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RESPONSE OF TWO OAT (*AVENA SATIVA* L.) GENOTYPES TO ASCORBIC AND SALICYLIC ACIDS SPRAYING AND THEIR INTERACTIONS WITH SILICON SPRAY

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Abstract

An experiment was conducted in one of private farm in the Mahaweel area (10 km west of Hilla city) at latitude 32.31 °N and longitude 44.21 °E in 2016/2017 and 2017/2018 growth seasons to study yield response of two oat cultivars (shafaa and oat 11) to spraying with 4 treatments of antioxidant reagent (50 mg.$L^{-1}$of ascorbic acid, 0.5 mM of salicylic acid, both acids and control treatment) and three levels of silicon (0.5 , 1.0 mM and control treatment). Spli-split arrangement in randomized complete block design with three replicates was used. Spraying was done two times (at tiller stage and elongation stage).The experimental unit contained 10 lines (20 cm between and 3 m long). The results showed that Shafaa cultivar was superior in parincles number per m^2, weight of 1000 grains, grain yield, biological yield and harvest index (516.8, 508.5 parincles.m^{-2}, 45.39, 47.45 g, 3.68, 4.08 t.ha^{-1}, 12.71, 13.08 t.$ha^{-1}$and 28.75 and 30.96% compared to oat 11 cultivar that was superior in grains number per panicle (43.07 and 41.87 grains). Spray of salicylic acid and ascorbic acid individually caused significantly increases panicles number.m^{-2} (463.7, 460.2 and 469.8, 464.3) , weight of 1000 grains (45.8, 45.4 and 47.7, 47.0 g), grain yield (3.78, 3.44 and 4.08, 3.89 t.ha^{-1}) ,biological yield (12.98, 12.75 and 13.19, 13.15 t.ha^{-1}) and harvest index (28.92, 27.95 and 30. 63 and 29.24) in both seasons respectively compared to control treatment that gave the lowest values. Silicon spraying with high concentration caused significant increases in panicles number. m^{-2}, weight of 1000 grains , grain yield, biological yield, and harvest index (460.1, 464.2 parincles.m^{-2}, 45.62, 47.21 g, 3.47, 3.75 t.$ha^{-1}$and 12.16, 12.81 t.ha^{-1} and 28.32 , 28.95%) , respectively compared to control treatment that gave the lowest values.

Key words: Oat cultivar, Salicylic acid, Ascorbic acid, Silicon

Introduction

Oats were not grown in Iraq except in some agricultural research. Studies indicate that it was grown in the pre-Christmas period in different parts of the world, and the normal white oats were cultivated in the cold and wet areas (Soratto *et al*., 2012). Oats grain were used in the food of both humans and animals due to its rich in important nutrients. Studies and research suggest that oatmeal is beneficial for heart health, as it contributes to lowering the levels of harmful cholesterol in the blood, and contributes to lowering the high blood pressure. The expansion of the cultivation of this crop requires the introduction of genetic structures that respond well to Iraqi environment factors as well as some plant and soil management. Previous experiences proved that there were low-yielding cultivars, so genotypes must be carefully studied and their response to the environment. In recent years, silicon component has attracted the attention of specialists in the field of plant physiology and nutrition. Numerous experiments have been conducted on this nutritious element and found its important role and effects on growth and yield, especially in plants exposed to biological and a biological stresses. Silicon is present as an essential element in cell walls, making it more rigid as in himicellulose (He *et al*., 2013). Silicon also caused an increase in the dry matter by improtning photosynthesis and these reflected in increasing grain and biological yield (Komdofer and Lepsch, 2001). Oats growth and yield can be increased by using some antioxidant compounds such as salicylic acid and ascorbic acid. Salsalic acid is a plant hormone that has important physiological roles in promoting plant growth, increasing the efficiency of photosynthesis, (Hayat and Ahmed 2008), and increasing the activity of antioxidant enzymes (Shi and 2008). Ascorbic has its role as an antioxidant in the plant (Smirnoff, 1996). It has a role in plant protection from photo-oxidation and its involved in the construction of ethylene, gibberellens and anthocyanin (Smirnoff, 2000), and play an important role in controlling the timing of flowering and initiation of aging (Barth and Tullio, 2006). The importance of this study was to determine the response of two oat genotypes to salicylic acid, ascorbic acid and silicon and determine the best suitable cultivar for Babylon governorate area in which it is first grown.

