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EFFECT OF SHEEP MANURE AND SULFUR ON GROWTH AND YIELD OF POTATO UNDER SALINE CONDITIONS

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ABSTRACT: Environmental stresses in arid and semi-arid regions represent a major obstacle to agricultural development, soil and water salinity are major abiotic stress affecting horticultural crops and threatening sustainable production, An open field experiment was carried out in the experimental farm of Desert Research Center, Ras Sudr, South Sinai governorate, Egypt for two seasons (2020/2021 and 2021/2022) to investigate the effects of sheep manure and sulfur on potato plants, three levels of sheep manure, 0, 15, and 25 m^3/fed, and three levels of sulfur, 0, 200, and 300 kg/fed, all treatments were applied to the soil before planting during soil preparation. Results indicated that the application of sheep manure and sulfur, either separately or together, alleviated the adverse effects of salt stress and improved potato growth and yield parameters. However, the combined treatment of 25 m^3 sheep manure/fed and 300 kg sulfur/fed resulted the maximum values of vegetative growth parameters (Plant height, stems number, leaves number, and chlorophyll). nutrients content (N, P, K, and S), yield and its components (tuber number per plant, tuber fresh and dry weight). Conclusively, it could be concluded that sheep manure and sulfur application are an effective approach to improve the growth and yield of potato plants grown under saline conditions.

Key words: *Solanum tuberosum*, salt stress, sheep manure, sulfur, potato, tuber quality, yield.

INTRODUCTION

The main obstacle to plant production in arid and semi-arid areas is salinity, which inhibits plant growth and decreases productivity under these areas **(Ramadan and Shalaby, 2016; Shalaby *et al.*, 2017)**. In arid and semi-arid areas, salt concentration in irrigation water and soil are relatively high, resulting in morphological and physiological damage to plants growing in these environments. This damage includes reductions in plant height and weight, as well as negative effects on all biological processes of plants, including nutrient status, nutrient absorption, osmotic pressure, and plant development **(Nazar *et al.*, 2011)**. Salt stress changes the soil's physical and chemical characteristics and their pH value, leading to excessive accumulation of sodium ions, and soil structure breakdown **(Lauchli and Epstein, 1990)**. To achieve large yield, farmers in the traditional farming system solely use chemical fertilizers, however, this practice degrades the soil and affects the nutritional quality of the crops when it is used extensively. However, organic manure boosts soil aeration, soil water holding capacity, and nutrient availability, by increasing the activity of soil microorganisms that make nutrients more available for plant uptake **(Sharma *et al.*, 2017)**. Organic manure is an alternative fertilizer that contains necessary nutrients for plant growth and development to produce healthy food for human consumption. Numerous studies have indicated that the application of organic fertilizers such as farm manure has been shown to improve plant productivity and soil characters by enhancing the biological and physical properties of the soil and improving plant nutrient uptake, thus increasing crop yield and quality. Organic fertilizer is environmentally friendly method for plant production and soil conservation, although

organic fertilizers have a good effect on plant development, further research is required to find a widespread answer to fertilizer management and plant nutrition, which will enhance soil management and conservation **(Hariadi *et al.*, 2016)**. Sheep manure is readily available in the arid environment of Egypt, so its use in agricultural production helps to maintain the soil, provides plants with nutrients, and is committed to the sustainable production of crops. Adding sheep manure to the soil improves electrical conductivity, provides nutrients for plant growth, and decreases the levels of heavy metals in the soil solution **(Elouear *et al.*, 2016)**. The application of sheep manure reduces the pathogen population in soil by 25 - 37% and increases plant growth compared to the control treatment **(Barakat *et al.*, 2009)**. The performance and productivity of tomato plants are improved by organic manure, providing an effective alternative method for plant production **(Mowa *et al.*, 2017)**. Organic fertilizers improve plant performance by improving soil fertility, soil structure, soil water holding capacity, soil aeration, pH, and microbial activity **(Babaji *et al.*, 2010)**.

