American-Eurasian J. Agric. & Environ. Sci., 14 (12): 1498-1505, 2014
ISSN 1818-6769
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DOI: 10.5829/idosi.aejaes.2014.14.12.12912

Growth and Physiological Changes Induced by Drought and Salicylic Acid Treatment of Wheat Genotypes (*Triticum aestivum* L.) at Vegetative Stage

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Abstract: Salicylic acid (SA) acts as an endogenous signal molecule inducing abiotic stress tolerance in plants including drought. A field experiment was conducted to study the effect of SA (0.5 mM) on the growth and some metabolites of two drought-stressed wheat genotypes (*Triticum aestivum* L.) under different levels of water stress at the vegetative stage. Exogenous application of SA increased plant growth significantly in both drought-stressed and well-watered conditions. While, SA increased the morphological characters of roots and shoots, the photosynthetic pigments and the building materials (carbohydrates and proteins), SA relatively reduced the proline content under the different drought stress levels. The role-play by SA in alleviation of the drought stress induces changes in growth criteria and the metabolic activity of the tested wheat genotypes. Results also signify the role of SA in regulating the drought response of plants at the vegetative stage and suggest that SA could be used as a potential growth regulator for improving vegetation in wheat plants under water stress.

Key words: Salicylic acid (SA) · Drought stress · Wheat · Vegetative stage · Proline

INTRODUCTION

Salicylic acid (SA) is considered as a hormone-like substance, which plays an important role in photosynthetic rate, stomatal conductance and transpiration [1]. Exogenous SA could regulate the activities of antioxidant enzymes and increase plant tolerance to abiotic stresses [2]. Wheat is an important food crop in the world and especially in Egypt. An important objective in Egypt is to reduce the dependence on imported wheat by enhancing grain yield production and cultivating new wheat genotypes and by reclaiming soil which suffer from drought and/or salinity [3]. Drought study has been one of the main directions in global plant biology and biological breeding. With progressive global climate change and increasing shortage of water resources and worsening eco-environment, crop production is influenced greatly [4, 5]. Severe drought stress may results in the arrest of photosynthesis, disturbance of metabolism and finally death of plant [6]. It reduces plant growth by affecting various physiological and biochemical processes, such as photosynthesis, respiration, translocation, ion uptake, carbohydrates, nutrient metabolism and growth promoters [7, 8]. It affects both elongation and expansion growth [9, 10]. The plant height was reduced up to 25% in water stressed citrus seedlings [11]. Stem length was significantly affected under water stress in potato [12], soybean [13] and parsley [14]. Greater plant fresh and dry weights under water limited conditions are desirable characters. A common adverse effect of water stress on crop plants is the reduction in fresh and dry biomass production [15]. Salicylic acid (SA) has been shown to play an important role in regulating a number of physiological processes in plants. Its exogenous application has promoted plant performance under biotic and abiotic stresses [16]. SA provides protection against a number of abiotic stresses such as heat stress in mustard seedlings [17], chilling damage in different plants [18], heavy metal stress in barley seedlings [19] and drought stress in wheat plants [20].

The present study investigated the effects of SA and water stress on growth and some physiological behavior of two wheat genotypes (Giza168 and Giza164) during the vegetative stage to estimate the variations in the drought tolerance of the two genotypes at the vegetative stage and also the variations in their response towards SA-treatment.

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MATERIALS AND METHODS

A field experiment was conducted using wheat (*Triticum aestivum* L.) grains that were surface sterilized by immersion in a mixture of ethanol 96% and H_2O_2 (1:1) for 3 minutes, followed by several washings with sterile distilled water, which were grown in large plastic pots (5 kg soil/ pot). Pots were flood-irrigated after sowing and soil was brought to the field capacity (38% soil moisture content) to enable the beginning of seedling emergence. Thereafter, the pots watered with the different levels of soil moisture content. Plants were grown with further irrigation at 90%, 70%, 50% and 30% field capacity (FC). The grains were left to grow for 60 days. Group of plants under each field capacity used sprayed with 0.5 mM of salicylic acid (SA) at the age of 40 days. Grains of the two wheat genotypes (Giza168 and Giza164), were obtained from Agricultural Research Centre, Giza, Egypt.