Materials and Methods

A field experiment was carried out during 2016/2017 and 2017/2018 growth seasons in a private field in bid'ah, Babel governorate within 32º31' latitude north and 44º21'east longitude, on oat crop to determine the effect of salicylic and ascorbic acid and there interactions with silicon on yield of two oat cultivars in silt clay loam soil. Split-split plots arrangement within randomized complete block design (RCBD) with three replications was used. The experimental unit area was $6m^2$ (3 × 2, contained 10 plant lines (3m long and 20 cm between). The seed rate was 100 $kg.ha^{-1}$. Recommended quantities of fertilizer for wheat plants was used. Nitrogen fertilizer was added at a rate of 160 kg N $.ha^{-1}$in urea form and phosphate fertilizer by 85 kg P_2O_5 ha^{-1}as triple superphosphate before seeding at 20/11/2016 and 25/11/2017. Two oat cultivars (shafaa and oat 11) were used in the main plots. Four treatments [control, Ascorbic 50$mg.L^{-1}$, salicylic acid 0,5 $mM.L^{-1}$ and spraying both of ascorbic and salicylic acid in sub plots. Three treatments of silicon spraying [control, 0.5 mM and 1.0 mM in sub-sub plots. The spray was done twice, at tiller and elongation phases. At maturity, 1 m^2 from each experimental unit was determine randomly by wood frame and harvest the plants in it to calculate the panicles number, gran number per panicle (as mean of ten panicles), dry plants weight , grain weight, weight of 1000 grans and harvest index. The data were analyzed and the means were compared according to $LSD_{0.05}$.

Results and Discussion

Table (1) showed that cultivars caused a significant effect and shafaa cultivar was superior in panicles number.m^{-2} (516.8 and 508.5), while oat 11gave the lowest number (379.4 and 391.5) for both seasons respectively. This result may be due to the genetic variation between the genotypes. This result is consistent with the findings of Mahmood *et al*. (2016). Salicylic acid spraying caused a significant effect by giving highest average of panicles number (463.7 and 469.8), while control treatment gave the lowest average (430.7 and 422.3), which did not differ significantly from the treatment of ascorbic acid spraying in both seasons. This was due to the effect of salicylic acid on plant growth and development, which stimulated to increase photosynthesis products, which promote the growth and reduce the competition between the tillers and its rapid growth and panicles formation without failure. As well as its role in increasing kinetin synthesis that increase cell diffusion and reducing apical dominance, led to increase tillers. This is consistent with Rizwan *et al*. (2011) and Ibrahim *et al*. (2014). Silicon spraying at 1.0 $mM.L^{-1}$ gave the highest average of 460.1 and 464.2 panicles. m^{-2}, while control treatment gave the lowest average of 435.8 and 436.8. This result was due to the increase in photosynthesis process net, which caused increasing the number of tillers per unit area, then accelerating growth speed to reach spike stage. This is consistent with Sarotto *et al*. (2012), which observed an increase in the number of tillers carrying the panicles in the plant. The interaction between cultivars and antioxidant spraying treatments caused a significant effect, and cultivar shafaa *ascorbic gave the highest mean of 530.4 and 522.9, while Oat11*control gave the lowest average of 357.2 and 350.8 for both seasons respectively. The interaction between cultivars and silicon caused a significant effect also and cultivar shafaa *silicon 1.0 mM gave the highest average of 526.7 and 518.7 while Oat11*silicon 0.5mMgave the lowest average of 367.2 and 377.4 for both seasons respectively. Spraying of salicylic acid and silicon at 1.0 mM on shafaa cultivar gave the highest average of 527.3 and 543.8, while the combination of Oat 11 *AS+SA*control and Oat 11 and without Spraying control gave a mean average of 353.8 and 342.7 both seasons respectively.

