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Optimization of Cowpea Productivity and Seed Quality under Soil Natural Salinity Stress Using some Different Protective Treatments

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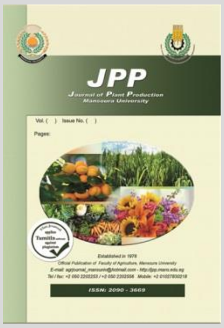

ABSTRACT

This study was conducted with the aim is amelioration salinity stress and optimizes flowering, seed productivity and quality of cowpea (Kaha 1) under the stress of natural soil salinity using some different treatments during both successive seasons 2018-2019. The seeds of seed priming were grown under the same levels of natural saline stress, medium (5dS/m) and high 7dS/m) in two fields of El-Serw Agricultural Research Center, Damietta governorate. Sulfur (0.4 ton/fed.) and sulfuric acid (10 L/fed.) as soil amendments and chitosan (200ppm), silicon (200ppm), and yeast extract (50ml/L) as different foliar applications in addition to untreated control. The layout of the current experiment was planned as split-split plot design in a completely randomized blocks design. The results conducted into a negative feedback of salinity stress on flowering, dry yield productivity and seed quality in comparing to improved ones by soil amendments or foliar applications. The major interaction in optimization flowering, dry yield and quality was less level of salinity stress (5dS/m) interacted with mixed treatment between sulfur (0.4 ton/fed.), followed by sulfuric acid (10 L/fed.) amended with soil and sprayed with chitosan (200ppm) or by yeast extract (50ml/L). Therefore, we recommend adding sulfur to the soil (0.4 ton/fed.) before planting as well as spraying plants with chitosan (200ppm) or spraying with yeast extract (50ml/L) after 20 days of planting 3 times every 10 days to increase plant tolerance on soil salinity to obtain the best flowering, seed productivity and the highest quality under the same conditions.

Keywords: Salinity stress, soil amendment, sulfur, sulphuric acid, foliar application, chitosan, silicon, yeast extract, seed quality.

INTRODUCTION

Soil salinity is one of the most brutal environmental factors as it threatens crop productivity and an increased risk and threat to food supplies around the world. Day after day, the more land area is affected by salinity and most of crop productivity and quality are sensitive to salinity (Shahbaz and Ashraf, 2013). Salinity stress reduces almost aspects of plant development such as the speed and percentage seed germination, the vegetative characteristics of plant, the content of photosynthetic pigments and different minerals either in plants and seeds (Qados and Moftah, 2015; Yahyaabadi *et al.*, 2016).

Cowpea (*Vigna unguiculata* L.), is an important grain legume grown in the tropics where it constitutes a valuable source of protein in the diets of millions of people (Boukar *et al.*, 2019). Salinity stress has a negative feedback on its germination, vegetative growth, productivity and quality of productive seeds (Gogile *et al.*, 2013; Win and Oo, 2015). In addition, there are a residual effect of soil salinity on the physiological quality of produced seeds (Neta *et al.*, 2016).

Application of soil amendments or growth stimulants is the most recent approach for overcoming salinity stress on the growth and productivity of plants. Soil amendments improve the main characteristics of soil for more suitability to cultivation. Sulphur and sulphuric acid are the main and most wide soil amendments of saline soil in this field especially in Egyptian soils. Their improvement was summarized by their main role in reduction of pH-value and improving availability of microelements in soil as well as transport microelements for plant growth and increase yields and related characteristics (Kineber *et al.*, 2004).

Meanwhile, chitosan, yeast, and silicon have recently been reviewed as important foliar and successful plant stimulants (Jabeen and Ahmad, 2013). Chitosan and its derivatives are known as bio renewable, biocompatible, biodegradable and bio-functional polysaccharide, and non-toxic, and environmentally friendly. It induces plants to be more resistant to unfavorable conditions and growth stimulator and improves yield productivity in many crop species (Zargar *et al.*, 2015; Bakhoum *et al.*, 2020). On the other hand, a promising and promoting natural plant growth at various crops is yeast extract which has high nutrient elements (Mohamed *et al.*, 2018). These element have ability for enhancing cell division and nutritional status, stem elongation, and improvement of vegetative and reproductive growth stages, crop quality and productivity These elements have a reflection on enhancing vegetative and reproductive growth stages and crop quality and productivity (Ibraheim, 2014; Mohamed and Almaroai, 2016). While, Silicon is one of the beneficial element in many of physiological processes of plants such as increasing the absorption of roots to necessary elements for plants development and activity of oxidative enzymes, improvement of photosynthesis process as well as reduction

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of toxicity of sodium accumulation and heavy metals (Adrees *et al.*, 2015). Additionally, silicon in plants elevates the concentration of sodium and potassium, supports cell wall and aerial parts of plants to be more resistant and ameliorates biotic and abiotic stresses, in special salt stress (Guerriero *et al.*, 2016). The current study was carried out for alleviating natural salinity stress and optimization of cowpea productivity by both applications; foliar application and application of soil amendment. Additionally, it is determined the effective application to optimize its productivity and residual effect of salinity and each of applied treatment on physiological quality of produced seeds.

MATERIALS AND METHODS

The current study was carried out at both different levels of natural soil salinity during the two successive 2018& 2019 at farm following to El-Serw Agricultural Research Center (EARC), Damietta Governorate, Egypt.

Heavy clay soil with alkaline pH is the main soil type. Both levels of salinity differentiated according to soil analysis (Table 1). High saline soil in the study area was attributed to increasing in the mean of electric conductivity (7.0 $dS.m^{-1}$) and increasing the concentration of different cations (sodium, calcium, and magnesium), Exchangeable Sodium Percentage (ESP), and ions as (chlorides, bicarbonates, and sulphates) in soil than moderate or lower level of salinity.

