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RESPONSE OF SIX WHEAT GENOTYPES IN SALINITY SOIL TO SILICON SPRAYING (VEGETATIVE GROWTH)

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ABSTRACT
Field experiment was conducted in 2015-2016growth season in Babylon governorate, in silty-clay soil under salt stress conditions. the experiment aimed to determine the effect of silicon spraying on growth and yield of six wheat genotypes (Triticum aestivum L.) in salinity soil (9.3 dSm^{-1}). Factorial experiment was conducted according to randomized complete block design (RCBD) with three replications included two levels of silicon spraying (0 and 25 mM.L^{-1} and six genotypes of bread wheat. Wheat genotypes of Hussein, Furat, Rashid, Uruk, Nukal and 884 were cultivated in 20/11/2015 and harvested at 10/5/2016. The data were analyzed statistically and the average were compared by less significant difference test. The results showed that silicon spraying was superior by giving the highest average of plant height, leaf area, spike length and chlorophyll content which amounted to 79.78 cm, 19.89 cm 2, 15. 19 cm and 51.62 SPAD respectively. Rashid genotype was superior by giving higher average in leaf area , spike length and chlorophyll content which amounted to 22.18 cm^2, 16.0 cm and 50.39 SPAD, respectively. Hussein genotype was superior by giving highest average number of tillers.plant^{-1}, root length and the dry weight of shoot and root, which amounted to 3.5, 15.92 cm, 12.49 g and 0.53 g respectively. Furat genotype was superior by giving the highest average of plant height which amounted to 92.53 cm.
KEY WORDS: *Silicon, Wheat genotypes, Wheat growth*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is important crop, vital to a large number of the world's population, including Iraq, as a source of food for more than 35% of the world's population. Total cultivated area in Iraq's wheat crop was 4147 hectares during the 2014-2015 season and the production was amounted to 2645 thousand tons for the season 2015 (Iraqi Agriculture statistics, 2015). Wheat is affected by environmental stress which affecting phenotypic and physiological growth. Salt stress is one of the most important factors limiting plant growth and yield worldwide (Fahad *et al.* 2015) and decrease plant productivity in the world, including Iraq. The negative effects of salinity on crop growth and productivity come through some effects caused by lack of water, toxic effect of salt ions or by ion balance disorder, since these factors causing negative effect in plant growth by reduction in germination percentage and speed, shoot and root length, low wet and dry weight, and reduction of leaf area (Datcu *et al*, 2017). Salinity also affect the process of carbohydrate and protein building, respiration, transpiration, transport across membranes, and photosynthesis (Ali *et al,* 2012a; Ianovici *et al,* 2010; Hamada, EL-Enany, 1994). The researchers tried to find appropriate solving to the problem of salinity through the reclamation of saline lands solutions, establishment of drainage networks and remove salts. Some researchers trying to devising genotypes which have tolerant to salinity and others using some materials such as growth regulators or nutrients that help to reduce the harmful effect of salts. Many studies have shown that silicon may increase plant tolerance to salinity in many types of plants through different mechanism which include low sodium absorption, transportation and improve plant water status (Ali *et al*, 2012 b; Toledo *et al*, 2012). Wheat is one of a medium endurance crops to salinity, therefore it is necessary to find suitable solving to increase its tolerance. The aim of this study was to estimate some of growth parameters of six wheat genotypes and the effect of silicon on it, in the condition of salty soil

MATERIALS AND METHODS

A field experiment was carried out at winter season 2015-2016 in Al-Tajiyah area, south of Babylon province in salty soil (silt-clay soil with pH= 7.6 and EC= 9.3 $dS.m^{-1}$) in order to study the vegetative growth of six wheat genotypes (Al Hussein, Rashid, Euphrates, Uruk, Nukal and 884) when spraying of silicon (0, 0.25mM). The experiment was carried out in accordance with randomized complete block design with three replications, in which the experimental unit was 6 m^2 (2 * 3). Triple superphosphate (P_2O_5 46%) at 100 $kg.ha^{-1}$was added. Urea fertilizer was added in two parts, the first was added after 30 days from sowing and the second part was added in the elongation phase . The plants were spraying with silicon at four-leaf stage in two levels (control and 0.25 mM) on plant at 4-5 leaves stage at morning, even full wet. At full flowering ten plants were chosen randomly from each experimental unit to calculate: plant height (cm) from the surface of the soil level to the end of main stalk spike, flag leaf area of main stalk, chlorophyll of flag leaves content (SPAD) at flowering stage (by chlorophyll meter) and weight of the flag leaf (g) after dried in oven at 70˚ for 72 hours and then weighed. Statistical program Genstat was used to analysis the data, and the means were compared by less significant difference (LSD) test at the level of probability of 0.05 (Steel & Torrie, 1980).