Grains Number Per Panicle

Table (2) showed that salicylic and ascorbic acids spraying and silicon concentrations alone or in combination had no significant effect. While cultivars caused a significant effect, and oat 11 cultivar was superior by giving the highest number of 43.7 and 41.87, while shafaa cultivar gave the lowest number (35.62 and 32.71). This is due to genotype variations (Al-Jubouri and Diaa, 2014). The interaction between cultivars and silicone spray treatments had an effect on the number of grains number per panicle, and cultivar Oat 11 *silicon 1.0mM, gave the highest mean number (43.35 and 42.10 grains per panicle), while the combination (cultivar shafaa *control) gave the lowest average (35.57 and 32.45) for both seasons respectively. The interaction between the cultivars and anti-oxidant spraying agents caused a significant effect and Oat 11* ascorbic gave highest grains number 45.23 and 44.23, while cultivar shafaa *ascorbic gave the lowest average (33.05 and 29.93) for both seasons respectively. The combination of Oat 11 *silicon 0.5mM *ascorbic gave the highest average of 46.29 and 45.04, while the combination of shafaa *silicon 1.0 Mm *ascorbic gave the lowest average of 31.76 and 28.64.

Weight of 1000 Grains

Table (3) showed that shafaa cultivar gave the highest weight of 1000 grains to 45.39 and 47.45 g, while oat 11 gave the lowest average of 43.68 and 45.11 g for both seasons respectively. This result may be due to genotype differences and environmental conditions during seed filling which affected on the duration and rate of carbohydrate supply (Gul *et al*., 2012). This result was consistent with Mahmood *et al* (2016).

Salicylic acid spray caused a significant increase in 1000 grains weight to 45.81 and 47.73 g which did not differ significantly from the treatment of ascorbic spray, while control treatment gave the lowest weight (42.92 and 44.45 g). This was due to the fact that grain weight is the result of the involvement of several factors, including sink capacity in the storage of representational materials and the ability of the source to supply the products of representation during the fullness period (Brdar *et al*., 2006). Some research indicate that antioxidants controlled the processes of source-sink relationship, which reflected on grain weight. This result was consistent with Rizwan *et al.* (2011), Ibrahim *et al.* (2014) and Jasim *et al.* (2017).Silicon spraying caused a significant effect and high concentration gave the highest average of 45.62 and 47.21 g in both seasons respectively compared to control treatment, which gave the lowest average of 43.56 g and 44.45 respectively. This result was consistent with Sarto *et al*. (2014) and Jassim and Iedan (2017). The interaction between cultivars and antioxidants caused a significant effect and shafaa with salicylic acid spraying gave the highest weight (48.33 and 50.47 g) in both seasons respectively compared to control treatments with both cultivars. The interaction between cultivars and silicon caused a significant effect and shafaa with silicon spraying (cultivar shafaa*silicon 1.0 mM) gave the highest weight (47.37 and 49.34 g) in both seasons respectively, while oat 11 with control (cultivar Oat 11* control) gave the lowest weight of 42.85 and 43.21 g respectively. The combination of (cultivar shafaa *salicylic *silicon 1.0mM and (cultivar shafaa* salicylic *silicon 0.5 mM gave the highest weight of 1000grains (48.92 and50.97 g).

