Effect of foliar application of silicon on some growth properties and forage yield of Oat cultivars (*Avena sativa* L.) grown under saline affected soils

Muqdad F. Hassan[1], Mohanad A. alsulaiman[2]

[1]MSc. Student, Department of Field Crops, College of Agriculture, University of Basrah, Basrah, Iraq[2]Dr.Department of Field Crops, College of Agriculture, University of Basrah, Basrah, Iraq

Correspondence:mohanad.alsulaiman@uobasrah.edu.iq

Abstract

Field experiment was conducted in winter session of 2021-2022 at Alhartha agricultural research station of college of agriculture, university of Basrah, Basrah, Iraq (30.65783 N, 47.74210E). The aim was to evaluate effect of foliar application of silicon and partitioning ofsilicon dosage on growth and forage yield of two oat varieties cultivated in saline affected soil. The experiment include three factors, three concentrations of silicon (control, 4%, 8%), partitioning of silicon dosage, once,twice and three times of application (at tillering, stem elongation and booting stage) and two oat varieties (Ganzania and Shifaa). The experimental design was split split plot design using randomized complete block design with three replicates. Oat varieties sowing at main plot, timing of application (once, twice and three times) at sub plot, silicon concentrations (control, 4% and 8%) at sub sub plot. The distance of experimental unit was 2x2 m^{-2}. The results revealed that, there is significant differences between Oat varieties, Shifaa gave highest green and dry forage yield as compared to Ganzania by 23.032 and 2.031 t ha^{-1}respectively. Silicon partitioning as compared to control treatment (once foliar application) lead to significantly increase tillers m^{-2}, plant high, stem dimeter, flag leaf area, Si% and K%. Foliar application of silicon lead to enhance all traits measured as compared to control treatment (0%), and 8% concentration of silicon gave highest tillers m^{-2}, flag leaf area, Si% and k%by 527.4 tillers m^{-2}, 44.11 cm^{-2}, 7.737%, 4.387% respectively. While no significant differences between 4% and 8% in CGR, green and dry forage yield by (8.35 and 8.55 g m^{-2} day^{-1}), (22.175 and 22.278 t ha^{-1}) and (2.128 and 2.289 t ha^{-1}) respectively. The results showed significant interaction for partitioning of silicon dosage and silicon concentration. Silicon partitioning of 4% and 8% concentration of silicon gave significant increased for plant height, flag leaf area cm^2, Si%, K%, green forage yield and dry forage yield.

Keyword: Oats, silicon, salinity, Forage yield

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1: Introduction

All most the world have been attacked by climate condition changelike high temperature, drought, high wind and flooding lead to reduce agricultural product for many crops(Lobell *et al.*, 2011; Osborne and Wheeler, 2013; Kissoudis *et al.*, 2016; Urban *et al.*, 2017). Moreover, Climate change lead to increased soil salinity which usually accompanies to increased water deficit in worldwide(Ma *et al.*, 2012; Ahmed, 2020). climate change also drastically accelerate the land deterioration that is now already occurring due to agricultural intensification and irrigation(DeLong *et al.*, 2015). Predictive study of (Long *et al.*, 2015)indicated that, the yield of three main crops (rice wheat and cassava) will not sufficient in future due to degradation in agriculture land. Moreover, in next future 2050, global Food demand increase by 70–110% and will presents a significant challenge to society. (Tilman *et al.*, 2011; Long *et al.*, 2015). Oat (*Avena sativa* L.) is one of most important cereal and forage crops ranks sixth in world cereal production after wheat, maize, rice, barley and sorghum (Pinto *et al.*, 2021). In addition, in Iraq Oats contribute to providing green fodder for animals in periods when green fodder is scarce(Alfreeh, 2021). This shortage occurs especially during the winter season when the productivity of alfalfa and berseem reduced due to the low temperatures(Alabdulla, 2019). There is increasing evidence to use more flexible varieties to mitigate the impact of climate condition change on crop production. In addition, to increased agricultural forage production it is important and beneficial to cultivate saline effected soil by both tolerant and sensitives forage crops. For the sensitives crops maywe can use some nutrition like silicon which will enhance their ability to tolerate effect of salinity(Liang *et al.*, 2003; Zhu *et al.*, 2004; Al-aghabary *et al.*, 2005; Ahmad *et al.*, 2011). Silicon (Si) is non-essential elements, that can enhance crop yield by promoting several desirable plant physiological processes (Korndörfer and Lepsch, 2001). Effect of climate change on crops can be to a large extent mitigated, or may even become favorable for crop productivity, if appropriate actions are taken. These actions include the use of resilient cultivars with adjusted planting date, and changing fertilizer strategies (Challinor *et al.*, 2014; Moore and Lobell, 2014). The aim of this study was to evaluate the effect of foliar application of silicon on growth and forage yield of two Oat cultivars under saline affected soils.