Growth Criteria: At the end of the experimental period plant height was determined by direct measurement from soil surface to the tip of the flag leaf. Determination of the dry matter involved harvesting and careful separation of fresh organs. Fresh organs were then dried in an aerated oven (Hotbox Oven, Gallenkamp, England) at 80°C. The plants were uprooted, roots carefully separated from the soil, washed and the length of the roots were measured. Leaf area was determined by measuring the leaf length and the maximum width and applying the formula; Leaf area = k (leaf length x leaf maximum width) cm^2 $plant^{-1}$. This formula provided a simple way for determination of leaf area particularly in the field where large leaves had to be measured. The coefficient k was calculated and assigned different values for different grasses [21, 22] and was recently reviewed and given a value of 0.75 for wheat [23].

Determination of Photosynthetic Pigments: The photosynthetic pigments were extracted from 0.1g fresh leaves samples. The leaves tissues were suspended in 5 ml of 95% ethyl alcohol in a test tube at 60°C, until colorless. Absorbance readings were determined with spectrophotometer. Chlorophylls and carotenoids concentrations were calculated using equations as cited by Lichtenthaler [24]. The pigment fractions were calculated as mg/g dry weight.

Determination of Total Carbohydrates: Total carbohydrates were estimated by the method of anthrone sulphoric reagent as in case of water-soluble carbohydrates, which was carried out by Fales [25] and Schlegel [26] and adopted by Badour [27]. Total carbohydrates were expressed as mg/g dry weight.

Determination of Protein: Total proteins were extracted by adding 10 ml of 0.5 N NaOH to about 100 mg of the oven-dry plant material and left over night. The extract was completed to 50 ml with distilled water [28]. Proteins were determined according to the method adopted by Lowery *et al.* [29].

Determination of Total Free Amino Acids: Free amino acids were extracted from plant tissues and determined according to the method of Moore and Stein [30]. However, in this method traces of proline and hydroxyl proline are encountered. A calibration curve was constructed using glycine. The free amino acids concentration was calculated as mg/g dry weight.

Determination of Proline: A definite weight of macerated dry tissue was homogenized in 5 ml of 3% sulfo-salicylic acid and then filtered through two Whatman filter papers. Free proline was determined according to Bates *et al.* [31]. The proline concentration was determined using a standard curve and calculated on a dry weight basis as mg/g dry weight.

Determination of Some Minerals: After preparing water extract of each tested treatment:

- Flame photometer method [32] using Carl Zeiss flame photometer was used. K^+ determined and the data were expressed as mg/g dry weight.
- The versene (disodium dihydrogen ethylene-diamine-tetra acetic acid) titration method [33] was employed for calcium and magnesium determination. Ca^{++} and Mg^{++} determined and the data were expressed as mg/g dry weight.

Statistical Analysis: The triplicate sets of experimental data for the different tested parameters were subjected to the one way analysis of variances (ANOVA test) using the SPSS version 16, LSD at P level of 0.05% and 0.01% [34].

RESULTS

From the data shown in Table 1, the different studied morphological parameters (number of leaves, plant height, root length and leaf area) were decreased markedly

Table 1: Effect of drought stress and SA treatment on some morphological characters of two wheat genotypes at vegetative stage

