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Effect of salicylic acid on morphological characteristics, yield and yield components of Corn (*Zea mays* L.) under drought condition

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ABSTRACT

In order to investigation of foliar spraying of different concentrations of salicylic acid on corn (KSC400 var.) yield and yield components under drought condition, an experiment was conducted based on Randomized Complete Block Design (RCBD) as Split Plot with three replications during 2011-2012 growing season at Sabzevar region, Iran. The treatments of drought tension were consisted of stress in 10-12 leaf stage, stress in flowering and grain filling and salicylic acid treatments including 0, 0.5, 1 and 1.5 Mm concentrations. Results of variance analysis showed drought stress reduced kernel yield, row no per ear, kernel no per row, cob diameter and ear length significantly. The highest and lowest kernel yield was recorded for stress in 10-12 leaf stage (7.13 ton/ha) and stress in flowering (4.76 ton/ha). Means comparison revealed that the effect of salicylic acid spraying on the growth of morphological traits and increasing in the corn yield was considerable and significantly inhibited of decreasing in plant height, ear height, leaf area of the main ear, row no/ear, kernel no/ row and ear length. 1 Mm concentration of salicylic acid at 10-12 leaf stage had the greatest impact on the relieving of drought stress. Results of simple correlation showed kernel yield had a positive and significant correlation with ear diameter, kernel no/row and ear height. Considering the stepwise regression results, ear diameter, cob diameter and anthesis-silking interval (ASI) were the most effective traits on kernel yield.

Keywords*:* Drought stress, salicylic acid, kernel yield, correlation, stepwise regression

INTRODUCTION

Corn (Zea mays L.) has been being cultivated and grown around the world and drought pressure was classified as one of the most deleterious environmental stresses which affects adversely the crop physiology at the cellular level [41] and restricts crop production [3,32,44,55,54]. Maize is one of the crops the have a high sensitivity to the drought pressure [21] which its yield could be reduced more than 50 percent [13] and 20-25 percent of the planting area of maize is affected by drought pressure in the world [23]. Drought stress affects leaf water content, photosynthesis via reduction in stomatal conductance, internal CO2 partial pressure and stomatal closure [57,58] and water use efficiency (WUE) as well[15]. The negative effect of water tension on crop plants is decreasing in production of fresh and dry biomass[7,20]. It was reported by Hu and Schmidhalter [24] that the mineral-nutrient relations in crops via nutrient availability, transport and portioning was affected by drought.

Salicylic acid (SA) (2-hydroxybenzoic acid), as a natural plant hormone [30] is an internal regulator of phenolic nature which regulates and different physiological processes in crops [62,51] and modulates plant reaction to different pressures such as drought, salt, chilling, heat, ultraviolet [12,25] and pathogens and disease resistance [18,27,46]. Salicylic acid enhances plant capacity and resistance to different stresses [34]. SA enhances the defensive compounds like betaine, glycine and praline [48]. It has been being a remarkable paid attention to SA because of its capability to protect of crop under drought pressure [10]. However its mechanism in improving the tolerance of drought pressure has not been completely clarified [49]. It ameliorates the growth of crop, enzyme activities, ion uptake and transport [30] ethylene synthesis, seed germination, fruit yield, glycolysis, the growth-inhibitory effect of abscisic acid [29], water relations and stomatal regulation [42]. Canakci [14] claimed that SA protects the crop against various tensions by changing the effects of abscisic acid, gibberellic acid and cytokinins. Khodary [33] observed that the fresh and dry weight of shoot and roots of stressed maize plants were enhanced by the application of SA which was due to the induction of antioxidant reactions that protect the crop from damaging [50] and photosynthesis and nutrient content enhanced [30]. The effectiveness of SA application depends on different factors such as the species, developmental stage of the plant, the manner of application and the concentration of SA [53].

Therefore, the present experiment was conducted to evaluate the role of exogenous SA application in improving of corn drought tolerance, based on assessing yield components and some morphological traits.