2: Material and Methods

A field experiment was conducted during 2021-2022 season at agricultural research station, College of agriculture, university of Basrah, Basrah, Iraq (32° 29' 0.0024'' N, 44° 26' 0.0024'' E). The aim was to investigate the effect of timing and foliar application of silicon on some growth properties and forage yield of two Oat cultivars (*Avena sativa* L.). The experiment include three factors, the first one is two Oat cultivars (Shifaa and Ganzania) which they are symbolized by V_1 and V_2. Second factor is partitioning of silicon dosage, (once, twice, three times which they are symbolized by C_1, C_2 and C_3) at tillering, stem elongation and booting stage. Third one is silicon (SiO_2) at three concentrations (control, 4, 8%) which they are symbolized by S_0, S_1 and S_2 respectively. The total number of experimental units is54 with a distance of 4 m^{-2}. A split split plot experiment was applied according to the randomized complete block design with three replicates. Oat varieties were applied at main units, partitioning of silicon dosage was applied at sub plots and silicon concentration applied at sub sub plots. Experimental soil was prepared by two orthogonal tillages and then, the soil leveled and grained by disc harrows. Random samples were taken from soil before planting (depth of 0-30cm), dried and passed in a 2 mm sieve to determine some physical and chemical properties of field (Table 1). Nitrogen fertilizer was added to the soil in form of urea, 46% N at 120 kg h^{-1} at two equal timing, the first one a week after seed sowingand the second one at stem elongation stage. Phosphate fertilizer was added to the soil at seed sowing in form of triple superphosphate 21% P_2O_5 at 100 kg h^{-1}. Potassium fertilizer was added to the soil at 120 kg h^{-1} at two equal times, seeding growth stage sowing and stem elongation in form of potassium sulfate 52% in form of triple superphosphate 21% P_2O_5 at 100 kg h^{-1}(Alabedy, 2011). Seeds were sowing a strip, 20 cm between line and another. Silicon was used in form of $SiO_2$and spired at the concentrations and timing that have determined. Tween 20 was used to decrease the surface tension of solution. Some growth properties were measured; tellers number, plant height, stem dimeter,flag leaf area, crop growth rate (CGR), Si%, K%, green forage yield (GFY) and dry forage yield (DFY). The data were collected and analyzed statistically by GenStat statistical software 12. Averages of data were compared by using least significant difference (LSD) at probability level of 0.05 (LSD ($P<0.05$).

Table 1 some physical and chemical properties of experimental soil before seeds sowing

Trait	code	Value	unite
Acidity	PH	7.45	IU
Conductivity	EC	15.16	dS m^{-1}
Calcium	Ca	8.8	mg kg^{-1}
Magnesium	Mg	3.7	
Sodium	Na	7335	
Bicarbonate	HCO3	5	
Chloride	CL	138.7	
Sulfate	SO4	5.4	
Potassium	K	7633	
Phosphate	PO4	3.07	
Nitrogen	(NO3+NH4)	49.6	
Total organic carbon	TOC	2.95	%
soil texture Clay loam	sand	560367	g kg^{-1}soil
	silt	650350	
	mud	311317	

1: Results and Discussion

1:1 Tillers number (tillers m^{-2})