Genotype		Giza168				Giz164			
Treatment	Irrigation at FC %	No. of leaves	R.L	SH.L	L.A (cm^2)	No. of leaves	R.L	SH.L	L.A (cm^2)
Control	90	6.0^{a}	30.0^{b}	60.0^{c}	153.34^{b}	6.0^{ab}	30.0^{b}	52^{c}	156.33^{b}
	70	6.0^{a}	30.0^{b}	52.0^{d}	149.21^{c}	6.0^{ab}	25.0d	50^{d}	148.56^{c}
	50	6.0^{a}	23.5^{c}	48.0^{e}	114.19^{f}	6.0^{ab}	23.0e	44^{f}	133.39^{e}
	30	6.0^{a}	20.0^{d}	46.5^{f}	108.73^{g}	5.0^{b}	22.0f	40^{g}	116.88^{g}
SA (0.5 mM)	90	7.0^{a}	34.0^{a}	63.6^{a}	159.82^{a}	7.0^{a}	26.0c	53^{b}	167.51^{a}
	70	7.0^{a}	30.0^{b}	60.0^{c}	153.47^{b}	7.0^{a}	32.0^{a}	56^{a}	156.43^{b}
	50	7.0^{a}	29.5^{b}	62.4^{b}	132.24^{d}	6.0^{ab}	32.0^{a}	48.5^{e}	140.71^{d}
	30	7.0^{a}	21.0^{d}	52.0^{d}	122.11^{e}	6.0^{ab}	30.0^{b}	44^{f}	126.46^{f}
LSD	0.05	1.224	1.268	0.735	0.743	1.376	0.689	0.810	0.823
	0.01	1.686	1.753	0.972	1.023	1.902	0.911	1.116	1.088

R.L: Root length (cm), SH.L: Shoot length (cm), L.A: Leaf area (cm^2), SA: Salicylic acid.

Within the same column means with different superscripts (letters) are significantly differ ($P \leq 0.05$)

Table 2: Effect of drought stress and SA treatment on dry weight yield and pigmentation of two wheat genotypes at vegetative stage

Genotype		Giza168			Giza164		
Treatment	Irrigation at FC %	Root dry weight (g)	Shoot dry weight (g)	Total pigments (mg/g DW)	Root dry weight (g)	Shoot dry weight (g)	Total pigments (mg/g DW)
Control	90	0.333^{d}	1.730^{a}	24.86^{c}	0.243^{c}	0.820^{c}	24.68^{b}
	70	0.300^{e}	1.273^{c}	22.13^{e}	0.183^{de}	0.776^{d}	22.99^{d}
	50	0.286^{f}	1.276^{c}	21.37^{f}	0.190^{d}	0.566^{e}	19.76^{f}
	30	0.253^{g}	0.830^{e}	18.90^{g}	0.173^{de}	0.490^{f}	18.25^{g}
SA(0.5 mM)	90	0.420^{b}	1.740^{a}	26.41^{b}	0.270^{b}	0.770^{d}	26.31^{a}
	70	0.436a	1.573^{b}	27.66^{a}	0.247^{c}	0.910^{b}	26.21^{a}
	50	0.350^{c}	1.250^{c}	24.08^{d}	0.306^{a}	0.970^{a}	23.49^{c}
	30	0.283^{f}	0.970^{d}	22.07^{e}	0.1760^{e}	0.540^{e}	21.09^{e}
LSD	0.05	0.057	0.057	0.456	0.057	0.057	0.415
	0.01	0.075	0.075	0.603	0.075	0.075	0.549

Within the same column means with different superscripts (letters) are significantly differ ($P \leq 0.05$)

by drought stress. Salicylic acid enhanced the growth of the two wheat genotypes at the different drought stressed plants than the well watered ones. The morphology of the two genotypes reflects their drought tolerance and tells us about more tolerance of the genotype Giza168 than Giza164 genotype. Giza168 not only gave best vegetation under the different drought stress levels and the well watered conditions but also it showed the best stimulation under SA-treatment. In Table 2, marked reduction was recorded in the dry matter of the two genotypes under drought stress conditions. The two genotypes exhibited different ways in dry matter allocation at the different organs (roots and shoots) under the different drought stress levels. The highest reduction in dry matter was recorded at the severe drought levels in shoots than in roots in both genotypes. Data presented in Table 3, indicated that proline content in Giza168 genotype remained around the control values in root by increasing drought stress level used while, it increased in shoot. SA decreased proline content in roots, while it increased in shoot significantly at severe drought stress level used (30% of FC). From data presented in Table 4, Giza164 genotype proline accumulated markedly in root than in shoot by increasing water stress imposed, while SA induced stimulation in proline accumulation in both root and shoot especially at the severe drought stress levels used.