Experimental design

Healthy seeds of cowpea (*Vigna unguiculata* L., cv. Kaha 1) were primed by their soaking in each of following solutions: tap water and others treated only with soil amendments. Meanwhile, other soaking solutions from each of foliar or spray substances either chitosan at 200 ppm, or silicon at 200 ppm, or yeast extract with the concentration at 20g/ l. period of seed soaking for 3 hours and half then dried back to their original water content.

Table 1. Clarifying the physical and chemical characteristics of soil samples collected from both study area (El-Serw Agricultural Research Center), Damietta Governorate, Egypt

Area	Type class	pH	EC (dSm^{-1})	C. Sand (%)	F. Sand (%)	Silt (%)	Clay (%)	Cl^-	HCO_3^-	CO_3^{--}	SO_4^{--}
				Percentage of soil particle size				Soluble Ions Concentration (%)			
Area 1	Heavy	8.22	4.95	1.64	9.5	22.64	66.06	33.15	1.48	----	14.85
Area 2	clay soil	8.38	7.05	1.7	11.47	21.47	66.26	43.35	1.85	----	26.75

Area	Soluble Cations (mg/100g dry soil)				Nutrients			
	Na^+	K^+	Ca^{++}	Mg^{++}	Organic matter (%)	Available N (ppm)	Available P (ppm)	Available K (ppm)
Area 1	33.9	0.64	7.22	7.19	9.55	34.5	8.83	464.5
Area 2	44.65	0.22	13.1	12.44	9.25	32	7.86	455.5

The layout of the current experiment was planned as split-split plot design in a completely randomized blocks design with three replicates. The main effect plot was both different levels of natural soil salinity, which different both types of protective treatments were randomly distributed as sub plots for soil amendments and sub-sub plots for second type of protective treatments; foliar applications. Net treatments from this experiment included twenty four treatments which were the interaction between two levels of natural soil salinity (main plot), three sub plot of soil amendments (control without any treatments, sulfuric acid and sulphur, and finally four sub-sub plots of foliar applications (control (tap water), potassium silicate, yeast extract, and chitosan as the following :

A. Main plots: Natural soil salinity level (dS/m)

1.Medium salinity level (Area 1, EC 5.0 dS/m)

2.High salinity level (Area 2, EC 7.0 dS/m)

B. Sub-plots, soil amendments

1.Control (without any treatments)

2.Sulfuric acid (10L./fed.)

3.Sulphur (0.4 ton/ fed.)

C. Sub-sub plots, foliar applications

1. control (Tap water)
2. Silicon (200ppm)
3. Yeast extract (50ml/L)
4. Chitosan (200ppm)

Seed-priming of cowpea was cultivated during the first week of May in both seasons. Seeds were sown on one side of the ridge (4 meters length and 0.70 meters width), at a spacing of 15 cm between hills within the same row, each hill contain about 3-4 seeds and thinned to one plant, The sub-sub experimental plot contained six ridges making an area of 16.8 m^2. The protocol of applied protective treatments were divided as soil amendments by addition of sulphur (0.4 ton/fed) during preparation of soil for cultivation and sulfuric acid, 10 L/fed., add to its subplot by the first irrigation, while foliar applications were sprayed during plant growth for triple times, first one after twenty days from seed sowing with ten days intervals.

Data collection

1. Flowering Parameters

During the flowering phase of cowpea, the average number of flowers at ten plants in each plot of experiment were randomly chosen, labeled and the following data were recorded:

- Number of flowers per plant: The whole number of the opened flowers per plant all over the season were recorded.
- Fruit set (%): according to the following equation:

$$\text{Fruit set (\%)} = \frac{\textit{Number of pods/plant}}{\text{Number of flowers/plant}} \times 100$$

2.Seed Yield and Its Components

-Average of pod length

-Average of pod weight

-Weight of 100-seeds

-Shelling ratio (%): Shelling ratio is the percentage of the net sum of the following equation according to (Marquard and Tipton, 1987)

$$\text{Shelling ratio (\%)} = \frac{\textit{weight seeds per 30 pods}}{\textit{Weight of 30 pods}} \times 100$$

- Number of pods/plant

-Total seed yield/fed.

3.Quality of productive seeds

Productive seeds of each treatment were full dryness. Productive seeds were separated according to treatment type. Soaking of seeds were carried out in distilled water with three replications, for three hours, and then transferred to a moistened filter paper for allowing them for germination. Eight days during the germination were observed for determined the quality of germination indices by different indices as the percentage of germination, rate of germination and seedling vigor index per each treatment. The percentage of germination was calculated by the following equation (Hartman *et al.*, 2002)

$$\text{Germination. \%} = \frac{\sum \textit{total sum of germinated seeds at total germinated } \text{day (8days)}}{\text{Total seeds number that processed for germination}} \times 100$$

Meanwhile, the rate of germination.% represented the relative germination percentage at each treatment to the germination rate at control as the following

$$\text{Germination rate \%} = \frac{\text{Germination precentage of each treatment}}{\text{Germination percentage at control}} \times 100$$

According to Abdul-Baki and Anderson (1973), Seedling Vigor index measured the strength of seedling by the following equation:

$$\text{Seedling Vigor index} = \sum(\text{average sum of radicle and pulumle length (cm)} \times \text{Germination \%.}$$

Meanwhile, the vegetative indices were expressed by the length and fresh& dry weight of radicle and plumule were recorded for detection the vegetative indices for germinated seeds.

Data analysis

All recorded data were processed by SPSS (Statistical Package for Social Sciences, Inc.) version 20.0 for Windows 7. The main statistical analyses were one way ANOVA with its Post-hoc analysis by Duncan's Multiple Range Test at 5% Level for detecting a statistically significant variance between the different treatments at $P<0.05$ (Snedecor and Cochran, 1982).