The results of analysis of variance (Table 2) showed that theirs significant effect forvarieties, partitioning of silicon dosage, silicon concentration and the interaction of varieties and silicon. The results of Table 3 revealed that Oatvarietyhave significant effect on tillers $m^{-2}$and Shifaa gave highest average by 506.5 tillers m^{-2} as compared to Ganzania which gave the lowest average by 482.0 tillers m^{-2}.Oat variety differ in their genetic ability and this result is convent with the results of (Saleem *et al.*, 2015). The results of table 3 indicated that partitioning of silicon dosage have significant effect on tillers m^{-2}. Moreover C3 treatment gave highest average by 500.8 tillers m^{-2}without any significant differences from C2 which gave 497.73 tillers m^{-2}. While, C1 gave the lowest average by 484.3 tillers m^{-2}. The partitioning of silicon dosage lead to increase the period of silicon availability,especially during the periods when plants need. The results of table 3 showed significant effect for silicon concentrations on tillers m^{-2}. Foliar application of silicon lead to increased tillers m^{-2}, and S2 gave highest average by 527.4 tillers m^{-2} as compared to the control treatment (S0) by 454.0 tillers m^{-2}. Foliar application of silicon helped to maintain abalanced and efficient absorption and translocation ofmineral elements required for better growth, in addition enhance growth by improving K^+ which was adversely influenced by salt stress (Table3). The current findings were also supported by(Anser *et al.*, 2012)who indicated an increase in dry matter yield with an increasing rate of Si nutrition in of Wheat crop. The results of table 3 indicated that there is significant effect for the interaction of Oat varieties and silicon concentration. Foliar application of silicon lead to increased tillers m^{-2} for both Oat varieties, and so Shifaa under foliar application of S2 gave the highest average by 532.5 tillers m^{-2} without any significant differences from the interaction of the same variety with S1 concentration by 524.1 tillers m^{-2} and the interaction of Ganzania with S2 concentration by 478.6 tillers m^{-2}.

1:2 Plant height (cm)

The results of analysis of variance (Table 2) showed that theirs significant effect for varieties, partitioning of silicon dosage, silicon concentration, the interaction of varieties with partitioning of silicon dosage, the interaction of varieties by silicon concentrations and the interaction of varieties withpartitioning of silicon dosage with silicon concentrations. The results of table 3 showed that, there are significant differences between Oat varieties in plant height. Ganzania gave highest average by 99.77 cm, while Shifaa gave the lowest by 91.50 cm. Oat varieties were differs in their genetic abilityand this result is convent with the results of (Saleem *et al.*, 2015) The results of table 3 showed that, there are significant differences between partitioning of silicon dosage in plant height, the treatment C2 gave highest average by 99.43 cm, whereas C1 gave the lowest average by 91.66 cm. silicon partitioning led to increased silicon availability for the plant during active growth periods. The results of table 3 showed significant effect for silicon concentrations on plant height. Both concentration of silicon S2 and S1 gave highest average by 102.45 and 99.22 cm respectively. Whereas the concentration of S0 gave the lowest average by 85.24 cm. foliar application of silicon lead to reduced nutrient imbalance and so improve plant growth (Ahmed *et al.*, 2008; Fan *et al.*, 2019)The results of Table 4 showed that, the interaction of varieties and silicon have a significant effect on plant height, and the increased of silicon lead to increase plant height for both Oat varieties. Ganzania under foliar application of S2 gave highest average by 108.51 cm. While Shifaa was under foliar application of S0 gave lowest average by 82.58 cm silicon application significantly enhanced plant growth and plant high (Lee *et al.*, 2010).The results of Table 5 revealed that the interaction of silicon concentration and silicon partitioning have a significant effect on plant height. The treatment of two times of foliar application by S2 silicon concentration gave highest plant height by 108.84 cm. While the interaction of (C2x S0), (C3xS0) and (C1XS0) gave the lowest average by 83.67,85.35 and 86.69 cm respectively. Partitioning of silicon (Si) lead to increased Si availability to the plants. Moreover, increase Si concentration lead to increased Plant growth.

1:3 Stem diameter

The results of analysis of variance (Table 2) showed that theirs significant effect for varieties, partitioning of silicon dosage, silicon concentration, the interaction of varieties with silicon partition on stem diameter. The results of table 3 showed that, there are significant differences between Oat varieties in stem diameter. Shifaa gave highest average of stem dimeter by 4.589 mm, while Ganzania gave the lowest by 3.654 mm. This is maybe because thatOat varieties differ in their genetic ability and may be because Ganzania is tallest than Shifaa (Table 3). This convenience with the finding of(Ullah *et al.*, 2018; Addaheri and Abood, 2020). The results of table 3 showed that, there is significant effect for partitioning of silicon dosage onstem diameter, the treatment of C3 and C2 gave highest average by 4.228 and 4.161 mm, whereas C1 gave the lowest average by 3.976mm. Silicon partitioning led toincreaseits availability for plant during active growth periods. The results of table 3 revealed that silicon concentrations have significant effect on stem diameter both S1and S2concentration gave highest average by 4.209 and 4.164 mm respectively. Foliar application of silicon leads to increase silicon. While, the control treatment (S0) gave the lowest average by 3.991mm. Similarly, in other studies conducted on Oat and wheat, un increased in stem diameter have been observed as results of Si application (Attia *et al.*, 2015; Saleem *et al.*, 2015). The results of Table 4 showed significand interaction for Oat varieties with silicon concentration, increased silicon concentration lead to increase stem dimeter for both Oat varieties. Moreover, Shifaa under foliar application of S2 and S1 gave highest average by 4.737 and 4.729 respectively. While Ganzania under S3concentration gave the lowest average by 3.592 with no significant differences from the interaction of Ganzania under S0 and S1 treatment. The results of Table 4 showed significant interaction among Oat varieties with partitioning of silicon dosage and silicon concentrations on stem diameter. Moreover,