Total proteins recorded in roots and shoots of Giza168 wheat genotype decreased gradually by drought stress. SA induced marked increase in the total protein content in both shoot and root. Accordingly an increase in total amino acids was recorded in the different organs under different drought stress level used. SA decreased in the total amino acids in roots and slightly increased it in shoot. On the other hand, total proteins decreased markedly in roots and shoots of Giza164 genotype.

Table 3: Effect of drought stress and SA treatment on some physiological parameters of Giza168 wheat genotypes at vegetative stage

Genotype		Giza168							
Treatment	Irrigation at FC %	R.P	SH.P	R.T.P	SH.T.P	R.T.FA	SH.T.FA	R.T.C	SH.T.C
Control	90	0.92^{a}	1.50^{e}	142.00^{c}	147.50^{d}	37.14^{c}	41.27^{e}	65.13^{c}	85.00^{b}
	70	0.83^{bc}	1.56^{e}	140.50^{d}	141.00^{e}	36.79^{cd}	41.48^{e}	54.80^{f}	70.67^{f}
	50	0.94^{a}	1.96^{c}	103.50^{f}	156.50^{c}	39.69^{b}	43.12^{bc}	52.78^{g}	67.83^{g}
	30	0.92^{a}	2.54^{b}	92.00^{g}	131.50^{g}	40.36^{a}	43.05^{c}	49.13^{h}	66.47^{h}
SA (0.5 mM)	90	0.64^{e}	1.86^{d}	182.00^{a}	131.50^{g}	36.53^{d}	42.42^{d}	73.83^{a}	87.67^{a}
	70	0.78^{cd}	1.40^{f}	146.50^{b}	193.50^{a}	36.86^{cd}	43.44^{abc}	71.58^{b}	83.87^{c}
	50	0.75^{d}	1.52^{e}	141.50^{c}	185.00^{b}	35.65^{e}	43.84^{a}	62.87^{d}	74.33^{d}
	30	0.86^{b}	2.78^{a}	116.50^{e}	136.50^{f}	34.42^{f}	43.60^{ab}	57.53^{e}	73.53^{e}
LSD	0.05	0.057	0.098	0.541	0.708	0.456	0.487	0.632	0.484
	0.01	0.075	0.131	0.715	0.935	0.603	0.644	0.836	0.639

R.P: Root proline (mg/g DW), SH.P: Shoot proline (mg/g DW), R.T.P: Root total protein (mg/g DW), SH.T.P: Shoot total protein (mg/g DW), R.T.FA: Root total free amino acids (mg/g DW), SH.T.FA = Shoot total free amino acids (mg/g DW), R.T.C: Root total carbohydrates (mg/g DW), SH.T.C = Shoot total carbohydrates (mg/g DW). SA: Salicylic acid.

Within the same column means with different superscripts (letters) are significantly differ ($P \leq 0.05$)

Table 4: Effect of drought stress and SA treatment on some physiological parameters of Giza164 wheat genotypes at vegetative stage