RESULTS AND DISCUSSION

1. Flowering& dry yield parameters

Effect of salinity

Represented data in Table (2) illustrated the effect of different levels of soil salinity on the main characteristics of flowering and dry yield; average of flowers number, fruit set percentage, length and weight of pods, weight of one hundred seeds and finally, yield mass during both growing seasons. Such data revealed that increasing the level of soil salinity was significantly reduced the characteristics of flowering and yield parameters overall both growing seasons. These results showed that delayed flowering and pod formation with decreasing the percentage of fruit set as well as pods length and weight coincided with the high level of salinity (area 2; EC7.0).

In sequence, the significant decrease of shelling ratio, weight of hundred seeds as yield index and mass yield were correlated with the increment of soil salinity levels at both seasons of harvest. The minimal average of them was detected at higher level of soil salinity, area 2. In opposite to area (area 1; EC 5.0) with lower level of soil, as illustrated in Table (2).

The significant reduction of yield parameters as the soil salinity stress was earlier concluded on cowpea (Manaf and Zayed, 2015; Tagliaferre *et al.*, 2018; Al-Hayany, 2020). That attributed to salinity which is significantly reduced chlorophyll contents, potassium concentrations, and thus distorted photosynthesis and hormonal regulation, causing nutritional imbalance, specific ion toxicity and osmotic effects in legumes. All of this, the reduction of reproductive growth has been available result by inhibiting the growth of flowers, pollen grains and embryos resulting in inappropriate ovule fertilization and less number of seeds grain yield and quality (Qados, 2010; Torabi *et al.*, 2013; Farooq *et al.*, 2017).

Effect of soil amendments

The data presented in Table (2) displayed the statistical analysis of the effect of applied soil amendments on the main parameters expressing the dry yield during 2018 and 2019 seasons. An extremely significant enhancer effect was revealed to add different applied soil amendments i.e., sulfuric acid and sulphur on all flowering and yield parameters when compared to the minimal one at untreated plants in control plot during both seasons. The highest yield parameters were mostly influenced by the addition of sulphur amended with soil, followed by sulfuric acid during both seasons of harvest. In this trend, many researchers supported this role of sulfur in increasing yield parameters and quality at different legumes which are in harmony with the current results. Among of them are the conclusions of Osman and Rady (2012) on pea, Zhao *et al.* (2008) and Mahrous *et al.* (2016) on soybean and Nascente *et al.* (2017) on common bean.

Effect of foliar application

The effect of usage different foliar application i.e., potassium silicate, yeast extract, and finally chitosan was clarified in Table (2) on various flowering and yield parameters. Statistically, an extremely significant effect of these formely foliar applications was correlated with all parameters. Moreover, apply of different foliar applications had a very significant improvement to all flowering and yield parameters in comparing to untreated plants at control plants. It was clarified in both seasons. The most improvable to flowering and yield parameters was spraying chitosan or yeast extract then potassium silicate at both seasons. In this trend, some studies supported the current result as on pea (Khan *et al.*, 2018) and cowpea (Abou El-Khair, 2015; Shabana *et al.*, 2019) who confirmed the efficiency of chitosan spraying in improvement of increasing flowers and pod number as well as length and weight of pods per plant. Meanwhile, similar positive results of chitosan on the pod or fruit weight and yield are in accordance with those obtained by by Sheikha (2011) on common bean, Amiri *et al.* (2015) on bean, and Farouk and Ramadan (2012) on cowpea.

Table 2. Effect of each of different levels of natural soil salinity, different applied of soil amendment s and finally foliar applications on flowering and dry yield parameters under natural soil salinity conditions during 2018 and 2019 seasons

A- Soil salinity (dS/m)	Flowering parameters				Yield parameters			
	Number of flowers /plant		Fruit set %		Pod length (cm)		Pod weight (g)	
	2018	2019	2018	2019	2018	2019	2018	2019
Area 1 (5.0)	25.28^{a}	27.3^{a}	84.90^{a}	76.91^{a}	11.06^{a}	11.47^{a}	21.37^{a}	22^{a}
Area 2 (7.0)	19.81^{b}	21.06^{b}	83.32^{b}	75.35^{b}	9.34^{b}	9.86^{b}	18.15^{b}	18.79^{b}
A- Soil salinity (dS/m)	**Yield parameters**							
	Shelling ratio (%)		**Weight of 100 seeds (g)**		**Number of pods/plant**		**Total yield (Kg/fed.)**	
	2018	2019	2018	2019	2018	2019	2018	2019
Area 1 (5.0)	70.07^{a}	70.24^{a}	23.89^{a}	24.81^{a}	19.72^{a}	21.00^{a}	1274^{a}	1297^{a}
Area 2 (7.0)	65.82^{b}	66.30^{b}	19.19^{b}	19.59^{b}	16.81^{b}	18.03^{b}	1034.^{b}	1037^{b}

Means followed by the same letter within each column do not significantly differed using Duncan's Multiple Rang Test at the level of 5%.

Also, these findings are consistent with Sakr *et al.* (2013); Ibraheim (2014); Saker *et al.* (2015); Ray *et al.* (2016a) and Al-Amery and Mohammed (2017) on other crops that confirmed the role of yeast extract in improvement of yield traits.

Effect of interaction

Triple interaction effect was clarified on the flowering and yield parameters i.e., the number of flowers and fruit set (%), as well as the pod length and weight, the number of pods per plant, the shelling ratio. the weight of hundred seeds as yield index, and mass yield per fed. (Table 3 a and b), at both seasons.

The prementioned triple interaction had an obvious improved effect on the number of flowers and percentage of fruit set during both seasons. However, statistical analysis clarified that a significant variation in the improvement of formely yield characteristics was attributed to different levels of soil salinity, applied of soil amendments and foliar application at both seasons. The mostly improved to formally yield characteristics was the combined interactions between lower natural soil salinity level treated by mixture of sulfur amended with soil and chitosan or yeast extract sprayed plants throughout growth. The combination between the prementioned role of sulphur with chitosan or yeast extract ameliorate the salinity stress during proper maturation of yield.