The potato is one of the most important horticulture crops and the fourth most widely grown crop in the world **(Lutaladio and Castaldi, 2009)**. In Egypt, there are 176670 hectare of total harvested area, resulting in 4896476 tonnes of potato tubers **(FAOSTAT, 2018)**. In addition to being an important source of carbohydrates and dietary fibers, potatoes are also a rich source of high-quality protein, phosphorus, iron, zinc, calcium, and potassium, as well as a significant amount of vitamin C. **(Singh *et al.*, 2020)**. Potatoes are moderately sensitive to salt stress, whether it occurs in the soil or irrigation water. Salt stress causes reduced biomass production, chlorophyll degradation, dwarfed plants, senescence, and early death in plants **(Jaarsma *et al.*, 2013)**. Abiotic stress factors such as salinity and drought restrict potato growth and productivity, just like they do with the most other vegetable crops in arid and semi-arid climates **(Hijmans, 2003)**. The agricultural lands in Egypt suffer from the problem of salinity, as 33% of arable land is affected by salinity **(Akladious and Mohamed, 2018)**. Salinity stress has a major impact on vegetables, with negative effects on water availability, nutrient uptake, osmotic potential, photosynthesis, and protein synthesis. As a result of these, fresh mass, nutrient content, and fruit yield are significantly decreased, while the sodium content is increased **(Shalaby *et al.*, 2017)**.

Sulfur is one of the essential nutrients that plants need to grow and develop properly. It is a crucial for the production of vitamins, proteins, enzymes, and amino acids like cysteine and methionine. Sulfur also plays an important role in the defense mechanism of plants under abiotic stress conditions **(Shalaby, 2018)**. Sulfur is used as a soil conditioner to modify soil properties as it decreases the exchangeable sodium and pH value of soil solution, and converts insoluble phosphorus into a soluble form, adding sulfur to potato plant increased tuber yield, and improved tuber quality in terms of protein, starch, carotene, vitamin C, and nutrient contents **(Klikocka and Głowacka, 2013; Sonmez *et al.*, 2016)**. Under saline conditions, sulfur application enhances plant growth characteristics, leaf nutritional content, yield, and quality of cauliflower **(Ramadan, 2018)**. This study aims to mitigate the adverse impacts of salt stress on potato plants by adding sulfur and sheep manure to the soil for enhancing growth and yield.

MATERIALS AND METHODS

Site description and experimental detail

An open field experiment was carried out in the experimental farm of Desert Research Center, Ras Sudr, South Sinai governorate, Egypt for two seasons (2020/2021and 2021/2022) to study the effect of adding sheep manure and sulfur to the soil on growth and tuber yield of potatoes under saline conditions. The region's soil was sandy loam in texture, highly calcareous and saline, with pH of 7.7, an EC of 8.65 mS/cm^{-1}, and $CaCO_3$ content of 56.99%. According to Burt (2004), the physical and chemical characteristics of the soil were determined. At 3-days intervals, saline water (4500 ppm) was used to irrigate the plants. This experiment included 9 treatments which were the combinations between three levels of sheep manure (0, 15, and 25 m^3/fed) and three levels of sulfur (0, 200, and 300 kg/fed)–arranged in a split-plot design with three replications, the levels of sheep manure were assigned in the main plots and sulfur levels in the sub-plots.

In the first week of October, potato tubers (*Solanum tuberosum* L cv. Sponta) obtained

from the Agriculture Research Center, Ministry of Agriculture, Egypt were planted in the open field on ridges, width 90 cm and 75 cm apart. Two drip irrigation lines were laid on each ridge to supply water for two rows of plants. Potato tubers were planted on the two sides of the ridge spaced 50 cm apart with a distance of 50 cm between plants. During the soil preparation process, both of sheep manure and sulfur treatments were mixed into the soil plots as per the treatment schedule. The chemical analysis of sheep manure is shown in Table 1. Agricultural practices such as weeding, irrigation, and pesticides were done uniformly to all plots as recommended by the Egyptian Ministry of Agriculture and Land Reclamation.

Table (1). Chemical analysis of sheep manure used in the Ras Sudr experimental farm

Chemical content %					Density Kg/m^3
N	P	K	Ash	Curd fiber	
2.31	0.96	0.89	9.75	19.75	542

Growth and Yield Parameters Measurements

After 45 days of planting, 5 plants were randomly taken from each treatment to determine the plant growth parameters in terms of plant height (cm), stem number/plant, leaves number/plant, and chlorophyll (SPAD). leaves samples were washed with distilled water and dried in an oven at 70 ℃ for 3 days. After oven drying, the samples were ground and digested for chemical analysis, N content was measured by the method of Kjeldahl **(Jackson, 1973)**, and P was colorimetrically estimated by using the chlorostannous reduced molybdophosphoric blue color method according to **Jackson (1973)**. K and Na were determined using the flame photometer as described by **Chapman and Pratt (1982)**. S was determined as described by **Rowell (1993)**. Cl content was determined using atomic absorption spectrophotometer apparatus as the methods described by **(Higinbotham *et al.*, 1967)**. At harvest, five plants were randomly taken from each plot, and the following yield features (tubers number/plant, tuber fresh weight, tuber dry weight, and total yield) were determined. A representative sample of 10 healthy tubers from each plot was selected to obtain tuber quality, starch, and protein content were evaluated according to **AOAC (2000)**, and total soluble solids (TSS %) were estimated by a hand refractometer according to **Cox and Pearson, (1962)**.