Grains Yield

Cultivars caused a significant effect on grains yield, and shafaa cultivar gave high yield of 3.68 and 4.08 t.ha^{-1}, while oat 11 gave low yield (3.02 and 3.07 t.ha^{-1} (table 4). This result was due to genotype differences and its responses to the environment conditions which reflected on yield components (Table 1,2,3) and then on yield. This was agreed with Mahmood *et al*. (2016). Salicylic acid spraying gave the highest grain yield of 3.78 and 4.08 t.ha^{-1} with an increase percentage of 41.0% and 29.1% compared to control that gave 2.87 and 3.15 t.ha^{-1}. Ascorbic acid spray did not differ significantly compared to salicylic acid spraying. This result was consist with Rizwan et al (2011) and Ibrahim *et al*. (2014). Silicon spraying caused a significant increase in grain yield compared to control treatment, and c2 and c3 gave the highest grain yield of 3.49 and 3.75 t.ha^{-1} in first season and second seasons respectively without significant differences between silicon0.5mM and 1.0mM. This result was due to silicon effect on increasing photosynthesis efficiency which caused a positive effect on yield components. This result was consist with Li et al (1999) and Sarto *et al*. (2014) that silicon caused an increase in grain yield. The interaction between cultivars and antioxidants caused a significant effect and shafaa cultivar with salicylic or ascorbic acid spraying gave high grains yield, while oat 11 with control gave the lowest grain yield in both seasons. The combination of shafaa *salicylic *silicon 1.0mM gave the highest grains yield (4.58 and 5.33 t.ha^{-1}) in both seasons, while a2 b1c1 gave the lowest grain yield (2.23 and 2.36 t.ha^{-1}).

Biological yield

Table 5 showed that cultivars caused a significant effect on grains yield, and shafaa cultivar gave high biological yield of 12.71 and 13.08 t.ha^{-1} compared to oat 11, which gave 11.42 and 11.89 t.ha^{-1} in both seasons respectively. This result was due to genotype differences and ite responses to the environmental conditions that reflected on biomass like tillers number and grain yield (Seleiman *et al*., 2011).Salicylic acid or ascorbic acid spraying caused an increase in biological yield both seasons compared to control treatment. This result was agreed with Razwan et al (2011) and Ibrahim *et al*. (2014). Silicon spraying caused a significant effect on biological yield compared to control treatment without significant differences between low and high concentrations (silicon 0.5 and 1.0 mM). This increase was due to the increase in plant growth which positively reflect in accumulation of dry matter in the vegetative parts and the grain yield. This is consistent with Sarto *et al*. (2014).

The combination of shafaa cultivar with ascorbic acid spraying gave the highest value (13.82 and 14.10 t.ha^{-1}), while oat 11 with control gave the lowest value (10.59 and 10.76 t.ha^{-1}). The combination of shafaa cultivar with silicon 0.5 mM gave the highest average of 12.98 and 13.55 t.ha^{-1}, while the combination of oat 11 with control gave lowest average (11.14 and 11.42 t.ha^{-1}).

Harvesting Index

Table (6) showed that shafaa cultivar significantly gave higher harvesting index (28.75 and 30.96), while oat 11 gave 26.24 and 25.63. This result was consistent with Mahmood *et al*. (2016). Salicylic acid spraying was superior by giving 28.92 and 30.63 compared to control treatment which gave the lowest average (26.07 and 27.45). There were no significance differences between spraying of ascorbic acidand salicylic acid. This result was consistent with Rizwan *et al*. (2011) and Ibrahim *et al*. (2014).

Silicon spraying 1.0Mm gave the highest average (28.32 and 28.95), which was not significantly different

from s2 but, while control treatment significantly gave the lowest value. This result was consistent with Sarto *et al*. (2014).Salicylic acid spraying on shafaa cultivar gave the highest average of 29.65 and 33.09, while the combination of a2b1 gave the lowest average of 23.19 and 23.90. Silicon spraying on shafaa cultivar gave the highest value (29.69 and 32.78), while oat 11 with control gave the lowest mean of 25.24 and 24.99. The combination of shafaa*control*silicon 1.0Mm gave highest value (30.98 and 33.98) in both seasons, while the combination of Oat 11*control*silicon0.5mM and Oat 11*AS+SA*silicon 1.0mM gave the lowest value.