1:4 Flag leaf area

The results of analysis of variance (Table 2) showed that theirs is significant effect for varieties, partitioning of silicon dosage, silicon concentration, the interaction of varieties by partitioning of silicon dosage, the interaction of varieties bysilicon concentration, interaction of partitioning of silicon dosage by silicon concentrations and the interaction of varieties by partitioning of silicon dosage by silicon concentrations on flag leaf area. The results of Table 3 showed significant differences between Oat cultivars, Shifaa gave highest by 38.38 cm^{-2}, whereas, Ganzania gave the lowest average by 35.22 cm^{-2}, maybe becausethat Oat varieties differ in their genetic ability.The obtained results confirm the results of that found by(Saleem *et al.*, 2015; Alzirkani, 2017; Alrubaiee, 2019). The results of Table 3 showed significant effect for partitioning of silicon dosage the treatment of C2 gave highest flag leaf area by 40.12 cm^{-2}. While no partitioning (C1) gave the lowest average by 31.80 cm^{-2}. Silicon partitioning led to increase its availability for plant during different growth periods under salinity and so makes leaves more erect(Sumida, 2002).The results of Table 3 showed significant differences between silicon concentrations on flag leaf area. The concentration of S2gave highest average by 44.11 cm^{-2}. While, the concentration of S0 gave the lowest average by 26.23 cm^{-2}.The addition of silicon leads to an increase in the balance and absorption of the elements in plant and enhanced plant growth (Laane, 2018; Zargar *et al.*, 2019).Similarly, in other study conducted on oats , a significant effect have been observed for silicon application in CGR (Alrubaiee, 2019). The results of Table 4 revealed significant interaction for Oat varieties and partitioning of silicon dosage. Shifaa under two and three time portioning of silicon gave highest average by 40.95 and 39.47 cm^{-2}respectively, while Ganzania under no partitioning of silicon gave lowest average by 28.89 cm^{-2}. The results of Table 4 indicated significant interaction for varieties by silicon concentrations. Shifaa under S2 concentration gave highest average by 44.79 cm-2. While Ganzania under S0 concentration of silicon was gave lowest average by 23.55 cm^{-2}. The effect of interactioncould be becausedue to the single effect of each treatment. The results of Table 5 showed significant interaction for partitioning of silicon dosage and silicon concentrations on flag leaf area. Two time application of S2 concentration of silicon gave highest flag leaf area by 49.81 cm^2. While the interaction of three, one and two time partitioning of silicon with S0 gave the lowest flag leaf area by 25.50, 26.31 and 26.89 cm^{-2} respectively.The effect of interaction wasmaybe due to the single effect of each treatment. The results of Table 6 showed significant effect for interaction of Oat varieties with silicon partitioning and with silicon concentration on flag leaf area. Treat Shifaa variety with two times foliar application of S3 concentration of silicon gave highest flag leaf area by 51.40 cm^{-2}. Whereas, treat Ganzania with one time foliar application of S0 concentration of silicon gave lowest flag leaf area by 21.63cm^{-2}. The effect of interaction maybe due to the single effect of each treatment.

1:5 Crop Growth Rate (g m^{-2} day^{-1})

The results of analysis of variance (Table 2) showed that theirs is significant effect for varieties, silicon concentration, the interaction of varieties by silicon concentration and the interaction of partitioning of silicon dosage by silicon concentrations on Crop Growth Rate (CGR). The results of Table 3 showed significant differences between Oat cultivars, Shifaa gave