This effect differentiated according to level of salinity stress. The results have proven that lower salinity stress treated by a mixture between soil amendments and foliar applications supported the better yield parameters than treated with one of protective treatments > untreated ones in comparing to likes at high level of salinity stress.

Table 3a. Effect of triple interaction among natural soil salinity level X soil amendments X foliar applications on flowering and dry yield parameters under natural soil salinity conditions during 2018 and 2019 seasons

A- Soil salinity (dS/m)	Soil amendments	Foliar applications	Flowering parameters				Yield parameters			
			No. of flowers /plant		Fruit set (%)		Pod length (cm)		Pod weight (g)	
			2018	2019	2018	2019	2018	2019	2018	2019
Area 1 (EC 5.0)	Control (0)	Without (Tap water)	13.33^{o}	11.33^{n}	50.25^{j}	60.07^{g}	6.3^{h}	6^{jk}	11.67^{j}	10.67^{k}
		silicon (200ppm)	18.33^{fg}	18.00^{ghi}	72.16^{f}	78.17^{def}	10.15^{bcdef}	10.66^{fghij}	17.33^{hi}	18.33^{ij}
		Yeast extract (50ml/l)	18.67^{ef}	18.33^{ghi}	72.71^{f}	82.26^{b-f}	10.33^{def}	10.8^{efghij}	18.83^{fg}	19.4^{fgh}
		Chitosan (200ppm)	19.33^{e}	19.33^{efg}	74.12^{e}	88.15^{a-d}	10.83^{de}	11.16^{defghi}	20.33^{def}	20.00^{efg}
	Sulfuric acid (10 L/ fed.)	Without (Tap water)	17.00^{i}	16.67^{ij}	63.97^{I}	74.07^{ef}	9.6^{f}	10.5^{defg}	18.10^{i}	19.33^{ij}
		silicon (200ppm)	21.33^{d}	23.67^{c}	83.09^{d}	90.62^{abc}	12.00^{bc}	12.27^{bcde}	23.17^{c}	23.4^{cdef}
		Yeast extract (50ml/l)	21.67^{cd}	24.67^{bc}	87.83^{ab}	92.28^{ab}	12.17^{abc}	12.50^{bcd}	23.50^{bc}	23.6^{bcde}
		Chitosan (200ppm)	23.00^{ab}	26.00^{ab}	88.45^{a}	95.65^{a}	12.93^{ab}	13.33^{ab}	24.70^{ab}	25.20^{ab}
	Sulphur (0.4 ton/ fed.)	Without (Tap water)	18.00^{fgh}	17.33^{hi}	65.36^{h}	76.53^{def}	10.1^{ef}	10.3^{defg}	18.33^{hi}	19.43^{i}
		silicon (200ppm)	22.33^{bc}	25.00^{bc}	87.99^{ab}	91.04^{abc}	12.17^{abc}	12.93^{abc}	23.27^{bc}	24.0^{abcd}
		Yeast extract (50ml/l)	22.67^{ab}	25.33^{ab}	88.15^{a}	94.14^{a}	12.72^{ab}	13.00^{abc}	24^{abc}	24.5^{abc}
		Chitosan (200ppm)	23.67^{a}	27.00^{a}	88.88^{a}	95.77^{a}	13.17^{a}	13.67^{a}	25.17^{a}	25.43^{a}
Area 2 (EC7.0)	Control (0)	Without (Tap water)	8.33^{q}	8.33^{m}	48.15^{k}	56.48^{g}	4.43^{i}	4.33^{k}	8.67^{k}	8.33^{l}
		silicon (200ppm)	13.67^{no}	15.00^{jk}	66.57^{h}	80.59^{cdef}	7.83^{g}	8.366^{jk}	15.63^{i}	16.20^{j}
		Yeast extract (50ml/l)	14.33^{mn}	15.67	68.06^{g}	81.43^{cdef}	8.2^{g}	8.63^{ghijk}	16.77^{hi}	17.07^{ij}
		Chitosan (200ppm)	15.00^{lm}	16.4^{hi}	71.68^{f}	82.22^{cdef}	8.5^{g}	9.5^{defghi}	17.83^{gh}	18.27^{hi}
	Sulfuric acid (10 L/ fed.)	Without (Tap water)	11.67^{p}	13.00^{l}	69.11^{g}	80.05^{def}	6.5^{def}	6.7^{ijk}	13.63^{i}	14.70^{j}
		silicon (200ppm)	15.50^{kl}	17.67^{hi}	83.01^{d}	86.08^{a-e}	10.77^{def}	11.5^{defghi}	21.23^{efg}	21.73^{gh}
		Yeast extract (50ml/l)	16.00^{jk}	18.67^{fgh}	83.92^{cd}	87.73^{a-d}	11.44^{cd}	12.00^{cdef}	21.10^{efg}	21.80^{fgh}
		Chitosan (200ppm)	17.33^{hi}	20.33^{de}	85.24^{bc}	92.36^{ab}	12.11^{abcd}	12.57^{abcd}	22.5^{cde}	23.3^{cdef}
	Sulphur (0.4 ton/ fed.)	Without (Tap water)	13.33^{o}	14.33^{k}	72.06^{f}	80.05^{def}	8.00^{g}	8.50^{hijk}	15.63^{i}	16.63^{ij}
		silicon (200ppm)	16.83^{ij}	20.00^{ef}	84.97^{bc}	85.37^{abcd}	10.7^{def}	11.6^{defgh}	20.5^{efg}	21.30^{efg}
		Yeast extract (50ml/l)	17.00^{i}	20.33^{de}	85.24^{bc}	88.32^{a-d}	12.00^{bc}	12.27^{bcde}	21.38^{ef}	22.47^{defg}
		Chitosan (200ppm)	17.67^{ghi}	21.6^{d}	86.15^{b}	92.57^{ab}	12.27^{abc}	13.03^{abc}	22.90^{cd}	23.6^{bcde}

Means followed by the same letter within each column do not significantly differed using Duncan's Multiple Rang Test at the level of 5%.