Genotype		Giza164							
Treatment	Irrigation at FC %	R.P	SH.P	R.T.P	SH.T.P	R.T.FA	SH.T.FA	R.T.C	SH.T.C
Control	90	0.32^{g}	0.99^{b}	143.0^{c}	158.00^{b}	31.01^{d}	33.08^{g}	56.33^{a}	66.60^{a}
	70	0.53^{e}	0.92^{bc}	141.5^{d}	129.50^{e}	29.81^{e}	31.52^{h}	51.47^{c}	56.60^{a}
	50	0.74^{c}	0.87^{cd}	112.2^{g}	121.00^{g}	38.77^{a}	34.35^{e}	40.87^{e}	54.80^{a}
	30	0.77^{bc}	0.80^{d}	100.00^{h}	112.50^{h}	35.36^{b}	35.04^{d}	36.27^{f}	47.51^{a}
SA (0.5 mM)	90	0.32^{g}	0.91^{bc}	150.5^{a}	161.53^{a}	34.27^{c}	39.85^{a}	56.60^{a}	68.80^{a}
	70	0.80^{ab}	0.89^{c}	145.0^{b}	146.00^{c}	31.11^{d}	34.12^{f}	56.53^{a}	64.17^{a}
	50	0.63^{d}	0.95^{bc}	138.0^{e}	135.50^{d}	34.00^{c}	36.40^{c}	54.40^{b}	60.40^{a}
	30	0.82^{a}	1.30^{a}	120.0^{f}	122.50^{f}	39.29^{a}	37.08^{b}	49.37^{d}	58.67^{a}
LSD	0.05	0.057	0.058	0.767	0.703	0.587	0.171	0.460	21.99
	0.01	0.074	0.079	1.014	0.929	0.776	0.226	0.608	29.07

R.P: Root proline (mg/g DW), SH.P: Shoot proline (mg/g DW), R.T.P: Root total protein (mg/g DW), SH.T.P: Shoot total protein (mg/g DW), R.T.FA: Root total free amino acids (mg/g DW), SH.T.FA = Shoot total free amino acids (mg/g DW), R.T.C: Root total carbohydrates (mg/g DW), SH.T.C = Shoot total carbohydrates (mg/g DW), SA: Salicylic acid.

Within the same column means with different superscripts (letters) are significantly differ ($P \leq 0.05$)

Table 5: Effect of drought stress and SA treatment on some minerals K^{+}, Ca^{++}, Mg^{++} (mg/g DW) of Giza168 and Giza164 wheat genotypes at vegetative growth stage

		Giza168						Giza164					
Genotype		Root			Shoot			Root			Shoot		
Treatment	Irrigation at FC %	K^{+}	Ca^{++}	Mg^{++}	K^{+}	Ca^{++}	Mg	K^{+}	Ca^{++}	Mg^{++}	K^{+}	Ca^{++}	Mg^{++}
Control	90	4.68^{f}	3.50^{d}	3.70^{c}	16.2^{d}	7.5^{e}	5.6^{c}	3.96^{f}	3.0^{c}	2.25^{g}	11.1^{e}	7.5^{c}	7.2^{c}
	70	4.98^{e}	3.35^{e}	3.6^{cd}	15.7^{e}	7.6^{de}	5.7^{c}	3.36^{g}	4.5^{a}	3.6^{a}	8.16^{g}	5.25^{d}	4.5^{e}
	50	4.31^{g}	4.25^{b}	3.25^{e}	15.2^{f}	8.5^{c}	5.6^{c}	4.80^{d}	4.50^{a}	5.40^{b}	9.06^{f}	5.50^{d}	5.40^{d}
	30	5.61^{d}	3.50^{d}	3.4d^{e}	17.1^{c}	9.0^{b}	5.7^{c}	6.99^{b}	4.5^{a}	4.5^{c}	13.38^{d}	4.5^{f}	4.5^{e}
SA (0.5 mM)	90	4.65^{f}	4.50^{a}	4.40^{a}	16.9^{c}	7.7^{d}	5.9^{b}	9.06^{a}	3.50^{b}	2.9^{f}	16.35^{a}	12.0^{a}	4.50^{e}
	70	6.69^{a}	4.50^{a}	4.3^{ab}	18.1^{b}	7.5^{e}	5.6^{c}	4.30^{e}	3.00^{c}	5.4^{b}	16.5^{a}	9.0^{b}	7.20^{c}
	50	6.33^{b}	4.00^{c}	4.2^{ab}	18.1^{b}	9.5^{a}	6.4^{a}	5.19^{c}	2.25^{d}	4.05 ^{d}	13.8^{c}	7.5^{c}	12.6^{a}
	30	5.83^{c}	4.50^{a}	4.10^{b}	19.3^{a}	8.5^{c}	6.5^{a}	4.77^{d}	4.5^{a}	7.2^{a}	16.1^{b}	7.5^{c}	9.4^{b}
LSD	0.05	0.127	0.139	0.273	0.296	0.221	0.14	0.180	0.235	0.347	0.242	0.399	0.374
	0.01	0.132	0.145	0.361	0.392	0.292	0.145	0.238	0.312	0.458	0.319	0.527	0.494