Statistical analysis

The obtained data were statistically analyzed by analysis of variance (ANOVA) using MSTAT-C software (Michigan State University, USA), and Duncan's test was used to compare the means of data according to **Gomez and Gomez (1984)**.

RESULTS AND DISCUSSION

Growth Parameters

The effect of sheep manure and sulfur on vegetative growth parameters of potato plants grown under saline stress conditions is varied (Table 2). Plant height, stems number, leaves number, and chlorophyll (SPAD) were greater in plants that received 25 m^3 sheep manure/fed., compared to other treatments, there were significant differences between sheep manure treatments in both seasons. These results are in agreement with **Azarmi *et al.* (2009), Farrag *et al.* (2009), Bucagu *et al.* (2017)** and **Ramadan (2018)**. This result may be due to the role of sheep manure in improving soil structure **(Bin, 1983; Dauda *et al.*, 2008)**, microbial biomass **(Suresh *et al.*, 2004)**, nutrient uptake, increasing soil organic matter and soil cation exchange capacity, and soil available N and improved plant N status **(Shufu and Huairui, 2004)** which certainly reflected positively effect on photosynthesis process and plant growth **(Bhangoo *et al.*, 1988)**. Concerning sulfur application**,** there was a significant increment in plant height, stems number, leaf number, and chlorophyll (SPAD) with increasing sulfur addition in both growing seasons. The highest values were obtained from 300 kg sulfur/fed, while the lowest values were obtained from the control treatment. Similar results were also obtained by **Ramadan (2018), Shalaby (2018)** and **Rathore *et al.* (2022)**. This increase might be due to the availability and utilization of

essential nutrients (N, P, and K), as these nutrients increased with the sulfur application **(Kopriva *et al.*, 2019)** due to their synergistic effects. The combined treatment, 25 m3 sheep manure/fed and 300kg sulfur/fed., resulted the highest values of vegetative growth and chlorophyll reading, as the potato plants were taller and produced more leaves and branches, as well as larger shoots than those of the other treatments.

Table (2). Effect of sheep manure, sulfur fertilization and their interaction on plant height, stem number, leaf **number and chlorophyll reading of potato at 45 days of planting in 2020/2021 and 2021/2022 seasons**

Treatments	2020/2021				2021/2022			
	Sulfur kg/fed							
Sheep manure m^3/fed	0	200	300	mean	0	200	300	mean
Plant height (cm)								
0	36.67h	37.80g	39.80f	38.09C	34.60g	36.57fg	38.27f	36.48C
15	42.00e	44.47c	48.00b	44.82B	41.13e	42.90e	45.47d	43.17B
25	43.57d	47.50b	51.80a	47.62A	52.17c	55.13b	58.23a	55.18A
mean	40.75C	43.26B	46.53A		42.63C	44.87B	47.32A	
Stem number/plant								
0	2.43h	3.37g	4.23f	3.34C	3.27g	4.10f	5.07e	4.15C
15	5.40e	6.03d	6.43c	5.95B	5.80d	6.47c	7.47b	6.58B
25	6.07d	7.27b	7.90a	7.08A	6.70c	7.63b	8.47a	7.60A
mean	4.63C	5.56B	6.19A		5.26C	6.07B	7.00A	
Leaf number/plant								
0	23.23i	25.77h	27.90g	25.63C	25.47i	29.47h	32.47g	29.14C
15	31.77f	34.57e	38.17d	34.84B	39.47f	44.33e	47.33d	43.71B
25	43.17c	46.53b	49.50a	46.40A	49.80c	51.80b	54.37a	51.99A
mean	32.72C	35.62B	38.52A		38.25C	41.87B	44.72A	
Chlorophyll (SPAD)								
0	21.37i	25.80h	29.30g	25.49C	21.57h	25.20g	28.27f	25.01C
15	32.57f	36.10e	40.70d	36.46B	32.03e	35.60d	38.87c	35.50B
25	42.33c	45.37b	48.87a	45.52A	43.47b	44.47ab	45.73a	44.56A
mean	32.09C	35.76B	39.62A		32.36C	35.09B	37.62A	

Means having the same letter (s) in each column are insignificantly different.