Conclusion

Its appear that cultivars were differed in yield and yield components, and Shafaa cultivar was the best in panicles number, 1000 grains weight, grain yield, biological yield, and harvest index compared to Oat 11 cultivar . number. This results were due to the genotype differences in tillers, leaf area, chlorophyll content (unpublished data) that increasing photosynthesis net that affected on panicles number and the formation of fertile panicles (Hassan, 2007 and Farrar *et al.*, 2000). The addition of salicylic acid and ascorbic acid individually improved plant growth and physiological processes as well as increasing antioxidant system (Vermerris and Nicholson, 2006) and caused significant increase is yield components. Silicon spray significantly increased panicles number, grain yield, biological yield and harvest index for its role in improving growth, leaf anatomical characteristics and photosynthesis.

Table 1 : Effect of cultivars antioxidants and silicon on panicles.m^{-2}

Si	oxidants	First season			Second season		
		Shafaa	**Oat 11**	**Si*Oxidants**	**Shafaa**	**Oat 11**	**Si*Oxidants**
control	control	484.6	356.6	420.6	473.6	342.7	408.2
	ascorbic	512.3	362.31	437.3	504.8	375.7	440.3
	salicylic	513.30	395.9	454.6	508.3	406.8	457.6
	As. +Sa.	507.9	353.8	430.9	498.0	384.4	441.2
0.5	control	513.9	355.3	434.6	503.0	341.4	422.2
	ascorbic	527.6	385.9	456.8	520.1	406.4	463.3
	salicylic	518.9	401.9	460.4	514.0	416.2	465.1
	As. +Sa.	515.6	366.9	441.3	505.7	385.4	445.6
1.0	control	514.3	359.5	436.9	504.5	368.4	436.4
	ascorbic	515.3	421.6	486.4	543.8	435.1	489.4
	salicylic	527.3	425.1	476.2	522.4	450.9	486.6
	As. +Sa.	513.9	367.4	440.7	504.0	384.5	444.3
Mean of A		516.8	379.4		508.5	391.5	
$LSD_{0.05}$		cv.= 17.9 cv.*Si*anti.=62		Si*anti.=43.8	Var.=22.1 var.**anti.*Si=58.09		cb=43.1
Interaction of A*C in 1st season					Interaction of A*C in 2nd season		
		Shafaa	Oat 11	Si mean	Shafaa	Oat 11	Si mean
control		504.5	367.2	435.8	496.2	377.4	436.8
0.5 mM		519.0	377.5	448.3	510.7	387.3	449.0
1.0 mM		526.7	393.4	460.1	518.7	409.7	464.2
$LSD_{0.05}$		Var.*Si =31		Si=21.9	Var. * Si=25.2		Si=19.7
Interaction of A*B							
		Shafaa	Oat 11	Antiox. mean	Shafaa	Oat 11	Antiox. mean
control		504.3	357.2	430.7	493.7	350.8	422.3
ascorbic		530.4	389.9	460.2	522.9	405.7	464.3
salicylic		519.8	407.7	463.7	514.9	424.6	469.8
As. +Sa.		512.5	362.7	437.6	502.6	384.8	443.7
$LSD_{0.05}$		cv.*anti.=35.8		Antiox.=25.31	cv.*antiox.=39.3		Antioxid.=31.2