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highest CGR by 7.99 g m^{-2} day^{-1}. Whereas, Ganzania gave the lowest CGR by 6.88 g m^{-2} day^{-1}. Maybe this is because Oat varieties differ in their genetic abilityand in addition Shifaa gave highest tillers m^{-2}, Stem dimeter and flag leaf area which reflect positively on CGR. The results of table 3 showed significant effect for silicon concentrations on CGR. Both concentration of silicon S2 and S1 gave highest average by 8.55 and 8.35 g m^{-2} day^{-1}respectively, whereasthe concentration of S0 gave the lowest average by 5.41 g m^{-2} day^{-1}. Foliar application of silicon lead to increased CGR because silicon significantly increased tillers m^{-2}, plant high and flag leaf area (Table 3) which have significant correlation with CGR by 0.7015**, 0.4849**and 0.6898** respectively. The results of Table 4 reveled that there is significant interaction between Oat cultivars and silicon concentrations. Foliar application of silicon leads to increased CGR for both Oat cultivars. Shifaa under 4%concentration gave highest CGR by 8.78 g m^{-2} day^{-1} with no significant differences from the interaction Shifaa under S2, Ganzania under both S2 and S1.While the Ganzania under S0 concentration gave the lowest CGR by 4.25 g m^{-2} day. The results of Table 5 showed that there is significant effect for the interaction of dosage number of silicon and silicon concentration on CGR. Two times of foliar application of S2 silicon concentration gave highest plant height by 108.84 cm. While one, two and three times of foliar application of S0 concentration gave the lowest average by 83.67,85.35 and 86.69 cm respectively. Silicon can alleviate salinity damage (Gong *et al.*, 2005).(Sumida, 2002; Gong *et al.*, 2005; Attia *et al.*, 2015)

1:6 silicon% (Si%)

The results of analysis of variance (Table 2) showed that theirs is significant effect for partitioning of silicon dosage, silicon concentration, interaction of partitioning of silicon dosage with silicon concentrations on silicon presentation(Si%). The results of Table 3 showed significant effect for partitioning of dosage of foliar application of silicon. The treatment of C3 and C2 gave highest Si% by 6.132 and 5.988% respectively. While no partitioning (C1) gave the lowest average by 5.083%. Partitioning of silicon dosage led to increase its availability for plant during different growth periods. The results of Table 3 showed significant differences between silicon concentrations on Si% in plant. The concentration of S2 gave highest average by 7.737%. While, the concentration of S0 gave the lowest average by 2.471%. Increased silicon concentrationlead to increase Si% in plants. The study of (Fan *et al.*, 2019)showed that application of Si–K fertilizer improved the accumulation of Si in plants.Table 5 showed significant interaction for partitioning of silicon dosage with silicon concentrations on Si% in plant. Two time application of S2 concentration of silicon gave highest Si% by 8.226% with no significant differences from three time application of S1 concentration of silicon by 7.798%. While the interaction of two, one and three time of partitioning of spray solution of silicon with S0concentration gave the lowest Si% by 2.321, 2.451and 2.642% respectively.

1:7 Potassium%

The results of analysis of variance (Table 2) showed that theirs is significant effect for partitioning of silicon dosage, silicon concentration, interaction of partitioning of silicon dosage by silicon concentrations on K%. The results of Table 3 showed significant effect for partitioning of silicon dosage. The treatment of C2 and C3 gave highest K% by 3.497 and 3.219% respectively. While no partitioning (C1) gave the lowest average by 2.553%.Partitioning of silicon dosage led to increase k% uptake during different growth periods(Crusciol *et al.*, 2013). The results of Table 3 showed significant differences between silicon concentrations on K% in plant. The concentration of S2 gave highest average by 4.387%. While, the concentration of S0 gave the lowest average of k% by 1.590%. Application of silicon lead to increase K% in plants (Fan *et al.*, 2019). Potassium and silicon play a big role in plant tolerant to salinity by reduced the concentration of Na^+ and Cl^- in the leaves by increasing carbohydrate, proline, phenolics and flavonoids(Oraee and Tehranifar, 2022).

Table 5 showed significant effect interaction for partitioning of silicon dosage with silicon concentrations on K% in plant. Two time application of S2 concentration of silicon gave highest K% by 5.092% with no significant differences from three time application of S2 concentration of silicon by 4.623%. While, the interaction of the three treatment of silicon partitioning (C3, C1, C2) with S0 concentration gave the lowest K% in plant by 1.434, 1.580 and 1.755%.The results showed high significant correlation between silicon foliar application and k% in Oat by 0.8783**.