Within the same column means with different superscripts (letters) are significantly differ ($P \leq 0.05$)

SA caused ameliorative effect at the different water stress levels used. Shoots and roots exhibited observed increase in total amino acids especially at severe drought stress levels. SA also increased total amino acids slightly especially at severe drought stress used. Total carbohydrates was decreased markedly in both genotypes, the highest reduction was recorded at highest drought stress level used. SA stimulated the increase in total carbohydrates in both genotypes at the different organs and different water stress levels used. The percent of reduction in total carbohydrates in shoots under severe drought stress level was about 21.5% and 29% in Giza168 and Giza164, respectively. From data presented in Table 5, translocation of the three tested minerals (K^+, Ca^{++} and Mg^{++}) from root to shoot is high (absolute amounts in shoots greater than in roots) in both tested genotypes. It was highest in Giza168 and especially observed in K^+ content; it was more than three folds in shoots than roots. More ability to translocate minerals at the different drought stress levels indicating more tolerance. SA enhanced the translocation of the different minerals especially at Giza164 wheat genotype under severe drought stress levels used.

DISCUSSION

Water deficit affect almost all plant life aspects and metabolism. Drought is an important factor that could influence the growth and physiological characteristics of plants [35, 36]. The responses of plants to drought stress depend on the species and genotype, the length and severity of water deficit and the age and stage of development [37]. The reduction in plant height might be associated with declined cell enlargement and cell growth due to the low turgor pressure and also more leaf senescence under drought stress [38]. Munns *et al.* [39] and Drew *et al.* [40] reported that, the reduction in leaves area by drought stress may be due to a reduction in leaf expansion, probably due to the effect of drought stress on cell division or cell expansion or both. Drought stress cause a reduction in dry weight of shoot and root in wheat plants of both genotypes, while SA alleviated drought stress damages on dry weight. SA stimulated the dry matter yield at the different drought stress levels. Singh and Usha [41] suggested that an increase in dry mass of water stressed plants in response to SA may be related to the induction of antioxidant responses that protect the plant from damage. Pigmentation reduced in the two wheat genotypes by drought stress and the highest reduction was at the severe drought level. Total pigments reduced by about 25% and 30% in Giza168 and Giza164 respectively, indicating drought tolerance for both genotypes but the most tolerant genotype is Giza168. The best stimulation by SA obtained at the higher drought stress levels. Water stress affected dry matter accumulation and their allocation within the two drought tolerant genotypes differently. It implied that genotype Giza168 had more resistant capacity to water deficits and well–developed root system than the less drought tolerant genotype Giza164. Root systems are complex and dynamic structures, water uptake may be limited by the amount of roots in a particular soil layer and enhancing root growth can increase drought-tolerance [42, 43].