Table 2 : Effect of cultivars antioxidants and silicon on grains per panicle

Si	Anti-oxidants	First season			Second season		
		Shafaa	**Oat 11**	**Si*Oxidants**	**Shafaa**	**Oat 11**	**Si*Oxidants**
Control	control	37.57	41.37	39.47	34.45	40.12	37.29
	ascorbic	33.78	44.76	39.27	30.66	44.08	37.37
	salicylic	32.59	42.02	38.66	32.17	40.77	36.47
	As. +Sa.	35.63	44.44	40.03	32.51	43.19	37.85
0.5	control	38.81	40.20	39.51	35.69	39.95	37.32
	ascorbic	34.83	46.29	39.95	30.49	45.04	37.77
	salicylic	36.90	41.87	38.35	31.71	40.62	36.17
	As. +Sa.	37.35	42.51	39.71	33.78	41.26	37.52
1.0	control	31.76	44.36	40.86	34.23	43.11	38.67
	ascorbic	34.50	44.63	38.20	28.64	43.38	36.01
	salicylic	37.43	40.66	37.58	33.85	39.41	36.63
	As. +Sa.	35.62	43.74	40.59	34.31	42.49	38.40
Mean of A		35.62	43.07		32.71	41.87	
$LSD_{0.05}$		Var.=4.62 anti.*Si= 5.23		Si*anti-oxidants=ns	cv=4.8 cv*Si*antiox=5.08		Si*anti-ox=3.3
Interaction of cv*Si in 1st season					Interaction of cv*Si in 2nd season		
		Shafaa	Oat 11	Si mean	Shafaa	Oat 11	Si mean
control		35.57	43.15	39.36	32.45	42.04	37.24
0.5 mM		36.04	42.72	39.38	32.92	41.47	37.19
1.0 mM		43.15	43.35	39.30	32.76	42.10	37.43
$LSD_{0.05}$		Cv*Si=3.5		Si=ns	Cv*Si=3.6		Si=ns
Interaction of A*B							
		Shafaa	Oat 11	anti mean	Shafaa	Oat 11	Antiox. mean
control		37.91	41.98	39.94	34.79	40.73	37.76
ascorbic		33.05	45.23	39.14	29.93	44.17	37.05
salicylic		34.87	41.52	38.20	32.58	40.27	36.42
As. +Sa.		36.65	43.56	40.11	33.53	42.31	37.92
$LSD_{0.05}$		Cv*antiox= 3.7		antiox=ns	Cv*antiox=3.9		antiox=ns

Table 3 : Effect of cultivars antioxidants and silicon on 1000 grains weight(g)

Si	Anti-oxidants	First season			Second season		
		Shafaa	**Oat 11**	**Si*Oxidants**	**Shafaa**	**Oat 11**	**Si*Oxidants**
Control	control	42.18	41.52	41.85	43.88	42.55	43.21
	ascorbic	44.19	44.22	44.21	46.22	44.99	45.60
	salicylic	48.24	42.53	45.39	49.94	43.92	46.93
	As. +Sa.	42.56	43.05	42.81	43.87	44.15	44.01
0.5	control	40.43	45.31	42.87	43.33	45.90	44.36
	ascorbic	46.52	44.06	45.29	49.21	47.29	48.25
	salicylic	47.83	44.39	46.11	50.97	46.11	48.54
	As. +Sa.	43.22	43.51	43.36	44.66	46.67	45.66
1.0	control	43.94	44.14	44.04	46.23	45.32	45.78
	ascorbic	49.29	44.31	46.80	50.56	43.99	47.27
	salicylic	48.92	42.98	45.95	50.49	44.96	47.73
	As. +Sa.	47.33	44.08	45.71	50.08	46.01	48.04
Mean of A		45.39	43.68		47.45	45.11	
$LSD_{0.05}$		cv=1.5cv.*Si*anti= 2.31		cb= 1.6	cv.=1.3cv.*Si *antiox=2.15		Si*antiox= 1.5
Interaction of A*C in 1st season					Interaction of A*C in 2nd season		
		Shafaa	Oat 11	Si mean	Shafaa	Oat 11	Si mean
control		44.29	42.83	43.56	45.95	43.90	44.45
0.5 mM		44.50	44.32	44.41	47.04	46.36	46.70
1.0 mM		47.37	43.88	45.62	49.34	45.07	47.21
$LSD_{0.05}$		cv.*Si= 1.3		Si= 0.9	cv.*Si= 1.18		Si= 0.8
Interaction of A*B							
		Shafaa	Oat 11	B mean	Shafaa	Oat 11	antiox mean
control		42.18	43.66	42.92	44.48	44.42	44.45
ascorbic		46.67	44.20	45.43	48.66	45.42	47.04
salicylic		48.33	43.30	45.81	50.47	45.00	47.73
As. +Sa.		44.37	43.55	43.96	46.20	45.61	45.91
$LSD_{0.05}$		cv.* antiox= 1.18		antio= 0.65	cv.*antiox=1.07		antiox=0.66