Table 3b. Effect of triple interaction among A. natural soil salinity level X B. soil amendments X C. foliar applications on flowering and dry yield parameters under natural soil salinity conditions during 2018 and 2019 seasons

A- Soil salinity (dS/m)	Soil amendments	Foliar applications	Yield parameters							
			Shelling ratio (%)		Weight of seeds (g)		Number of pods /plant		Total yield (Kg/fed.)	
			2018	2019	2018	2019	2018	2019	2018	2019
Area 1 (EC 5.0)	Control (0)	Without (Tap water)	63.00^{kl}	60.00^{k}	16^{g}	17.5^{g}	8.00^{p}	5.67^{l}	1093^{g}	1123^{e}
		silicon (200ppm)	67.66^{de}	68.66^{gh}	21^{ef}	22.5^{ef}	14.33^{hij}	13.00^{i}	1267de	1293^{c}
		Yeast extract (50ml/l)	69.33^{cd}	69.33^{fgh}	23^{cd}	23.9^{ef}	15.33^{fgh}	13.33^{hi}	1277de	1300^{c}
		Chitosan (200ppm)	70.33^{bc}	70.50^{efg}	23.8^{cd}	24.5^{de}	17.00^{e}	14.33^{gh}	1283de	1303^{c}
	Sulfuric acid (10 L/ fed.)	Without (Tap water)	66.83^{fg}	67.31^{ij}	21^{d}	21.5^{f}	13^{kl}	10.67^{j}	1106.429	1190^{d}
		silicon (200ppm)	70.33^{cd}	70.53^{de}f	24.5^{cd}	25^{cd}	19.33^{d}	19.67^{d}	1327^{bc}	1350^{b}
		Yeast extract (50ml/l)	71.66^{bc}	72.53^{cd}	26.5^{bc}	27.5^{abc}	20.00^{d}	21.67^{c}	1340^{ab}	1360^{ab}
		Chitosan (200ppm)	74.50^{a}	74.66^{ab}	27.9^{ab}	28^{a}	22.00^{ab}	23.00^{ab}	1367^{ab}	1377^{ab}
	Sulphur (0.4 ton/ fed.)	Without (Tap water)	68.33^{ef}	68.33^{ij}	21.5^{ef}	22^{ef}	13.33^{jkl}	11.33^{j}	1183.2^{de}	1216.66^{d}
		silicon (200ppm)	70.50^{bc}	71.33^{cde}	25.5^{ab}	26^{bc}	20.33^{cd}	22.00^{bc}	1333^{b}	1357^{ab}
		Yeast extract (50ml/l)	72.53^{ab}	73.33^{bc}	27^{bc}	28.8^{ab}	21.33^{bc}	22.33^{bc}	1342^{ab}	1365^{ab}
		Chitosan (200ppm)	75.83^{a}	76.33^{a}	29^{a}	30.5^{a}	22.67^{a}	24.00^{a}	1377^{a}	1397^{a}
Area 2 (EC7.0)	Control (0)	Without (Tap water)	57.33^{j}	57.00^{k}	13.33^{i}	14.33^{h}	4.67^{q}	4.00^{m}	810^{g}	796.667^{i}
		silicon (200ppm)	63.66^{ijk}	64.00^{j}	17.5^{hi}	19^{g}	11.00^{n}	10.00^{jk}	1001.33^{f}	1012.67^{gh}
		Yeast extract (50ml/l)	64.33^{hi}	64.83^{ij}	19.5^{h}	20.4^{g}	11.67^{mn}	10.67^{j}	1010^{f}	1020^{g}
		Chitosan (200ppm)	65.66^{gh}	66.00^{ij}	20.3^{h}	21^{g}	12.33^{lm}	12.67^{i}	1016.33^{f}	1023.33^{g}
	Sulfuric acid (10 L/ fed.)	Without (Tap water)	61.00^{jkl}	62.83^{j}	15.6^{i}	16.33^{g}	9.33^{o}	9.00^{k}	995^{f}	1010^{f}
		silicon (200ppm)	66.50^{f}g	66.66^{hi}	21^{g}	21.5^{f}	13.33^{jkl}	14.67^{fg}	1066.667^{e}	1071.67^{ef}
		Yeast extract (50ml/l)	69.33^{de}	69.50^{fgh}	22.2^{f}	23.2^{f}	14.00^{ijk}	15.67^{f}	1073.33^{e}	1080^{ef}
		Chitosan (200ppm)	71.00^{bc}	71.16^{def}	24.1^{f}	24.5^{ef}	16.00^{efg}	17.33^{e}	1100de	1105^{e}
	Sulphur (0.4 ton/ fed.)	Without (Tap water)	64.33^{hij}	64.58^{ij}	17^{hi}	17.2^{g}	10.67^{n}	10.33^{j}	995.667^{f}	1017^{gh}
		silicon (200ppm)	67.08^{ghi}	67.33^{hi}	21.4^{f}	21.9^{def}	14.33^{hij}	17.00^{e}	1096.667^{e}	1088.33^{de}
		Yeast extract (50ml/l)	68.33^{de}	69.83^{gh}	23.5^{ef}	25.3^{def}	15.00^{ghi}	17.33^{e}	1103.667^{de}	1096.5^{ef}
		Chitosan (200ppm)	71.33^{bc}	71.83^{cd}	25.5^{cd}	26.2^{cde}	16.33^{ef}	18.67^{d}	1140290de	1126.67^{e}

Means followed by the same letter within each column do not significantly differed using Duncan's Multiple Rang Test at the level of 5%.