Nutritional Content of Leaves

Sheep manure and sulfur applications achieve a markedly positive effect on the nutritional content of potato leaves grown under saline conditions (Table 3). Application of 25 m^3 sheep manure/fed. significantly increased N, P, K, and S contents, while the same treatment gave the lowest Na and Cl contents. On the other hand, the exclusion of sheep manure (control) resulted in lower values of N, P, K, and S and higher values of Na and Cl in potato leaf in both seasons. Similar results were obtained by **Mahmoodabadi *et al.* (2011), El Gammal and Salama (2016), Elouear *et al.* (2016)** and **Ramadan (2018)**.

Table (3). Effect of sheep manure, sulfur fertilization and their interaction on N, P, K, S, Na and Cl percent in potato leaves at 45 days of plantining in 2020/2021 and 2021/2022 seasons

Treatments	2020/2021				2021/2022			
	Sulfur kg/fed							
Sheep manure m^3/fed	0	200	300	mean	0	200	300	Mean
N %								
0	1.41h	1.43h	1.48g	1.44C	1.16i	1.23h	1.26g	1.22C
15	1.52f	1.56e	1.61d	1.56B	1.35f	1.41e	1.47d	1.41B
25	1.64c	1.68b	1.74a	1.69A	1.51c	1.57b	1.63a	1.57A
Mean	1.52C	1.56B	1.61A		1.34C	1.40B	1.45A	
P%								
0	0.17i	0.20h	0.22g	0.20C	0.15i	0.17h	0.18g	0.17C
15	0.25f	0.27e	0.28d	0.27B	0.21f	0.23e	0.26d	0.23B
25	0.31c	0.34b	0.37a	0.34A	0.29c	0.33b	0.38a	0.33A
Mean	0.24C	0.27B	0.29A		0.22C	0.24B	0.27A	
K%								
0	0.44g	0.52f	0.64d	0.53C	0.31g	0.41f	0.51e	0.41C
15	0.50f	0.60e	0.71c	0.61B	0.42f	0.54e	0.77c	0.58B
25	0.56e	0.73b	0.77a	0.69A	0.74d	0.84b	0.97a	0.85A
Mean	0.50C	0.62B	0.71A		0.49C	0.60B	0.75A	
S%								
0	1.05h	1.05h	1.06g	1.05C	1.04h	1.05g	1.06g	1.05C
15	1.11f	1.14e	1.18d	1.14B	1.09f	1.11e	1.16d	1.12B
25	1.21c	1.25b	1.30a	1.25A	1.19c	1.23b	1.28a	1.23A
Mean	1.12C	1.15B	1.18A		1.11C	1.13B	1.17A	
Na%								
0	1.43a	1.33a	1.04b	1.27A	1.41a	1.37a	1.16b	1.31A
15	1.02b	0.89bc	0.77cd	0.89B	1.03c	0.85d	0.81d	0.90B
25	0.77cd	0.72cd	0.69d	0.73C	0.77de	0.72ef	0.65f	0.71C
Mean	1.07A	0.98B	0.83C		1.07A	0.98B	0.87C	
Cl%								
0	1.50a	1.34b	1.23c	1.36A	1.64a	1.34b	1.11c	1.36A
1	0.86d	0.80e	0.69f	0.78B	0.91d	0.81e	0.74f	0.82B
2	0.61g	0.52h	0.41i	0.51C	0.63g	0.55h	0.43i	0.54C
Mean	0.99A	0.89B	0.78C		1.06A	0.90B	0.76C	

Means having the same letter (s) in each column are insignificantly different**.**

The increase in the N, P, K, and S contents with the addition of sheep manure can be attributed to the important role played by organic fertilizers in improving the fertility and quality of the immature soil by adjusting the pH and organic matter content of the soil, which is the basis of soil fertility and quality **(Li *et al.*, 2022)**, also organic fertilizers could effectively improve available P, and total N in the soil **(Li *et al.*, 2021)**, which promotes the availability of nutrients in the soil and enhances nutrients absorption by plant roots and its translocation to upper parts of plants **(Kandil and Gad, 2009)**.