Table 4 : Effect of cultivars antioxidants and silicon on grains yield (t.ha^{-1})

Si	Anti-oxidants	First season			Second season		
		Shafaa	**Oat 11**	**Si*Oxidants**	**Shafaa**	**Oat 11**	**Si*Oxidants**
control	control	2.89	2.32	3.34	3.05	2.36	2.70
	ascorbic	3.49	2.84	3.17	3.86	2.89	3.38
	salicylic	3.48	3.09	3.28	3.97	3.15	3.56
	As. +Sa.	3.51	3.10	3.31	3.51	3.10	3.30
0.5	control	3.41	2.41	3.83	3.93	2.74	3.33
	ascorbic	4.31	3.17	3.74	4.86	3.24	4.05
	salicylic	4.01	3.89	3.95	4.45	3.88	4.16
	As. +Sa.	3.59	3.08	3.34	3.64	3.12	3.38
1.0	control	3.53	2.87	3.85	4.14	2.68	3.41
	ascorbic	4.33	3.59	3.88	4.90	3.55	4.23
	salicylic	4.58	3.78	4.11	5.33	3.69	4.51
	As. +Sa.	2.97	3.15	2.80	3.29	2.42	2.86
Mean of A		3.68	3.02		4.08	3.07	
$LSD_{0.05}$		cv.=0.28cv.*Si*anti=0.56		cb= 0.69	cv.=0.29cv.*Si*antiox=0.9		Si*anti=0.65
Interaction of Cv.*Si in 1st season					Interaction of cv.*Si in 2nd season		
		Shafaa	Oat 11	C mean	Shafaa	Oat 11	C mean
control		3.34	2.84	3.09	3.59	2.88	3.24
0.5 mM		3.83	3.14	3.49	4.22	3.22	3.73
1.0 mM		3.85	3.09	3.47	4.42	3.09	3.75
$LSD_{0.05}$		cv.*Si=0.49		Si=0.35	cv.*Si=0.44		Si=0.36
Interaction of cv. * antioxidants							
		Shafaa	Oat 11	B mean	Shafaa	Oat 11	B mean
control		3.28	2.47	2.68	3.71	2.59	3.15
ascorbic		4.05	3.15	3.44	4.54	3.23	3.89
salicylic		4.02	3.54	3.63	4.58	3.58	4.08
As. +Sa.		3.36	2.94	2.63	3.48	2.88	3.18
$LSD_{0.05}$		cv.*antioxid=0.56		antio=0.40	cv.*antiox=0.40		antioxid=0.31

Table 5 : Effect of cultivars antioxidants and silicon on biological yield (t.ha^{-1})