1:8 Green forage yield (t ha^{-1})

The results of analysis of variance (Table 2) showed that theirs is significant effect for varieties, silicon concentration, the interaction of varieties by silicon concentration, interaction of partitioning of silicon dosage with silicon concentrations on green forage yield (GFY). The results of Table 3 showed significant differences between Oat cultivars, Shifaa gave highest GFY by 23.032 t ha^{-1}. While, Ganzania gave the lowest GFY by 19.379 t ha^{-1}. Shifaa variety gave highest tillers m^{-2}, stem dimeter, flag leaf area, CGR (table 3) and this reflect positively on GFY. The results of table 3 showed significant effect for silicon concentrations on GFY. Both concentration of silicon S2 and S1 gave highest average by 22.278 and 22.175 t ha^{-1} respectively, whereas the concentration of S0 gave the lowest average by 19.163 t ha^{-1}. Foliar application of silicon lead to increased tillers m^{-2}, plant high, stem dimeter, flag leaf area and CGR (Table 3) which reflect positively on GFY. In addition the results of correlation showed high significant correlation between Green forage yield and tillers m^{-2}, plant high, stem dimeter, flag leaf area and CGR by 0.5127**, 0.8188**, 0.6087** and 0.4374** respectively. Foliar application of silicon lead to alleviate salinity effect (Stadnik and Tobiasz-Salach, 2022). The results of Table 5 showed that there is significant effect for partitioning of silicon dosage and foliar application of silicon on GFY. Silicon partitioning and foliar application lead to significantly increased GFY as compared to control treatment (no silicon). The interaction of (C2xS2), (C3xS1), (C3xS3) and (C2xS1) gave highest GFY by 22.675, 22.633, 22.325 and 22.232 t ha^{-1}respectively because silicon partitioning and application lead to increase all traits measured. The results of Table 6 showed significant effect for interaction of Oat varieties with silicon partitioning and with silicon concentration on GFY. Treat Shifaa by two time of foliar application of S3 concentration gave highest GFY by 24.771 t ha^{-1}. While, treat Ganzania by one time foliar application of S0 gave the lowest GFY by 18.216 t ha^{-1}.

1:9 Dry forage yield (t ha^{-1})

The results of analysis of variance (Table 2) showed that theirs is significant effect for varieties, silicon concentration and the interaction of partitioning of silicon dosage by silicon concentrations on dry forage yield (DFY). The results of Table 3 showed significant differences between Oat cultivars, Shifaa gave highest DFY by 2.031 t ha^{-1}. While, Ganzania gave the lowest GFY by 1.826 t ha^{-1}. Shifaa gave highest green forage yield as compared to Ganzania (table 3) and this reflected positively on DFY. The results of table 3 showed significant effect for silicon concentrations on DFY. Silicon concentration of S2 gave highest average by 2.289 t ha^{-1} .Whereas, control treatment (S0) gave the lowest average by 1.369 t ha^{-1}. Foliar application of silicon lead to increased green forage yield (Table 3) and this reflect positively on dry forage yield. The results of Table 5 showed that there is significant effect for the interaction of dosage number of silicon foliar application and silicon concentration on DFY. The portioning of silicon dosage and silicon concentrations foliar lead to significantly increased DFY as compared to control treatment (no silicon). The interaction of (C2xS2), (C3xS2), (C3xS1) and (C1xS2) gave highest DFY by 2.396, 2.250, 2.229 and 2.221 t ha^{-1} respectively. Both partitioning of Silicon dosage and foliar application of silicon lead to increase GFY (Table 5) which reflect positively to increase DFY.In addition the results of correlation showed high significant correlation between Green forage yield and Dry

Conclusion

We conclude that Shifaa is more resilient to grow under silt affected soil as compared to Ganzania.Shifaa gave highest green and dry forage yield by, 23.032 t ha^{-1} and 2.031 t ha^{-1} respectively. Foliar applications of silicon ameliorate harsh effect of salinity.Foliar application of silicon and partitioning its dosage improvedgrowth, K%, green and dry forage yield for both Oat varieties that grown under silt affected soils.The interaction ofpartitioning of silicon dosage for two times and the concentration of 4% silicon gave highgreenand dry forage yield by22.675 t ha^{-1}and2.396 t ha^{-1}.