The two studied genotypes are drought tolerant genotypes in the vegetative growth stage. This was judged not only by the criteria of growth but also with photosynthetic activity and some metabolites. Moreover, drought stress increased proline content, total amino acid content and sugar content in both genotypes. The production of these osmotic adjustments is a common response of plant tolerance. Vendruscolo *et al.* [44] stated that proline might confer drought stress tolerance to wheat plants by increasing the antioxidant system rather than as an osmotic adjustment. The relative ability of a plant to increase the concentration of solutes in its tissues (osmotic adjustment) will partially determine its tolerance to stress conditions [45]. There is a considerable difference in the accumulation and distribution of proline among the two wheat genotypes from one hand and among their organs from the other hand. The observed losses in total saccharides as well as in total proteins were accompanied with a marked and progressive increase in total amino acid content, thus, water stress may stimulate the conversion of proteins into amino acids and/or inhibit amino acid incorporation into proteins. This pattern was more obvious in Giza168 genotype. The differences in the accumulation and distribution of saccharides among the two wheat genotypes might indicate the genetic variation among these genotypes. In this respect, Ballbrea *et al.* [46] stated that the sugar accumulation and its distribution in different parts of the plants could be a valid trait to discriminate cultivars of different tolerance to water stress. Accordingly, from a physiological point of view, the two wheat genotypes could be genetically varied. SA increased the sugar content as compared to plant under drought stress or the control plants in both genotypes, these results are in agreement with those obtained by Baghizadeh *et al.* [47]. K^+, Mg^{+2} and Ca^{+2} in

shoots and roots of both genotypes were decreased dramatically with increasing drought levels stress, these results are in agreement with those reported by Al-Hakimi [48], while SA treatment increased the uptake of K^+ Mg^{++} and Ca^{++} in the different organs of tested plants. In this context, Gunes *et al.* [49, 50] and Yildirim *et al.* [51] found that exogenous SA applications inhibited Na accumulation, but stimulated N, P, K, Mg, Fe, Mn and Cu uptake. The largest accumulation of K^+ was recorded under severe drought stress condition at both organs and genotypes tested. SA stimulated increase in K^+ content in both genotypes; it was markedly observed in shoot than in root. In Giza168 Ca^{++} was nearly around the control values in root but it succeeded to translocate more Ca^{++} content toward shoot that Ca $^{++}$content increased markedly in shoot by increasing drought stress level used. SA increased Ca^{++} content under the different drought stress levels.

In Giza164, Ca^{++} content was increased by drought stress in roots but decreased in shoots and this mean less translocation than the previous genotype ascertaining more drought tolerance toward Giza168 genotype. SA tried to offer more translocation of Ca^{++} from root to shoot, so Ca^{++} content decreased in root except at severe-drought root (little increase recorded). Mg^{+2} content decreased in roots, while it was nearly around the control values in shoots of Giza168 genotype by increasing drought stress. In Giza164 genotype Mg^{++} increased and accumulated in root by increasing drought stress in soil, while decreased markedly in shoot (failed to translocate more Mg from root to shoot). SA increased Mg accumulation in root and shoot of both tested genotypes. Better accumulation was recorded in Giza 164 than Giza168 genotype and in shoots especially at severe drought stress level used. Drought stress reduced nearly all the studied parameters in the two wheat genotypes Giza168 and Giza164.

Results conferred that both the studied genotypes tolerated the drought stress and Giza168 genotype is the most tolerant one. Drought treatments affected differently the vegetation of the two wheat genotypes. The strategy of Giza168 to tolerate drought stress depends mainly on increasing the different cellular osmotic solutes such as total amino acids in both roots and shoots at the expense of total protein. In accordance with this Giza168 succeeded also to increase the proline content by increasing drought stress level. The largest accumulation and better translocation of K^+, $Ca^{++}$and Mg^{++} content was recorded also in this genotype. The interaction between SA and drought stress was significant for nearly all the studied parameters. In most cases SA was more effective under drought stress than non-stress conditions. While, Giza168 wheat genotype exhibited more drought tolerance than Giza164 genotype, the last seemed to exhibit more SA stimulation in most cases. SA could be a very promising compound for the reduction of the abiotic stress sensitivity of crops, because in this study it has been found to mitigate the damaging effects of drought stress treatment in wheat plants.

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