2. Productive seeds quality

Effect of salinity

Quality of productive seeds under salinity stress was determined during the current study. As shown in Table (4), the effect of different levels of salinity stress had an extremely significant difference on all indices of germination and vegetative developments expressing the quality of productive seeds. Such data also confirmed a significantly decrease in the germination and vegetative indices with increasing the concentration of salinity, where the productive seeds from the lower level of soil salinity (area 1) were the more germinated and vegetative seeds than higher saline area (area 2). In harmony with the current results, many studies at different crops indicated the similar results among of them as on cowpea (Abdel-Haleem and El-Shaieny, 2015; Kandil *et al.*, 2017; Tsague *et al.*, 2017; Islam *et al.*, 2019). In this trend, Khan and Rizvi (1994) attributed this result to salinity that may cause alteration of enzymes and hormones contained in the seeds, the toxicity of salt constituents or lower osmotic potential of germination media lead to imbalance in water uptake (Munns, 2002). Meanwhile, Neta *et al.* (2016) stated that the productive seeds under salinity stress characterize with a lower physiological quality, in terms of germination.

Table 4. Effect of natural soil salinity level on Quality indices of germination in productive seeds from plants during 2018 and 2019 seasons

A-Natural soil salinity level (dSm^{-1})	Germination development indices				Vegetative indices					
	Promptness index	Germination %	Germination rate	Seedling vigor index	Radicle length (cm)	Plumule length (cm)	Radicle fresh W. (g)	Plumule fresh W. (g)	Radicle dry W. (g)	Plumule dry W.
Area 1 (EC 5.0)	7.84^{a}	90.93^{a}	93.75^{a}	945.2^{a}	4.23^{a}	6.15^{a}	0.52^{a}	0.85^{a}	0.04^{a}	0.20^{a}
Area 2 (EC7.0)	6.59^{b}	87.43^{b}	90.13^{b}	874^{b}	3.94^{b}	6.01^{b}	0.51^{b}	0.83^{b}	0.03^{b}	0.19^{b}

Means followed by the same letter within each column do not significantly differed using Duncan's Multiple Rang Test at the level of 5%.

Effect of soil amendments

The residual effect of protective treatment by soil amendments on productive seeds of plants grown under salinity stress was clarified in Table (5). Residual effect of soil amendments had an extremely significant effect on the indices of seeds' quality of produced seeds either germinative or vegetative indices. Additionally, a significant improved was detected in the residual effect of the applied soil amendments on germinative and vegetative indices of produced seeds in comparing with untreated productive seeds exposed to natural soil salinity.

The most germinated seeds were the treated productive seeds by sulphur which recorded the highest germinated and vegetative appearance, followed to that, improved seeds by sulfuric acid, as shown in Table (5). Numerous studies confirmed the importance of sulfur in providing the best germination and reduction the effect of salinity stress during seed production because sulfur increases protein, total sugars, and amino compounds as stated by ur Rehman *et al.* (2013).

Effect of foliar application

As shown in Table (6), the protective treatments by foliar application had a significant effect on the quality of productive seeds for next germination by its germinative and vegetative indices of seedling. Moreover, the significant variation in its improvement between the applied foliar application in comparing with productive seeds of untreated plant exposing to salinity. Data revealed that chitosan or yeast extract ranked the most foliar application under natural soil salinity that produced the highest quality of seeds either by its maximum average of germinative and vegetative indices.

Table 5. Effect of soil amendments on quality indices of germination in productive seeds from plants under natural soil salinity conditions during 2018 and 2019 seasons

B-Soil amendments	Germination development indices				Vegetative indices					
	Promptness index	Germination %	Germination rate	Seedling vigor index	Radicle length (cm)	Plumule length (cm)	Radicle fresh W. (g)	Plumule fresh W. (g)	Radicle dry W. (g)	Plumule dry W.
Control (0)	6.57^{c}	86.70^{c}	88.69^{c}	873^{c}	3.9^{c}	5.93^{c}	0.50^{b}	0.80^{b}	0.03^{b}	0.18^{b}
Sulfuric acid (10 L/ fed.)	7.31^{b}	90.15^{b}	92.95^{b}	925^{b}	4.1^{b}	6.04^{b}	0.51^{a}	0.83^{a}	0.032^{b}	0.19^{a}
Sulphur (0.4 ton/ fed.)	7.67^{a}	90.34^{a}	93.13^{a}	930^{a}	4.2^{a}	6.14^{a}	0.52^{a}	0.84^{a}	0.04^{a}	0.20^{a}

Table 6. Effect of foliar applications on Quality indices of germination in productive seeds from plants under natural soil salinity conditions.

C. Foliar application	Germination development indices				Vegetative indices					
	Promptness index	Germination %	Germination rate	Seedling vigor index	Radicle length	Plumule length	Radicle fresh W. (g)	Plumule fresh W. (g)	Radicle dry W. (g)	Plumule dry W. (g)
Without	5.75^{d}	82^{d}	83.63^{d}	790^{d}	3.62^{d}	5.57^{d}	0.46^{d}	0.78^{d}	0.03^{d}	0.16^{c}
Silicone (200ppm)	7.33^{c}	88.7^{c}	91.53^{c}	900^{c}	4.05^{c}	6.09^{c}	0.52^{c}	0.83^{c}	0.03^{c}	0.19^{c}
Yeast extract (50ml/L)	7.67^{sb}	91.8^{sb}	94.59^{sb}	950^{sb}	4.15^{ab}	6.21^{ab}	0.53^{ab}	0.85^{ab}	0.04^{ab}	0.20^{ab}
Chitosan (200ppm)	7.98^{a}	93.7^{a}	96.62^{a}	997^{a}	4.35^{a}	6.29^{a}	0.55^{a}	0.87^{a}	0.04^{a}	0.20^{a}

Means followed by the same letter within each column do not significantly differed using Duncan's Multiple Rang Test at the level of 5%.