MATERIALS AND METHODS

This experiment was conducted under field condition of Sabzevar (6 km of Sabzevar road, 5765E longitude and 3620N latitude, altitude 985 m above sea level, relatively warm and dry climate with cold winters), Khorasan-Razavi Province, Iran in 2011. Soil test was done in order to determine the condition of the soil. Before the preparation of the field, soil sampling was done of twelve regions from 0-15, 15-30 and 30-45 cm depth randomly. Based on the results of soil test, the texture of the soil was loamy and alkali acidity with medium salinity to 45 cm depth. Furthermore, its organic matter, nitrogen and phosphorus nutrients was very low and the potassium was medium. Field preparation after barley harvesting was done in June and after deep ploughing, disking, leveling and fertilizer were performed. Fertilizers needed including super phosphate triple, potassium sulphate and urea at the rates of 150, 150 and 300 kg/ha were applied, respectively. All the phosphorus and potash fertilizers accompanying with 25 percent of urea were used before planting and the rest of nitrogen top-dressing fertilizer was used at 6-8 and 10-12 leaf stages. The experiment was performed based on a randomized complete block design (RCBD) in split plot scheme with three replications. Drought stress including (stress in 10-12 leaf stage, stress in flowering and grain filling) and salicylic acid spraying consisted of (0, 0.5, 1 and 1.5 Mm) at three different stages before drought. Drought tension and salicylic acid spraying were allocated to main and sub plots, respectively. The corn variety was KSC400 single cross. Each sub plot included 4 lines with length of 5m, 75 cm row spacing, plant spacing of 17.5 cm and plant density of 75000 plants/ha. Seeds were sterilized with vitavax . In every pile, 2 seeds were planted at 6 cm depth and after establishment and emergence of seedlings at 4 leaf stage, 1 plant was removed and thinning up operation was done. The distance between blocks was 1 m and the irrigation was performed at 8 days intervals. Weed removing and thinning were done handy by the workforces and diazinon was used against pests. During the growth season, plant dates, days to silking and days to grain filling based on the appearance of trait in 50 percent of plants in every plot were noted. The measured traits were plant height, ear height, leaf total number, total number of upper leaves, leaf area, stem diameter, mean of total kernel number on 10 competitive plants in each plot, randomly. After removal of the marginal effects, grain yield and biological yield were weighed and the number of kernel per row, number of row per ear, 1000-kernel weight, ear diameter and length, cob diameter and kernel depth were measured on 10 competitive plants in each plot, randomly.

After taking notes and recording data in Excel, data normal test was performed using the MSTAT-C statistical package and data conversion for numeric and percentage data was done. Variance analysis and means comparison were performed using SAS (version 9.1).

RESULTS AND DISCUSSION

Analyze variance showed the effects of drought stress and salicylic acid application were significant on kernel yield ($p<0.01$). The highest kernel yield was obtained from drought stress at 10-12 leaf stage (7.13 ton/ha) and the lowest one was obtained from drought stress at tasseling (4.76 ton/ha). By salicylic acid spraying, the maximum kernel yield was recorded for 1 Mm concentration of salicylic acid (6.85 ton/ha) and the minimum one was recorded for the control (4.48 ton/ha). Similar to our results Sharafizad *et al*., [52] and Mehrabian Moghadam *et al*., [38] stated that the effect of salicylic acid on the growth improvement and increasing in kernel yield at stress and non-stress conditions was significant. Bideshki and Arvin [12] reported that application of SA improved garlic yield in both drought and control conditions. Shakirova *et al*., [51] claimed that salicylic acid enhanced wheat yield. Canakci [14] announced that application of 0.7 mMol salicylic acid showed the highest kernel yield. Dawood *et al*., [17] observed that increase in kernel yield and yield components of sunflower by salicylic acid were due to the effect of physiological and biochemical processes that were led to ameliorate in vegetative growth and active assimilation translocation from source to sink. It was stated by Ali *et al*., [5] and Mehrabian Moghadam *et al*., [38] that higher yield in non-stress condition could be due to the decrease in ASI and increase in fecundity rate and in stress condition damage to the pollen and inadequate number of pollen during tasseling are the reasons of decrease in kernel yield.