Si	Anti-oxidants	First season			Second season		
		Shafaa	**Oat 11**	**Si*Oxidants**	**Shafaa**	**Oat 11**	**Si*Oxidants**
control control	control	11.10	9.47	10.29	11.15	9.81	10.48
	ascorbic	12.42	11.41	11.92	12.09	11.82	11.96
	salicylic	12.18	11.85	12.02	12.61	11.85	12.23
	As. +Sa.	13.25	11.83	12.54	13.46	12.20	12.83
0.5	control	11.33	10.73	11.03	12.22	10.91	11.56
	ascorbic	14.59	11.77	13.18	15.26	12.18	13.72
	salicylic	13.47	13.21	13.34	14.00	13.38	13.69
	As. +Sa.	12.53	11.12	11.82	12.74	11.54	12.14
1.0	control	11.40	10.56	11048	12.29	11.57	11.93
	ascorbic	14.45	11.86	13.16	14.96	12.57	13.77
	salicylic	14.94	12.23	13.59	14.77	12.54	13.65
	As. +Sa.	10.81	9.99	10.40	11.45	12.32	11.89
Mean of A		12.71	11.42		13.08	11.89	
$LSD_{0.05}$		cv. =0.61 cv*Si*anti=2.09		Si*anti=1.48	cv.=0.85 cv.*Si*antiox=2.02		Si*antioxidants=1.4
Interaction of cv.* Si in 1st season					Interaction of cv.* Si in 2nd season		
		Shafaa	Oat 11	Si mean	Shafaa	Oat 11	Si mean
control		12.24	11.14	11.69	12.33	11.42	11.87
0.5 mM		12.98	11.71	12.34	13.55	12.00	12.78
1.0 mM		12.90	11.41	12.16	13.37	12.25	12.81
$LSD_{0.05}$		cv.*Si =1.04		c=0.74	ac=1.02		c=0.82
Interaction of Cv. * anti-oxidants							
		Shafaa	Oat 11	Antiox. mean	Shafaa	Oat 11	Antioxidant mean
control		11.28	10.59	10.93	11.89	10.76	11.32
ascorbic		13.82	11.68	12.75	14.10	12.19	13.15
salicylic		13.53	12.43	12.98	13.79	12.59	13.19
As. +Sa.		12.20	10.98	11.59	12.55	12.02	12.29
$LSD_{0.05}$		cv.*anti=1.21		anti=0.86	cv.*antioxid.=0.81		antioxidant=0.57

Table 6 : Effect of cultivars antioxidants and silicon on harvest index

Si	Anti-oxidants	First season			Second season		
		Shafaa	Oat 11	Si*Oxidants	Shafaa	Oat 11	Si*Oxidants
Control	control	25.81	24.28	27.04	27.14	23.38	25.49
	ascorbic	27.49	24.75	26.12	31.58	24.37	27.98
	salicylic	28.45	25.72	27.08	31.34	26.26	28.85
	As. +Sa.	26.42	26.22	26.32	26.00	25.41	25.71
0.5	control	30.08	22.24	29.52	32.15	24.80	28.49
	ascorbic	29.55	26.97	28.26	31.86	26.63	29.25
	salicylic	29.84	29.26	29.55	31.85	28.78	30.32
	As. +Sa.	28.60	27.67	28.13	28.51	26.96	27.74
1.0	control	30.98	23.05	29.69	33.68	23.05	28.37
	ascorbic	29.91	29.05	29.48	32.75	28.28	30.51
	salicylic	30.67	29.56	30.12	36.07	29.39	32.73
	As. +Sa.	27.19	26.12	26.65	28.64	19.72	24.18
Mean of A		28.75	26.24		30.96	25.63	
$LSD_{0.05}$		cv.=1.33 cv*si*anti=4.61		Si*anti=3.3	cv=0.29 cv*si*anti =3.92		Si*antiox=2.86
Interaction of Cultivar*Si in 1st season					Interaction of Cultivar*Si in 2nd season		
		Shafaa	Oat 11	Si mean	Shafaa	Oat 11	Si mean
control		27.04	25.24	26.14	29.02	24.99	27.00
0.5 mM		29.52	26.53	28.03	31.09	26.80	28.95
1.0 mM		29.69	26.95	28.32	32.78	25.11	28.96
$LSD_{0.05}$		cv.*Si=2.31		Si=1.63	cv.*Si =1.76		Si=1.52
Interaction of Cultivar*Anti-oxidants							
Anti-oxidant		Shafaa	Oat 11	Anti. mean	Shafaa	Oat 11	Antiox. mean
control		28.96	23.19	26.07	30.99	23.90	27.45
ascorbic		28.98	26.92	27.95	32.06	26.43	29.24
salicylic		29.65	28.18	28.92	33.09	28.18	30.63
As. +Sa.		27.40	26.67	27.03	27.72	24.03	25.87
$LSD_{0.05}$		cv.*antiox=2.7		anti=1.89	cv.*antioxidants =1.95		antiox=1.59

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