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Table 2 Analysis of variance represented by Mean of Square of some Growth properties and Forage yield of Oat cultivars grown under saline soils
*** Significant at P<0.05; ** Significant at P<0.01**

S.O.V	d.f.	Tillers m^{-2}	plant height (cm)	Stem Diameter (mm)	Flag leaf area cm	C.G.R. g m^{-2} day^{-1}	Si%	K%	GFY (t ha^{-1})	DFY (t ha^{-1})
Replicate	5	291.35	2.451	0.01977	21.465	2.882	0.1273	0.2304	0.3368	0.02769
V	1	8060.31*	924.711*	11.81607**	135.000*	16.693*	0.3832	0.0874	180.1633**	0.56857*
Error A	5	127.53	30.009	0.04402	5.456	0.150	0.2809	0.1169	0.0039	0.01964
C	5	1374.92*	272.611*	0.30747**	349.725**	0.380	5.8251**	4.2375**	0.2639	0.01175
VxC	5	317.57	89.112	0.00576	24.006**	0.156	0.5464	0.2574	0.5505	0.09361
Error B	1	112.44	20.530	0.00440	1.563	0.392	0.1248	0.4975	0.1261	0.03757
S	5	24919.16**	1506.24**	0.23834**	1580.350**	55.592**	146.2244**	35.7679**	56.3392**	4.34230**
VxS	5	1564.59**	54.756**	0.34362**	18.514**	5.557*	0.5351	0.0838	0.0579	0.06959
CxS	6	199.00	132.587**	0.01443	93.556**	0.666	1.8371**	1.0966*	1.8050**	0.09370**
VxCxS	6	249.17	26.025*	0.14494*	19.994**	0.854	1.0549	0.0356	0.7143*	0.02605
Error C	56	91.38	6.753	0.03370	2.236	1.245	0.1994	0.1775	0.1889	0.02562
Total	73	37307.4	3065.785	12.97245	55713167	84.567	157.1386	42.5885	240.5498	5.31609

Table 3 Effect of partitioning of silicon dosage and of foliar application of silicon on some growth properties and forage yield of Oat varieties grown under saline soils

Treatment	Traits measured								
	Tillers m^{-2}	Plant height cm	Stem dimeter mm	Flag leaf area cm^2	CGR g m^{-2} day^{-1}	Si%	K%	G.F.Y. (t h^{-2})	D.F.Y. (t h^{-2})
Janzania	482.0	99.77	3.654	35.22	6.88	5.818	3.130	19.379	1.826
Shifaa	506.5	91.50	4.589	38.38	7.99	5.650	3.049	23.032	2.031
LSD (P<0.05)	13.22	6.415	0.2457	2.735	0.453	N.S	N.S	0.1727	0.1641
C1	484.3	91.66	3.976	31.80	7.53	5.083	2.553	21.068	1.917
C2	497.7	99.43	4.161	40.12	7.51	5.988	3.497	21.250	1.958
C3	500.8	95.81	4.228	38.48	7.27	6.132	3.219	21.298	1.912
LSD (P<0.05)	8.15	3.483	0.0510	0.961	N.S	0.2716	0.5422	N.S	N.S
S0	454.0	85.24	3.991	26.23	5.41	2.471	1.590	19.163	1.369
S1	501.4	99.22	4.209	40.05	8.35	6.995	3.292	22.175	2.128
S2	527.4	102.45	4.164	44.11	8.55	7.737	4.387	22.278	2.289
LSD (P<0.05)	6.58	15370	0.1263	1.029	0.768	0.3072	0.2898	0.299	0.1101

Table 4Interaction effect of Oat varieties and partitioning of silicon dosageand the interaction of Oat varieties and silicon concentrations on somegrowth properties and forage yield

Treatment		Traits measured								
		Tillers m^{-2}	Plant height cm	Stem dimeter mm	Flag leaf area cm^2	CGR g $m^{-2}day^{-1}$	Si%	K%	G.F.Y. (t h^{-2})	D.F.Y. (t h^{-2})
Janzania	C1	476.9	51307	3.491	28.89	6.87	5.345	2.594	19.213	1.752
	C2	482.8	103.51	3.712	39.28	6.98	6.063	3.417	19.264	1.838
	C3	486.3	97.76	3.758	37.48	6.79	6.047	3.378	19.659	1.888
Shifaa	C1	491.7	85.27	4.460	34.71	8.19	4.820	2.511	22.924	2.081
	C2	512.5	95.35	4.610	40.95	8.04	5.913	3.577	23.235	2.078
	C3	515.2	53315	4.698	39.47	7.75	6.217	3.060	22.937	1.935
LSD (P<0.05)		N.S	N.S	N.S	2.108	N.S	N.S	N.S	N.S	N.S
Ganzania	S0	445.3	87.89	3.680	23.55	4.25	2.385	1.701	17.329	1.204
	S1	478.6	102.92	3.689	38.67	7.92	7.254	3.267	20.409	2.087
	S3	522.2	108.51	3.592	43.42	8.47	7.816	4.422	20.399	2.187
Shifaa	S0	462.7	82.58	4.302	28.92	6.58	2.557	1.479	20.998	1.535
	S1	524.1	95.52	4.729	41.42	8.78	6.736	3.317	23.941	2.169
	S2	532.5	96.39	4.737	44.79	8.63	7.657	4.352	24.157	2.390
LSD (P<0.05)		10.67	4.921	0.2006	2.077	0.909	N.S	N.S	N.S	N.S