Table 1. Variance analysis of morphological traits, yield and yield components of corn

		MS								
S.O.V	**df**	**Days to anthesis**	**Silking**	**ASI**	**Plant height**	**Ear height**	**Leaves no**	**Upper leaves no**	**Stem diameter**	**Leaf area**
Block	2	11.86	14.25	0.36	66.58	36.62	0.01	0.07	1.82	209.10
Drought stress	2	0.69ns	0.58ns	0.44ns	53.65ns	107.31ns	0.26ns	0.01ns	0.53ns	1439.48ns
Error	4	4.19	4.58	0.11	65.93	22.78	0.03	0.02	0.66	555.69
Salicylic acid	3	4.56ns	5.33ns	2.48**	449.70**	169.12**	1.19**	0.20**	1.72*	3363.36**
Interaction	6	4.81ns	6.36ns	0.59ns	145.56**	68.12**	0.26ns	0.03ns	0.82ns	1182.25**
Error	18	1.86	2.88	0.31	14.43	4.29	0.16	0.03	0.41	137.49
CV (%)		2.43	2.89	21.17	3.43	3.74	2.51	2.65	3.12	3.33

***, *, ns: Significant at 1 and 5 % probability levels and non significant, respectively.*

Table 1. Continue

		MS								
S.O.V	**df**	**Kernel yield**	**1000-kernel weight**	**Row no/ear**	**Kernel no/row**	**Mean of total kernel no**	**Ear diameter**	**Cob diameter**	**Kernel depth**	**Ear length**
Block	2	1.38	15.85	2.01	11.94	7786.43	5.32	0.02	1.21	3.06
Drought stress	2	17.28**	218.70ns	2.38**	109.6*	18062.3ns	11.10ns	7.60**	1.34ns	10.16*
Error	4	0.16	350.89	0.08	12.50	8610.83	2.51	0.16	0.88	0.96
Salicylic acid	3	8.80**	1698.7**	3.34**	128.29**	59550.0**	25.89**	0.10ns	6.31**	14.03**
Interaction	6	0.45ns	363.84ns	1.82**	32.02*	3884.18ns	1.57ns	0.15ns	0.35ns	3.35*
Error	18	0.31	206.03	0.44	9.15	5171.04	1.63	0.18	0.31	1.20
CV (%)		9.51	4.94	5.08	11.60	21.48	3.23	1.89	6.60	8.46

***, *, ns: Significant at 1 and 5 % probability levels and non significant, respectively.*

Table 2. Effect of drought stress on morphological traits, yield and yield components of corn

	MS								
Drought stress	**Days to anthesis**	**Silking**	**ASI (day)**	**Plant height (cm)**	**Ear height (cm)**	**Leaves no**	**Upper leaves no**	**Stem diameter (mm)**	**Leaf area (cm2)**
10-12 leaf stage	55.92a	58.42a	2.50a	108.41a	51.93a	15.57a	6.19a	20.89a	360.14a
Flowering stage	55.92a	58.75a	2.83a	112.17a	56.98a	15.86a	6.16a	20.48a	339.59a
Kernel set	56.33a	58.83a	2.50a	111.97a	57.23a	15.68a	6.22a	20.60a	356.44a

Means followed by the same letters in each column-according to Duncan's multiple range test are not significantly (p<0.05)

Table 2. Continue

	MS								
Drought stress	**Kernel yield (ton/ha)**	**1000-kernel weight (gr)**	**Row no/ear**	**Kernel no/row**	**Mean of total kernel no**	**Ear diameter (mm)**	**Cob diameter (mm)**	**Kernel depth (mm)**	**Ear length (cm)**
10-12 leaf stage	7.13a	293.06a	13.36a	27.56a	369.49a	40.46a	23.58a	8.44a	13.30a
Flowering stage	4.76c	293.01a	12.58b	22.59b	292.91a	38.54a	22.46b	8.04a	11.92b
Kernel set	5.61b	285.64a	13.35a	28.06a	342.01a	39.44a	22.04b	8.70a	13.67a

