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Growth Response of Sunflower to Potassium Sulphate Application in Saline-sodic Soil

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Authors' contributions

This work was carried out in collaboration between all authors. Author BUZ designed the study, wrote the protocol and conducted study with author JUD. Author AA with author MA managed the literature searches. Authors MS and MY performed the statistical analysis. Author SA provided chemical and germplasm for the experiment. Author BUZ wrote the final draft of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate the effect of SO_4^{2-} and K^+ application on growth of sunflower hybrids besides on growth parameters in a saline sodic soil.
Study Design: Laid out the experiment in Complete Randomized Design in triplicates, applying potassium sulphate in saline- sodic soil for the growth of sunflower.
Place and Duration of Study: The study was conducted in Soil Salinity and Bio-saline Research green house of Land Resources Research Institute at National Agricultural Research Centre, Islamabad, Pakistan during the period from January to March, 2018.
Methodology: Applied potassium sulphate @ 50 mg kg^{-1} in saline- sodic soil (ECe = 6.5dS m^{-1}, pH = 7.7, SAR = 17) for the growth of sunflower hybrids viz. SMH-9706 and PARSUN-3.
Results: Sunflower responded significantly (P = 0.01) for growth and chemical parameters. Fresh and dry mass of PARSUN-3 were higher 14 and 12 percent respectively than that of SMH-9706.

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Sulphur and potassium ions uptakes were higher 32 and 22 percent respectively in PARSUN-3 than SMH-9706. Sulphur and potassium decreased Na^+/K^+ ratio in both the hybrids.
However, this decline was higher in PARSUN-3 than SMH-9706.
Conclusion: This study identified the way to evaluate promising genotypes of sunflower for growth and production with sulphur and potassium nutrition under saline sodic soil.

Keywords: Sunflower hybrids; saline-sodic soil; bio-mass; potassium sulphate; Na^+/K^+ ratio.

1. INTRODUCTION

Growth of plants is dependent on positive association of ions within the system. Synergistic or antagonistic linkage between specific ions out side a plant exists in micro environments of roots. This type of scenario can be seen when a crop plant such as sunflower is grown in saline soil conditions. Sunflower is a moderate salt tolerant oil seed crop [1]. It has economic and nutritional importance allover the world. Besides oil extraction, its seeds are also consumed as 'dry fruit'. For the growth of crops, application of potassium sulphate is imperative [2]. Potassium and sulphate ions are in synergistic relations with in and out side of a plant under normal conditions or salt stress. Potassium ion enjoys the status of most demanding nutrients in the group of triad having N and P. Potassium ion is well known for accelerating enzymatic metabolism [3]. Al though, it does not contribute directly to biomass as tissue accrual, but K^+ is the need of other macro ions to complete biochemical reactions for biomass building up. In soil, it may be available in soil solutions from some clay minerals [4], otherwise the requirement is fulfilled through the application of appropriate fertilizer. In saline-sodic soil, it is desirable as [5] researched usefulness of potassium application in saline-sodic soils. Potassium ion has antagonistic relation with sodium ion [6]. In a saline sodic soil, sodium ion creates water stress, nutrients improper ratios besides imbalance. Plants intake sulphur as sulphate ion through their root system [7]. Sulphur as nutrient is synergistic to potassium ion. Sulphur has important role in biomass buildup as it is an important constituent of amino acids in plant. It acts in line with nitrogen, phosphorus and potassium in plant metabolism. Now sulphur has gained importance as the fourth important macronutrient for crop plants. Therefore, after the inclusion of sulphur, it forms the group as tetrad. The journey of plant nutrients from triad to tetrad formation with the inclusion of sulphur is quite beneficial for plant metabolism. Sulphur when strengthens the metabolism of a crop plant working with K^+ may lessen the salinity effects on plant growth. Sulphate and potassium ions when applied together as potassium sulphate fertilizer may be beneficial for growth of a plant. With in a particular crop plant, its genotype response may be variable due to genetic make up. Its exploration under salt stress is a continuous process due to genetic variability, macro and micro environment changes and nutrients availability. A study was conducted to evaluate the effect of SO_4^{2-} and K^+ application on growth of sunflower hybrids besides chemical parameters in a saline sodic soil.