RESULTS AND DISCUSSIONS

Table (1) showed significant effect of silicon in the root length, and silicon spraying gave highest average of root length (17.36 cm) compared to control treatment (13.36 cm). This is attributable to the effect of silicon on photosynthesis and increase apical root cell division (Lu, 1997), and increasing the absorption of nutrients, phosphorus, nitrogen and increase metabolism and transport operations, as well as its role in encouraging the production of compounds and antioxidant enzymes, which remove toxic free radicals oxygen substances (ROS) (Zhu *et al.* 2004). Silicon softens damage of salt stress by reducing the permeability of cell membranes and oxidation of fat while maintaining the effectiveness of cellular membranes (Liang, 1999). This is consistent with the results of Ahmed *et al.* (2008), Ali *et al.* (2012 b) and Toledo *et al.* (2012).

Wheat genotype were varied significantly in root length, and Rashid gave the highest average of root length (15.90 cm), while Uruk gave the lowest length (14.15 cm). This is due to poor root cells growth when increasing salinity and thus the lack of production of certain hormones like cytokinens or direct effect of salinity in reducing metabolism of cytokinins. This was agreed with Alwan *et al.* (2015) and Jamal *et al.* (2011). The interaction between the genotypes and silicon spraying had a significant effect and Rashid genotype when spraying silicon gave the highest root length (18.81 cm), while Euphrates without silicon treatment gave the lowest average root length, which amounted to 12.52 cm.

TABLE 1. Effect of silicon spraying on root length of six wheat genotypes

Wheat genotypes	silicon		average
	Si 0	Si 1	
Husain	13.06	18.77	15.92
Furat	12.52	15.47	13.99
Rashid	12.99	18.81	15.90
Uruk	12.31	15.98	14.15
Nugal	13.07	18.48	15.78
884	14.10	16.65	15.38
average	13.01	17.36	
$LSD_{0.05}$	Si= 0.995 genotype =1.723 interaction =2.437		

Table (2) showed that silicon spraying caused a significant effect on the root dry weight, which gave highest average of roots dry weight (0.32 g), while control treatment gave lowest average (0.39 g). This is due to the role of silicon in increasing root thickness (Fallah, 2012) as well as its role in increasing the photosynthesis process and increase apical root cells division (Lu, 1997). This is consistent with Ahmed *et al.* (2008) and Ali *et al.* (2012 b).Wheat genotypes differed significantly in roots dry weight, and Husain genotype gave the highest average weight (0.53 g), while Uruk and 884 recorded the lowest average roots dry weight (0.25 g). The reason for this decline probably due to the lack of the ability of these genotypes to exclude the element sodium and retain the element of calcium or potassium at high concentrations on the cell membrane sites of root hairs, which reflected negatively on growth indicators. This was agreed with Kafi & Rahimi (2011). The interaction between the genotypes and silicon spraying had a significant effect and Husain genotype with silicon gave the highest average (0.53 g), while Uruk genotype without silicon gave the lowest average (0.23 g).

TABLE 2. Effect of silicon on root dry weight (g) of six wheat genotypes

Wheat genotypes	silicon		average
	Si 0	Si 1	
Husain	0.48	0.58	0.53
Furat	0.30	0.33	0.31
Rashid	0.47	0.55	0.51
Uruk	0.22	0.28	0.25
Nugal	0.23	0.33	0.28
884	0.22	0.27	0.25
average	0.32	0.39	
$LSD_{0.05}$	Si=0.021 genotype=0.037 interaction=0.053		

Table (3) showed a significant effect of silicon in increasing plant height to 79.78 cm compared to control treatment which gave the lowest height (76.71 cm). This was attributed to the role of silicon in increasing the length of the internodes (Fallah, 2012) as well as its role in reducing salt stress, which helps in the removal of toxic substances resulting from the salts. This result was consistent with the findings of Ali *et al (*2012b), Fallah (2012), Abro *et al.* (2009) and Ahmed *et al.* (2008) in wheat. It also attributed to the role of silicon in increasing water and nutrient absorption and thus accelerate growth (Epstein,1999 and 2001). These are consistent with the findings of Gong *et al* (2003) and Zou *et al.* (2007) that the addition of silicon leads to increase plant height.

