 30. Bars with the same letter are not different at the 0.05 probability level. Means separated by the Tukey's range test.

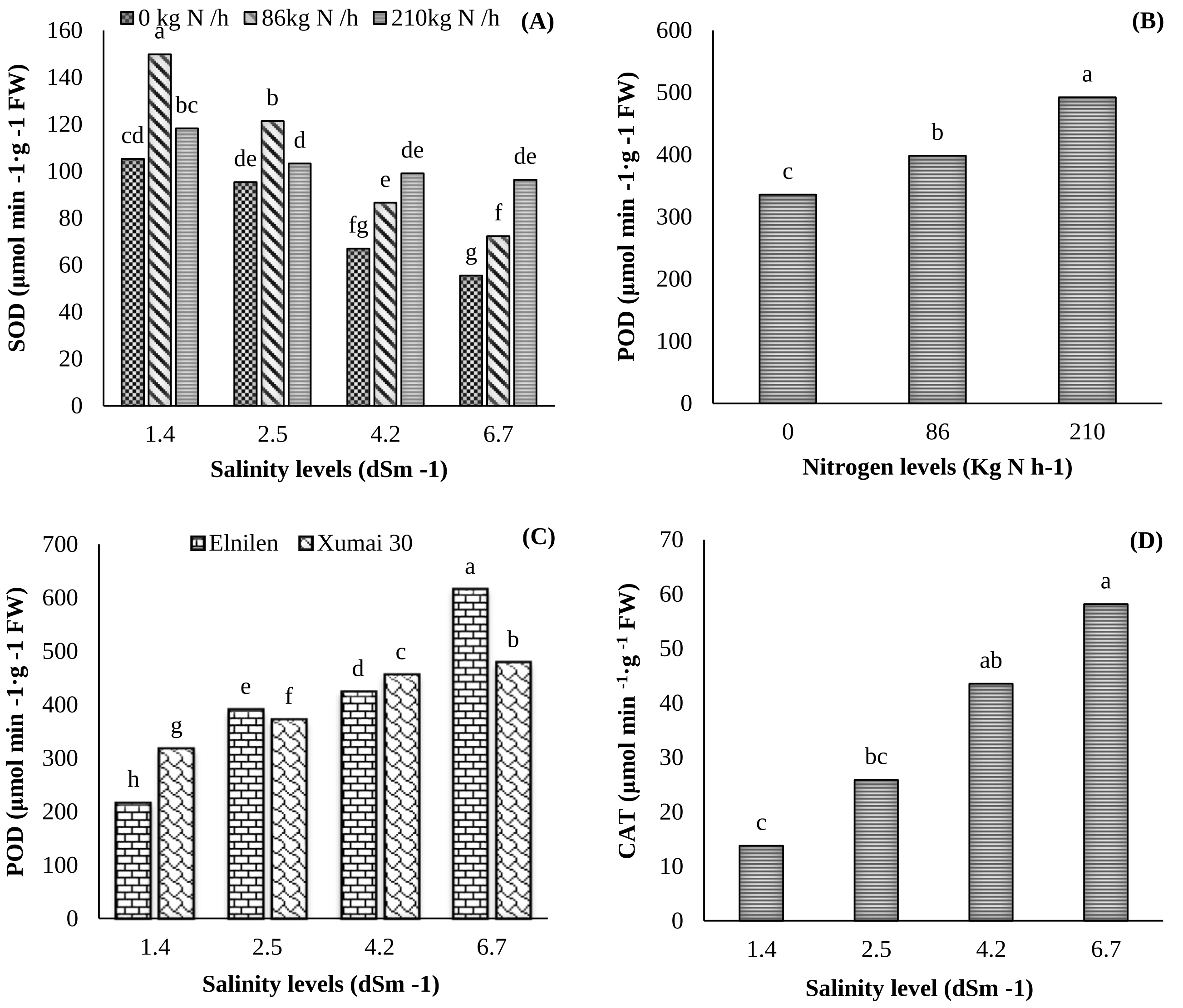

Fig. 4. Effects of (A) the interaction between nitrogen and salinity on SOD (B), nitrogen on POD, (C) the interaction between variety and salinity on POD, and salinity (D) on CAT of wheat varieties of Elnilein and Xumai 30. Bars with the same letter are not different at the 0.05 probability level. Means separated by the Tukey's range test.

Conclusion

Present study examined the effects of nitrogen on seedling emergence, seedling growth characteristics and some physiological responses of two wheat varieties exposed to salinity. The results showed that the seedling emergence and seedling growth were inhibited significantly by high salinity and appropriate use of nitrogen application reduced the adverse impacts of sodium chloride on seedling growth and physiological responses. Therefore, fertilizers management is needed in the salt-affected regions to reduce the degradation of soil. In this study, we conclude that, 86 kg N ha^{-1} nitrogen rate was more efficient than 210 kg N ha^{-1} in alleviating adverse effects of salinity on different parameters that were investigated. The results from this study showed that variety Elnilein tended to have higher nitrogen response at 86 kg N ha^{-1} and that breeding for nitrogen use efficiency could be a potential way to increase yield. However, Xumai 30 had better performance at higher salinity level (7.6 dS m^{-1}) and is useful for breeding under saline conditions. furthermore, more investigations are needed to optimize the effectiveness of nitrogen fertilizer and apply different sources of nitrogen on more varieties of wheat under saline conditions.

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