2. MATERIALS AND METHODS

2.1 Experimental Site, Soil Processing, Sunflower Hybrids

The study was conducted in Soil Salinity and Bio-saline Research green house of Land Resources Research Institute at National Agricultural Research Centre, Islamabad, Pakistan during the period from January to March, 2018. Saline-sodic soil was collected, dried, processed and passed through 2mm sieve. The soil was analyzed for pertinent physico- chemical properties (Table1). Filled the pots with 3 kg of the soil. Applied potassium sulphate @ 0 and 50 mg kg^{-1} of the soil. Sowed sunflower hybrids i.e. SMH-9706 and PARSUN-3 in triplicates using Complete Randomized Design. Optimum moisture was maintained in soil with distilled water. Four seeds were germinated and raised up to 35 days for vegetative growth.

2.2 Plant Sampling, Chemical and Statistical Analysis

Sampled the shoots of the plants. Rinsed these with deionised water and blotted with tissue paper. After recording fresh mass of the shoot, dried these at 65°C to constant mass. Recorded dry mass of each sample and cut into minute pieces. Digested these samples in 1:2 perchloric-nitric acid mixture [8]. Determined membrane stability index (MSI) of leaf as given by [9]. For chlorophyll concentration in leaves, dimethyl sulphoxide (DMSO) chlorophyll extraction method of [10] was used. Total leaf chlorophyll was calculated by using the formulae developed by [11]. Determined concentration of potassium and sodium ions in the digested material by flame photometry. Sulphur in the digested material was found out as given by [12]. Analyzed the data statistically according to two factors complete randomized design and compared treatment means using LSD test by using the statistical software, Statistix 8.1 [13].

Table 1. Physico chemical properties of saline sodic soil

Parameters	Units	Value
pH (1:2)	-	7.7
ECe (1:2)	dS m^{-1}	6.5
Cl^{-1}	mmol L^{-1}	4.3
CO_3^{-2}		0.8
HCO_3^{-1}		1.8
SO_4^{-2}		5.3
P (ABDTPA extractable)	µg g^{-1}	4.1
SAR	$(mol\ L^{-1})^{1/2}$	17.0
Saturation	%	32
Clay	-	40.69
Silt	-	44.00
Sand	-	15.31
Text. class	-	Silty clay

3. RESULTS

Application of potassium sulphate @ 50 mg kg^{-1} in saline sodic soil, affected significantly (P = 0.01) growth and ionic parameters of sunflower hybrids viz. SMH-9706 and PARSUN-3.

3.1 Fresh and Dry Mass

With potassium sulphate application, growth parameters were affected. Shoot fresh mass of SMH-9706 increased 7 percent than the control. In PARSUN-3, it increased 11 percent then the control. In control, fresh mass of PARSUN-3 increased 10 percent than that of SMH-9706. Under potassium sulphate application, shoot fresh mass of PARSUN-3 increased 14 percent than that of SMH-9706. Shoot dry mass of SMH-9706 increased 5 percent than the control. In PARSUN-3, it increased 9 percent then the control. In control, shoot dry mass of PARSUN-3 increased 8 percent than that of SMH-9706. Under potassium sulphate application, shoot dry mass of PARSUN-3 increased 12 percent than that of SMH-9706 (Table 2).

3.2 Potassium and Sulphur Uptake

With potassium sulphate application, ion and biochemical parameters were also affected under non-saline and saline conditions. Potassium uptake in shoot of SMH-9706 increased 10 percent than the control. In PARSUN-3, it increased 14 percent then the control. In control, potassium uptake of PARSUN-3 increased 18 percent than that of SMH-9706. Under potassium sulphate application, potassium uptake in shoot of PARSUN-3 increased 22 percent than that of SMH-9706. Sulphur uptake in shoot of SMH-9706 increased 12 percent than the control. In PARSUN-3, it increased 17 percent then the control. In control, sulphur uptake of PARSUN-3 increased 27 percent than that of SMH-9706. With potassium sulphate application, sulphur uptake in shoot of PARSUN-3 increased 32 percent than that of SMH-9706 (Table 3).

3.3 Sodium Uptake and Chlorophyll

Sodium uptake in shoot of SMH-9706 decreased 28 percent than the control. In PARSUN-3, it decreased 5 percent then the control. In control, sodium uptake of PARSUN-3 decreased 19 percent than that of SMH-9706. Under potassium sulphate application, sodium uptake in shoot of PARSUN-3 decreased 10 percent than that of SMH-9706. Chlorophyll in leaves of SMH-9706 increased 12 percent than the control. In PARSUN-3, it increased 13 percent then the control. In control, chlorophyll of PARSUN-3 increased 8 percent than that of SMH-9706. Under potassium sulphate application, chlorophyll of PARSUN-3 increased 10 percent than that of SMH-9706 (Table 4).