Genotypes were differ in plant height, where Furat gave the highest average (90.53 cm), while 884 gave less height (65.12 cm). This reduction was return to the differences in the genotypes inheritance and differences in salt tolerance, which reflex in difference of physiological processes such as reduced cell division, photosynthesis and reduced plant growth (Okcu *et al.,* 2005). These findings were consistent with Alam *et al.* (2004) in wheat and rice respectively. The decline is due to increasing salinity in soil, which leads to increase negative osmotic potential , then to water shortages and inhibits cell division process and auxin content (Yassin *et al,* 1989). The interaction between the genotypes and silicon caused a significant effect and the largest height (92.12 cm) resulted from Furat genotype at silicon spraying compared with less height (62.13 cm) resulted from 884 genotype without silicon spraying.

TABLE 3. Effect of silicon spraying on plant height (cm) of six wheat genotypes

Wheat genotypes	silicon		average
	Si 0	Si 1	
Husain	85.65	90.43	87.54
Furat	87.17	92.10	90.53
Rashid	88.53	91.10	89.82
Uruk	67.67	69.13	68.40
Nugal	67.70	69.27	68.48
884	62.13	68.10	65.12
average	76.71	79.78	
$LSD_{0.05}$	Si =3.024 genotype= 5.238 interaction =7.407		

TABLE 4. Effect of silicon spraying on plant tillers of six wheat genotypes

Wheat genotypes	silicon		average
	Si 0	Si 1	
Husain	3.167	3.875	3.521
Furat	2.967	2.833	2.900
Rashid	3.133	3.733	3.433
Uruk	2.800	2.933	2.867
Nugal	3.00	3.567	3.283
884	2.833	2.967	2.833
average	2.984	3.311	
$LSD_{0.05}$	Si =0.230 genotype =0.399 interaction=0.564		

Table (4) that silicon treatment caused a significant effect in increasing plant tillers to 3.31 compared to control treatment which gave the lowest tillers (2.96). This was attributed to the role of silicon in increasing plant growth under abiotic stress (Epstein, 1999) by promoting growth and increasing potassium absorption by increasing H-ATPase activity (Mali & Aery, 2008 a,b), as well as its role in promoting antioxidant enzymes and compounds, which remove the ROS (Zhu *et al,* 2004) and this reflected in increasing tillers under salt stress (Tahir *et al,* 2006). The genotypes differed in its tillers, and the genotype Husain gave the highest average tillers.plant^{-1} (3.52), while the genotype 884 gave less number (2.83). This was due to the genetic differences between the genotypes, as well as its variation in salt stress tolerance (Tahir *et al.,* 2006). This is consistent with Akram *et al.* (2001) and Tahir *et al* (2006). The interaction between the genotypes and silicon caused a significant effect and the highest tillers.plant^{-1} obtained from the genotype Hussein with silicon treatment (3.88) compared to Uruk without silicon which gave the lowest average (2.80). This is in line with Tahir *et al* (2006).

Table (5) showed that silicon treatment caused a significant effect increase in flag leaf area to 19.89 cm^2 compared to control treatment (16.39cm^2). This is due to the effect of silicon in increasing the rate of photosynthesis and the behavior of the stomata, with lower transpiration rates values (Gao *et al.* 2006) as well as its function to make the leaves in vertical status which reduces shading, its accumulates in the epidermis cells, which affect leaf angle and its role in encouraging the production of the antioxidants (Zhu *et al*. 2004). This is consistent with Kaya *et al.* (2006) and Zhiming *et al* (2014).