The result from this study indicated that the N, P, K, S, Na, and Cl contents were positively affected by sulfur application (Table 3). In detail, compared to the control, there was a significant increase in the N, P, K, and S and a significant decrease in the Na and Cl contents by the addition of sulfur in both seasons. Adding 300kg S/fed into soil gave the highest values of N, P, K, and S contents and the lowest values of Na, and Cl contents compared to the other treatments. In agreement with the results of this study, a similar observation was found by **Sarg *et al.* (2007), Ramadan (2018)** and **Shalaby (2018)**. The increase in N, P, K, and S contents may be due to the availability and utilization of essential nutrients (N, P, and K), as these nutrients increased with S application **(Kopriva *et al.*, 2019)** due to their synergistic effects. The acidifying effect of sulfur lowers soil pH and the release the nutrients from unavailable pools to soil solution may also enhance nutrient uptake by plants **(Karimizarchi *et al.*, 2014)**. As regards to the sheep manure and sulfur interaction, the highest N, P, K, and S contents were obtained in plants that received 25m^3/fed of sheep manure and 300kg S/fed, the same treatment recorded a lowest Na and Cl contents in both seasons.

Yield and its Characteristics

Potato yield and its characteristics were significantly affected by the tested treatments (Table 4). The results indicated that the tuber number per plant, tuber fresh weight, tuber dry weight, and total yield were increased with sheep manure addition. The highest values were recorded by adding 25m^3/fed sheep manure into the soil in both seasons. A similar response was also observed in chili pepper **(Yahaya *et al.*, 2010)** and cowpea **(Babaji *et al.*, 2010)**. The enhancement of potato yield and its features may be due to the stimulating effect of sheep manure on growth characteristics (Table 2) and the uptake of nutrients and their accumulation in the plant (Table 3). Obtained results agreed with those of **Borin (1987)** and **Brwaldh (1992)** who reported that organic manure improves the soil texture. The structural improvement can encourage the plant to have a good root development by improving soil aeration, resulting in increased plant growth and productivity, this result may be due to the role of organic manure in a slowely continuous supply of nutrients, improve soil physical properties and increase water retention **(Abd-Elmoez et al., 1995; Fliessbach, 2000)**.

Plants subjected to 300kg/fed of sulfur produced more tubers and greater tuber fresh and dry weight, as well as total tuber yield than those in the control group in both seasons. Similar results were reported by **Klikocka and Głowacka (2013)**, **Ramadan (2018),** and **Shalaby (2018),** they reported that the addition of sulfur mitigated the adverse effects of salt stress on plant and improved the yield and its components. The increase in potato yield and its features in response to sulfur addition can be attributed to the increase in soil nutrient availability due to soil pH reduction which certainly reflected a positively effects on plant growth and then on yield and its features **(Rathore *et al.*, 2022)**. The interaction between sheep manure and sulfur treatments statistically affected the yield and characteristics of potato plants under saline conditions at 25m^3/fed of sheep manure and 300kg/fed of sulfur in the soil in both growing seasons.

Table (4). Effect of sheep manure, sulfur fertilization and their interaction on plant tuber number, tuber fresh weight, tuber dry weight and total yield in 2020/2021 and 2021/2022 seasons

Treatments	2020/2021				2021/2022			
	Sulfur kg/fed							
Sheep manure m^3/fed	0	200	300	mean	0	200	300	mean
Tuber number/plant								
0	2.67e	2.67e	4.33d	3.22C	3.00e	3.67d	4.00d	3.56C
15	4.67d	5.67c	7.00ab	5.78B	5.33c	5.67c	6.00c	5.67B
25	6.00bc	7.00ab	8.00a	7.00A	7.33b	7.00b	8.00a	7.44A
mean	4.45C	5.11B	6.44A		5.22B	5.45B	6.00A	
Tuber fresh weight (g)								
0	44.90i	54.67h	67.03g	55.53C	48.33i	56.67h	61.27g	55.42C
15	92.33f	100.70e	117.20d	103.41B	81.90f	96.67e	142.87c	107.15B
25	123.67c	148.80b	175.83a	149.43A	114.70d	160.07b	176.63a	150.47A
mean	86.97C	101.39B	120.02A		81.64C	104.47B	126.92A	
Tuber dry weight (g)								
0	4.47h	5.43gh	6.70g	5.53C	3.93h	4.50h	5.37g	4.60C
15	12.17f	14.30e	16.30d	14.26B	10.43f	17.65e	32.50c	20.19B
25	19.13c	25.47b	35.33a	26.64A	20.68d	34.80b	42.50a	32.66A
mean	11.92C	15.07B	19.44A		11.68C	18.98B	26.79A	
Total yield (ton/fed)								
0	4.77i	5.20h	5.43g	5.13C	4.20h	4.60g	5.00f	4.60C
15	6.87f	7.20e	7.77d	7.28B	5.43e	6.10d	6.40c	5.98B
25	8.30c	8.97b	9.30a	8.86A	6.43c	7.10b	7.90a	7.14A
mean	6.65C	7.12B	7.50A		5.35C	5.93B	6.43A	