That result was accordance with the importance of chitosan in improving the germination of seeds, vegetative and yield characters which optimize the character of seeds to be more resistant to stress and increase the availability of amino compounds (Chibu and Shibayama, 2001), uptake of water and essential nutrients (Guan *et al.*, 2009), in addition of increase the accumulation of photosynthesis output compounds, total protein, total carbohydrates N, P and K in seeds (El-Sayed *et al.*, 2014; Behboudi *et al.*, 2018).

Effect of interaction

Regarding to the effect of triple interaction between different levels of salinity in combining with both protective treatments; soil amendments and foliar treatments on indices of productive seeds. A significant effect of formely interaction was detected on the germinative and vegetative indices (Table 7) in productive seeds.

Moreover, such data clarified reduction in the germinated seeds that produced from area of high saline level (Area 2) even with treatments and was clarified by the lower mean of germination indices and vegetative indices in comparing to productive seeds subjected to lower level of natural soil salinity (Area 1). Additionally, the quality of produced seeds from all treatments for germination improved more significant result than the saline control.

Although the difference of salinity levels, productive seeds that previous treated by sulfur in combination with chitosan or yeast extract under salinity stress represented the highest mean in germination indices and vegetative either in productive seeds from low saline area (Area 1) in comparing to their treatment in each level of salinity. The best interaction between salinity and treatments of the productive seeds for next germination was the seeds of low level of natural soil salinity that treated with the combination between sulfur as soil amendment and chitosan or or yeast extract as foliar application, followed by sulfuric acid and chitosan at the same level of soil salinity. Those results were accordant with the importance of sulfur, chitosan and yeast extract in improvement the seed quality under salinity stress as clarified in previous discussion.

Table 7. Effect of triple interaction among natural soil salinity level X soil amendments X foliar applications on seed quality indices of productive seeds under natural soil salinity conditions

A soil salinity	B- Soil amendments	C- Foliar applications	Germination indices				Vegetative indices					
			Promptness index	Germination %	Germination rate	Seedling vigor index	Radicle length	Plumule length	Radicle fresh W. (g)	Plumule fresh W. (g)	Radicle dry W. (g)	Plumule dry W. (g)
Area 1 (EC 5.0)	Control (0)	Without	5.25^{o}	76^{k}	78.35^{k}	732^{k}	3.87^{hi}	5.5^{h}	0.45^{i}	0.79^{f}	. 038^{ef}	0.17^{g}
		silicon (200ppm)	7.08^{hig}	90.1^{f}	92.89^{f}	928^{efg}	4.2^{bcd}	6.1^{l}	0.53^{cde}	0.84^{c}	.04de	0.19^{cde}
		Yeast extract (50ml/l)	7.25^{gh}	93.1^{c}	95.98^{c}	978^{bc}	4.2^{bcd}	6.3^{l}	0.53^{cde}	0.86^{b}	.045^{bc}	0.20^{b}
		Chitosan (200ppm)	7.88^{cdef}	95.1^{b}	98.04^{a}	1037^{a}	4.5^{a}	6.25^{cde}	0.56^{a}	0.88^{a}	0.48^{a}	0.22^{ab}
	Sulfuric acid (10 L/ fed.)	Without	5.92^{n}	87.87^{f}	90.59^{g}	891^{i}	3.75^{i}	5.69^{m}	0.47^{n}	0.79^{f}	0.0 4^{cde}	0.18^{de}
		silicon (200ppm)	7.67^{efg}	90.6^{e}	93.40^{ef}	931^{e}	4.16^{cde}	6.12^{jik}	0.52^{e}	0.84^{c}	0.044^{bc}	0.20^{bc}
		Yeast extract (50ml/l)	8.17^{bcd}	93.3^{c}	96.19^{c}	979^{bc}	4.26^{bc}	6.23^{def}	0.53^{cde}	0.86^{b}	0.046^{b}	0.22^{abc}
		Chitosan (200ppm)	8.33^{abc}	93.4^{a}	98.14^{ab}	973^{b}	4.27$^{b c}$	6.32^{bcd}	0.53^{cde}	0.86^{b}	0.05^{a}	0.24^{a}
	Sulphur (0.4 ton/ fed.)	Without	6.67^{jkl}	88.2^{f}	90.93^{g}	893^{h}	4.09^{ef}	6.03^{l}	0.50^{gh}	0.82^{d}	0.040^{cd}	0.19^{cde}
		silicon (200ppm)	8.0^{cde}	90.4^{d}	96.29^{c}	939^{ae}	4.18^{bcde}	6.15^{fghij}	0.52^{ef}	0.84^{c}	0.044^{bc}	0.23^{c}
		Yeast extract (50ml/l)	8.50^{ab}	95.2^{a}	97.20^{ab}	1026^{a}	4.46^{a}	6.34^{ab}	0.55^{ab}	0.88^{a}	0.048^{ab}	0.25^{ab}
		Chitosan (200ppm)	8.67^{a}	95.5^{a}	98.45^{a}	1033^{a}	4.48^{a}	6.40^{a}	0.55^{ab}	0.88^{a}	0.053^{a}	0.26^{a}
Area 2 (EC7.0)	Control (0)	Without	5.08^{o}	70^{k}	66.67^{l}	557^{l}	2.6^{g}	4.66^{o}	0.4^{g}	0.68^{g}	0.038^{de}	0.16^{f}
		silicon (200ppm)	6.58^{klm}	87.1^{n}	89.79^{h}	871^{i}	3.9^{hi}	6.1^{jkl}	0.51^{gh}	0.82^{d}	0.041^{cd}	0.18^{de}
		Yeast extract (50ml/l)	6.75^{ijk}	90.1^{f}	92.89^{af}	928^{efg}	4.1^{def}	6.2^{efghi}	0.52^{ef}	0.84^{c}	0.043^{bc}	0.19^{cd}
		Chitosan (200ppm)	6.68^{efg}	92.1^{d}	94.95^{a}	959^{a}	4.2^{bcd}	6.21^{defg}	0.54^{bc}	0.87^{a}	0.045^{a}	0.21^{bc}
	Sulfuric acid (10 L/ fed.)	Without	5.42^{o}	84.77^{i}	87.4^{i}	828^{j}	3.48^{l}	5.59^{m}	0.46^{i}	0.77^{f}	0.036^{de}	0.17^{def}
		silicon (200ppm)	7.17^{hi}	87.2^{h}	89.9^{h}	867^{i}	3.92^{h}	6.02^{l}	0.5^{gh}	0.82^{d}	0.042^{cd}	0.19^{cde}
		Yeast extract (50ml/l)	7.67^{efg}	90.2^{f}	92.99^{f}	916^{g}	4.03^{fg}	6.13^{hij}	0.52^{e}	0.84^{f}	0.043^{b}	0.21^{bc}
		Chitosan (200ppm)	8^{cde}	92.1^{d}	94.95^{a}	962^{a}	4.23^{bc}	6.22^{defg}	0.54^{bc}	0.86^{b}	0.046^{a}	0.23^{ab}
	Sulphur (0.4 ton/ fed.)	Without	6.17^{mn}	85.20^{i}	87.84^{i}	841^{j}	3.94^{gh}	5.93^{m}	0.49^{h}	0.8^{e}	0.038^{de}	0.18^{de}
		silicon (200ppm)	7.5^{fgh}	87.3^{h}	90^{h}	870^{i}	3.93^{gh}	6.04^{kl}	0.51^{fg}	0.82^{d}	0.04^{cd}	0.22^{c}
		Yeast extract (50ml/l)	7.83^{def}	90.4^{ef}	93.2^{ef}	921^{fg}	4.05^{f}	6.14^{ghij}	0.53^{cde}	0.85^{b}	0.045^{bc}	0.24^{ab}
		Chitosan (200ppm)	8.17^{bcd}	92.3^{d}	95.15^{d}	968^{cd}	4.25^{bc}	6.24^{cde}	0.54^{bc}	0.87^{a}	0.048^{a}	0.25^{a}