Wheat genotypes were differed in leaf area, and highest leaf area obtained from Rashid and Hussein (22.18 and 22.17 cm^2, respectively), while Furat scored the lowest rate (13.93 cm^2). This is attributed largely to the genetic variation of these genotypes (Tahir *et al.,* 2006) and its differ in tolerance of salt stress that leads to different expression to salt stress which increase transpiration rate and leading to a lack of leaf area (Bahrani & Haghjoo, 2012). Leaf expansion is very sensitive, which return to the cells swell as a result of outside and inside pressure on the walls, which was decreased at salt stress, and then hindering movement of nutrients from the roots due to lack of the amount the water absorption (Zhu, 2007; Munns, 2002). This result was agreed with Brisson & Casals (2005). The interaction had a significant effect on this trait, and Hussein genotype with silicon treatment gave the highest rate (24.74 cm^2) compared to Uruk without silicon that scored less rate (12.80 cm^2).

TABLE 5. Effect of silicon on leaf area (cm^2)of six wheat genotypes

Wheat genotypes	silicon		average
	Si 0	Si 1	
Husain	19.59	24.74	22.17
Furat	19.40	22.59	21.00
Rashid	20.65	23.72	22.18
Uruk	12.80	15.56	14.18
Nugal	12.93	14.98	13.93
884	12.96	17.76	15.36
average	16.39	19.89	
LSD $_{0.05}$	Si =1.047 genotype= 1.813 interaction=2.565		

TABLE 6. Effect of silicon on shoot dry weight (g) of six wheat genotypes

Wheat genotypes	silicon		average
	Si 0	Si 1	
Husain	10.57	14.42	12.49
Furat	7.37	9.11	8.24
Rashid	10.16	13.94	12.05
Uruk	6.76	8.71	7.37
Nugal	7.36	9.08	8.22
884	6.99	9.10	8.04
average	8.20	10.73	
LSD $_{0.05}$	Si=0.29 genotype= 0.50 interaction = 0.71		

Table (6) showed that silicon treatment caused significant effect on shoot dry weight, and gave the highest average dry weight (10.73 g), while control treatment gave lowest average (8.20 g). This is due to silicon role in mitigating salt stress by inhibiting the transport of sodium ion to the leaves (Tuna *et al.* 2008). This is consistent with Gong *et al* (2003).

The genotypes differed significantly in dry weight of shoots, and Husain genotype gave the highest dry shoot weight (12.49 g), while Uruk genotype gave the lowest average weight (7.37 g). This is due to lower plant height, number of plant tillers and leaf area (table 4, 5 and 6), and to different genetic traits, as well as differing performance existence of salinity. This was agreed with Tahir *et al* (2006).The lack of water potential led to a lack of cell expansion as a result of the lack of movement of water, nutrients and hormones. The interaction had a significant effect, and Husain genotype with silicon gave the highest average weight (14.42 g), while Uruk genotype without silicon gave less average weight (6.76 g).

Table (7) showed that silicon treatment caused significant effect in spike length and gave highest average length (15.18 cm) compared to control treatment (13.09 cm). This is due to the increase in accumulation of dry matter (Table 6) and to the role of silicon in reducing sodium absorption by the plant under salt stress (Mukkram *et al.* 2006), as well as increased water and nutrients absorption. This results is consistent with the findings of the Ahmed *et al*. (2008) and Abro *et al* (2009). Wheat genotypes differed significantly in spike length and the highest average for the spike length obtained from Rashid genotype (16.00 cm), while Nukal genotype gave less average (12.5 cm). This is due largely to the different genetic traits (Peymaninia *et al,* 2012), as well as to the difference in these genotypes to salt stress tolerance, which is reflected in gene expression in this trait (Asgari *et al,* 2012; Shirazi *et al*, 2015). The interaction between the genotypes and silicon significantly affected spike length, in which Rashid and Hussein genotypes gave high spike length (17.37 cm) when treated with silicon, while Nukal genotype gave less spike length (11.65 cm).

TABLE 7. Effect of silicon on spike length(cm) of six wheat genotypes

Wheat genotypes	silicon		average
	Si 0	Si 1	
Husain	13.97	17.37	15.67
Furat	12.80	14.10	13.45
Rashid	14.63	17.37	16.00
Uruk	12.83	13.97	13.40
Nugal	11.63	13.37	12.5
884	12.67	14.90	13.78
average	13.09	15.18	
LSD $_{0.05}$	Si =0.758 genotype=1.312 interaction =1.856		

CONCLUSIONS

It could be concluded that Rashid and Husain genotype were superior compared to other studied genotypes. On the other hand, silicon spraying enhanced most vegetative growth traits.

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