Table 5 The interaction effect of timing of application of silicon and silicon concentrations on some growth properties and forage yield

Treatment		Traits measured								
		Tillers m^{-2}	Plant height cm	Stem dimeter mm	Flag leaf area cm^2	CGR g $m^{-2}day^{-1}$	Si%	K%	G.F.Y. (t h^{-2})	D.F.Y. (t h^{-2})
C1	S0	450.4	86.69	3.793	26.31	5.82	2.451	1.580	19.712	1.497
	S1	485.3	92.95	4.083	32.51	8.39	5.770	2.633	21.659	2.032
	S2	517.3	95.33	4.050	36.57	8.38	7.027	3.446	21.835	2.221
C2	S0	453.0	83.67	4.083	26.89	5.13	2.321	1.755	18.842	1.355
	S1	510.1	105.79	4.207	43.66	8.42	7.417	3.644	22.232	2.123
	S2	529.9	108.84	4.193	49.81	8.99	8.226	5.092	22.675	2.396
C3	S0	458.6	85.35	4.097	25.50	5.29	2.642	1.434	18.937	1.256
	S1	508.7	98.92	4.337	43.97	8.24	7.798	3.599	22.633	2.229
	S2	535.0	103.17	4.250	45.95	8.28	53651	4.623	22.325	2.250
LSD (P<0.05)		N.S	4.067	NS	1.668	N.S	0.4914	0.6418	0.4820	035036

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Table 6 Effect of interaction of foliar application of silicon, and timing of application on some growth properties and forage yield of Oat varieties grown under saline soils

Treatment			Traits measured								
			Tillers m^{-2}	Plant height cm	Stem dimeter mm	Flag leaf area cm^2	CGR $g\ m^{-2}\ day^{-1}$	Si%	K%	G.F.Y. ($t\ h^{-2}$)	D.F.Y. ($t\ h^{-2}$)
Ganzania	C1	S0	445.5	93.35	3.307	21.63	4.75	2.469	1.642	18.216	1.236
		S1	469.6	98.79	3.607	29.96	7.68	6.241	2.664	19.635	1.946
		S2	515.7	102.01	3.560	35.07	8.19	7.325	3.477	19.788	2.074
	C2	S0	435.1	83.69	3.773	27.25	3.69	2.221	1.755	16.558	1.127
		S1	488.3	110.36	3.673	42.39	8.51	7.257	3.539	20.656	2.116
		S2	525.1	116.50	3.690	48.22	8.75	8.711	4.957	20.579	2.272
	C3	S0	455.2	86.63	3.960	21.78	4.30	2.466	1.705	17.212	1.249
		S1	477.8	99.62	3.787	43.67	7.59	8.263	3.597	20.935	2.199
		S2	525.9	107.01	3.527	46.99	8.48	7.412	4.832	20.831	2.216
Shifaa	C1	S0	455.3	80.03	4.280	30.99	6.89	2.432	1.518	21.208	1.758
		S1	500.9	87.10	4.560	35.07	9.10	5.298	2.602	23.683	2.119
		S2	518.9	88.66	4.540	38.07	8.58	6.729	3.415	23.882	2.367
	C2	S0	470.8	83.65	4.393	26.53	6.56	2.421	1.756	21.125	1.583
		S1	532.0	101.23	4.740	44.93	8.34	7.577	3.748	23.808	2.130
		S2	534.7	101.58	4.697	51.40	9.22	7.740	5.228	24.771	2.521
	C3	S0	462.1	84.07	4.233	29.23	6.28	2.817	1.163	20.662	1.263
		S1	539.5	98.22	4.887	44.27	8.89	7.332	3.602	24.332	2.258
		S2	544.0	99.33	4.973	44.92	8.08	8.502	4.415	23.818	2.283
LSD (P<0.05)			N.S	63066	N.S	2.658	N.S	0.7328	N.S	0.6539	N.S

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