Means followed by the same letter within each column do not significantly differed using Duncan's Multiple Rang Test at the level of 5%.

In conclusion, salinity stress had not only a significant feedback on the main parameters of flowering and dry yield but also extended to the quality of productive seeds. The success of soil amendments and foliar applications had a promising trend for alleviating salinity stress and optimizing yield productivity and quality of productive seeds under the natural soil salinity. The current study revealed the most improvable tool is the mixture between sulphur (0.4 ton/ fed.) followed by sulfuric acid (10 L/ fed.) amended with soil with chitosan (200ppm) or yeast extract (50m/L) as foliar application for achieving the maximal goal between alleviating salinity stress, optimizing yield productivity, and increasing the quality of productive seeds under soil salinity.

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تحسين انتاجية وجودة بذور اللوبيا تحت إجهاد ملوحة التربة الطبيعية باستخدام بعض المعالجات المختلفة

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أجريت هذه الدراسة بهدف تحسين التزهير وانتاجية وجودة بذور اللوبيا (صنف قها 1) تحت إجهاد ملوحة التربة الطبيعية باستخدام بعض المعالجات المختلفة. وقد تم زراعة البذور المتهيئة للإنبات (Seed priming) تحت نفس مستويي الإجهاد الملحى الطبيعي؛ متوسطة (5 dS/m) وعالية (7dS/m) فى حقلين تابعين لمركز البحوث الزراعية بالسرو محافظة دمياط، خلال موسمين متتاليين 2018- 2019، كما عوملت التربة بمعاملات أرضية قبل الزراعة كالكبريت (0.4 طن/فدان) وحمض الكبريتيك (10 لتر/فدان) ومعاملات بالرش وتشمل: الشيتوزان (200ppm)، سليكون (200ppm)، مستخلص الخميرة (50مل/لتر) مقارنة بالكنترول بدون أى معاملة. وقد صممت التجربة بنظام القطع المنشقة مرتين بتوزيع عشوائى. وقد اوضحت النتائج تأثير زيادة الإجهاد الملحى السلبى على التزهير ومحصول البذرة بالإضافة إلى قلة صفات جودة البذرة المنتجة. وقد أبرزت النتائج وجود فروق معنوية واضحة عند استخدام المعالجات الأرضية أوالمعاملات إذا ما قورن بالنباتات غير المعاملة فى الصفات السابقة. كما سجل التفاعل بين المعاملات الأرضية مع الرش أفضل النتائج وخصوصا اضافة الكبريت (0.4 طن/فدان) للتربة يليها حمض الكبريتيك (10 لتر/فدان) مع الرش بالشيتوزان (200ppm) إذا ما قورن باستخدام نوع واحد أو بدون معاملة بالنسبة للكنترول, لذا نوصي بنقع البذورلتهيئتها للإنبات (Seed priming) مع معالجة التربة بإضافة الكبريت (0.4 طن/فدان) قبل الزراعة وكذلك رش النباتات اثناء نموها بعد 20 يوم من الزراعة 3 مرات على فترات 10 يوم، بالشيتوزان (200ppm) أو الرش بمستخلص الخميرة (50مل/لتر) لزيادة تحمل النبات لملوحة التربة الطبيعية للحصول على أفضل أزهار وإنتاجيه وللحصول علي أعلى جودة من المحصول البذرى تحت نفس الظروف.