Table 2. Effect of potassium sulphate on fresh and dry mass (mg plant-^{1}) of sunflower grown in saline sodic soil

Potassium sulphate applied (mg kg^{-1})	Fresh mass			Dry mass		
	Hybrids		Means	Hybrids		Means
	SMH-9706	PARSUN-3		SMH-9706	PARSUN-3	
Control	3687.4 d	4052.3 b	3869.9 B	345.2 d	373.5 b	359.4 B
50	3948.4 c	4500.2 a	4224.3 A	363.4 c	407.4 a	385.4 A
Means	3817.9 B	4276.3 A		354.3 B	390.5 A	

Means sharing similar letter(s) for a parameter do not differ significantly at p < 0.01
CV (p < 0.01) = 0.02 percent for FM; 0.03 percent for DM

Table 3. Effect of potassium sulphate on potassium and sulphur uptake (μg mg^{-1}) in sunflower grown in saline sodic soil

Potassium sulphate applied (mg kg^{-1})	K uptake			S uptake		
	Hybrids		Means	Hybrids		Means
	SMH-9706	PARSUN-3		SMH-9706	PARSUN-3	
Control	7.95 d	9.45 b	8.70 B	0.94 d	1.19 b	1.06 B
50	8.76 c	10.67 a	9.72 A	1.05 c	1.39 a	1.22 A
Means	8.36 B	10.06 A		1.00 B	1.29 A	

Means sharing similar letter(s) for a parameter do not differ significantly at $p < 0.01$
CV ($p < 0.01$) = 0.17 percent for K uptake; 1.2 percent for sulphur uptake

Table 4. Effect of potassium sulphate on sodium uptake (μg mg^{-1}) and total chlorophyll (μg mg^{-1}) fresh mass of leaf in sunflower grown in saline sodic soil

Potassium sulphate applied (mg kg^{-1})	Na uptake			Chlorophyll		
	Hybrids		Means	Hybrids		Means
	SMH-9706	PARSUN-3		SMH-9706	PARSUN-3	SMH-9706
Control	0.1073 a	0.0903 c	0.0988 A	2.13 d	2.31 c	2.22 B
50	0.0947 b	0.0860 d	0.0903 B	2.38 b	2.62 a	2.50 A
Means	0.1010 A	0.0882 B		2.26 B	2.47 A	

Means sharing similar letter(s) for a parameter do not differ significantly at $p < 0.01$
CV ($p < 0.01$) = 0.75 percent for Na^+ uptake; 0.24 percent for chlorophyll

3.4 Membrane Stability Index and Sodium Potassium Ratio

Membrane stability index (MSI) in leaves of SMH-9706 increased 7 percent than the control. In PARSUN-3, it increased 11 percent then the control. In control, MSI of PARSUN-3 increased 18 percent than that of SMH-9706. On potassium sulphate application, MSI of PARSUN-3 increased 21 percent than that of SMH-9706. Sodium potassium ratio in leaves of SMH-9706 increased 33 percent than the control. In PARSUN-3 it increased 32 percent then the control. In control, Na^+/K^+ ratio of PARSUN-3 decreased 29 percent than that of SMH-9706. Under potassium sulphate application, Na^+/K^+ ratio of PARSUN-3 decreased 33 percent than that of SMH-9706 (Fig. 1).

4. DISCUSSION

4.1 Growth

Use of potassium sulphate as fertilizer, especially in saline sodic soil provides assistance in growth to sunflower. Fresh mass is an indicator signifying the moisture having water and dissolved chemicals in it for binding the tissues [6]. The more the fresh mass of a plant, the more moisture it has. Further, under salt stress, water retention by tissue of glycophyte is low. Potassium sulphate having sulphur, builds in the plant bio mass as reflected in dry mass of shoot. It is carried out in a good coordination of sulphur with potassium. Dry mass of plant material is the net out come of the resultant metabolic activities [14].

4.2 Up Take of IONS

A nutrient uptake by a plant organ indicates that a particular nutrient is available in the growth medium and its translocation through root system to the shoot portion is carried out successfully. Uptake of sulphur was in synergistic relation with potassium ion. Potassium plays a positive role to lessen negative effects of sodium ion on growth of sunflower. Sodium ion is similar to potassium ion; many K^+ transporters do not discriminate sufficiently between these cat ions. This results undesirable accumulation of sodium ions in plant cell [15]. Therefore, application of potassium at a higher concentration is beneficial for the growth of sunflower as [15]. Tester and Davenport [16] found that potassium ion is a co-factor for many enzymes, therefore high dose of K^+ is applied for attachment of tRNA to the ribosomes. This study also revealed genetic variability, as uptake of sulphur and potassium was higher in PARSUN-3 than SMH-9706. Some genes may be stitched off or absent in SMH-9706 to transport ions from the growth medium via roots.