Means having the same letter (s) in each column are insignificantly different.

Tuber quality of potato

Data in table 5 demonstrated that the sheep manure treatments had a significant impact on potato tuber quality in terms of starch, protein, and soluble sugar contents. In both seasons, plants received up to 25 t/fed of sheep manure exhibited higher tuber quality index values than other treatments. Similar findings were reported by **El Gammal and Salama (2016) and Ramadan (2018)**. Sheep manure application improved the physical and chemical characteristics of the soil and increased its capacity to hold water and nutrients, thus, improved the tuber quality **(Moskal *et al.*, 2001; Whalen *et al.*, 2002; Yamada, 2002)**. Also, stimulating sheep manure for nutrient absorption had a good effect on photosynthesis, which in turn improved tuber quality **(Hegazi *et al.*, 2007)**. According to the results, all evaluated tuber quality indicators were significantly affected by the sulfur treatments (Table 5), plants treated with 300 kg/fed of sulfur had higher values of starch, protein, and soluble sugar in both seasons. These results are partially in line with those of **Klikocka and Głowacka (2013) and Sonmez *et al.* (2016)**. The function of sulfur in protein synthesis and N assimilation, as well as its involvement as a structural component of some coenzymes and prosthetic groups, may account for this **(Marschner, 1995)**. Sulfur facilitates carbohydrate metabolism and raises plant carbohydrate content **(Kumar *et al.*, 2015)**. It improves the plant's capacity to absorb nutrients, which is

reflected in nutritional optimization and results in a higher percentage of starch and soluble sugar in the plant **(Ducsay and Varga, 2004)**. In regards to the interaction between sheep manure and sulfur, it was found that 25m^3/fed of sheep manure and 300kg/fed of sulfur resulted in the highest starch, protein, and soluble sugar percentages in potato tubers in both seasons.

Table (5). Effect of sheep manure, sulfur fertilization and their interaction on starch, protein and soluble sugar percent in potato tubers in 2020/2021 and 2021/2022 seasons

Treatments	2020/2021				2021/2022			
	Sulfur kg/fed							
Sheep m^3/fed	0	200	300	mean	0	200	300	mean
	Tuber starch %							
0	8.20i	8.80h	9.13g	8.71C	8.00h	8.60g	9.13f	8.58C
15	9.60f	10.13e	10.70d	10.14B	9.70e	10.80d	11.60c	10.70B
25	11.03c	11.60b	12.00a	11.54A	12.47b	13.30a	13.50a	13.09A
mean	9.61C	10.18B	10.61A		10.06C	10.90B	11.41A	
	Tuber protein %							
0	8.20i	8.60h	8.83g	8.54C	8.47i	8.80h	9.20g	8.82C
15	9.10f	9.47e	9.80d	9.46B	9.60f	9.90e	10.20d	9.90B
25	10.10c	10.53b	11.00a	10.54A	10.67c	11.20b	11.70a	11.19A
mean	9.13C	9.53B	9.88A		9.58C	9.97B	10.37A	
	Total Soluble sugar %							
0	2.31a	2.19b	2.14c	2.21A	2.22a	2.16b	2.06c	2.15A
15	1.99d	1.88e	1.76f	1.88B	1.99d	1.85e	1.73f	1.86B
25	1.66g	1.44h	1.36i	1.49C	1.65g	1.62h	1.56i	1.61C
mean	1.99A	1.84B	1.75C		1.95A	1.88B	1.78C	

Means having the same letter (s) in each column are insignificantly different.

Conclusions

Sheep manure and sulfur and their interaction alleviated the deleterious effects of salt stress on plant growth and yield of potatoes, plants grew much better and produced more yield, and leaf sodium content was significantly lower than those in the control group

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RESEARCH ARTICLE

Effect of sheep manure and sulfur on growth and yield of potato under saline conditions

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