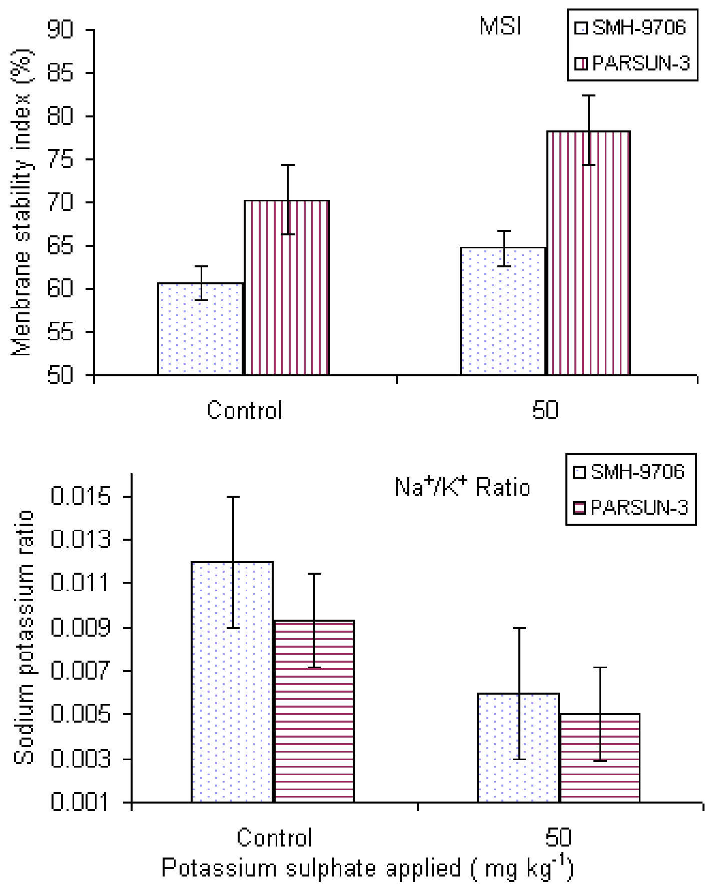

Fig. 1. Effect of potassium sulphate on membrane stability index (MSI) and sodium potassium ratio of sunflower grown in saline sodic soil

4.3 Chlorophyll, Membrane Stability Index and Sodium Potassium Ratio

Chlorophyll concentration enhanced with potassium sulphate application. Additional sulphur application enhanced chlorophyll in crops [17]. Potassium deficiency in plants results deficiency of chlorophyll [18]. With the application of potassium sulphate, chlorophyll increased in both the hybrids of sunflower. However this increase was higher in PARSUN-3 than SMH-9706. Since physiological and genetic traits work in proper coordination, so both the hybrids revealed these facts. Increasing permeability of the cellular membranes to ions and electrolytes decreases membrane stability index (MSI). Potassium sulphate application checked the permeability of sodium ion in both the cultivars. Its application improved MSI 21 percent of PARSUN-3 than SMH-9706. High concentrations of Na^+ cause membrane disorganization and inhibition of cell division and expansion [19]. Salinity may result in water deficit, osmotic stress and ion toxicity. Tuteja N [20] found that salinity confines membrane permeability. This also declines spreading of cell wall and cessation of the growth. Under potassium sulphate application, Na^+/K^+ ratio of PARSUN-3 decreased 42 percent than that of SMH-9706. PARSUN-3 was not genetically accumulator of sodium ion under the presence of potassium sulphate. In sunflower, being a glycophyte, potassium and sulphate ions are inversed to Na^+ [6] (Badar-uz-Zaman et al., 2017). This study also showed that PARSUN-3 is salt tolerant and has the capacity to maintain a high K^+/Na^+ ratio. According to [21], change in ratios of ions in plants may be a resultant of same pathways of sodium and potassium ions. Sodium ion competes with potassium ion uptake through Na^+- K^+ co-transporters [22].

5. CONCLUSIONS

Under saline sodic soil growth of sunflower is improved with potassium sulphate application. However, its application also revealed genotypes differential response to ion and biochemical parameters under salt stress.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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