Means followed by the same letters in each column-according to Duncan's multiple range test are not significantly (p<0.05)

Table 3. Effect of salicylic acid on morphological traits, yield and yield components of corn

				MS					
Salicylic acid (Mm)	**Days to anthesis**	**Silking**	**ASI (day)**	**Plant height (cm)**	**Ear height (cm)**	**Leaves no**	**Upper leaves no**	**Stem diameter (mm)**	**Leaf area (cm2)**
0	55.56a	58.89a	3.33a	103.13b	50.26d	15.32c	6b	20.07b	326.20c
0.5	56.67a	58.89a	2.22b	114.02a	56.81b	15.96ab	6.20ab	20.69ab	358.05ab
1	55.33a	57.56a	2.22b	119.03a	60.49a	16.07a	6.37a	21.13a	372.47a
1.5	56.67a	59.33a	2.67ab	107.20b	53.98c	15.47bc	6.19ab	20.74ab	351.51b

Means followed by the same letters in each column-according to Duncan's multiple range test are not significantly (p<0.05)

Table 3. Continue

				MS					
Salicylic acid (Mm)	**Kernel yield (ton/ha)**	**1000-kernel weight (gr)**	**Row no/ear**	**Kernel no/row**	**Mean of total kernel no**	**Ear diameter (mm)**	**Cob diameter (mm)**	**Kernel depth (mm)**	**Ear length (cm)**
0	4.48c	272.59b	12.26b	20.92b	219.49b	37.25c	22.70a	7.28c	11.24b
0.5	6.02b	287.87ab	13.07ab	25.61a	337.18a	39.10b	22.59a	8.26b	12.91a
1	6.85a	304.23a	13.64a	29.29a	400.48a	41a	22.65a	9.18a	14.09a
1.5	5.98b	297.58a	13.42a	28.46a	382.07a	40.58ab	22.83a	8.87ab	13.61a

Means followed by the same letters in each column-according to Duncan's multiple range test are not significantly (p<0.05)

Table 4. Interaction effect of drought stress and salicylic acid on morphological traits, yield and yield components of corn

Drought stress	**Salicylic acid (Mm)**	**Plant height (cm)**	**Ear height (cm)**	**Lead area (cm2)**	**Row no/ear**	**Kernel no/row**	**Ear length (cm)**
	0	92.33e	39.80e	308.57d	13.03a	22.23b	11.32bc
10-12 leaf stage	0.5	111bcd	54.07cd	373.68b	13.40a	26.87ab	13.20ab
	1	126a	62.70a	402.94a	13.67a	31.90a	15.18a
	1.5	104.30d	51.17d	355.37bc	13.33a	29.23ab	13.50ab
	0	106.73cd	55.70bcd	317.95d	10.53b	13.13c	8.97c
Flowering stage	0.5	115.73bc	58.40abc	348.54bc	12.40a	21.93b	11.97b
	1	119.80ab	60.67ab	357.90bc	13.80a	27.77ab	13.50ab
	1.5	106.40cd	53.17cd	333.99cd	13.60a	27.53ab	13.25ab
	0	110.33bcd	55.27bcd	352.08bc	13.20a	27.40ab	13.43ab
Kernel set	0.5	115.33bc	57.97abc	351.93bc	13.40a	28.03ab	13.56ab
	1	111.30bcd	58.10abc	356.56bc	13.47a	28.20ab	13.60ab
	1.5	110.90bcd	57.60abc	365.18b	13.33a	28.60ab	14.08ab

Means followed by the same letters in each column-according to Duncan's multiple range test are not significantly (p<0.05)

The results revealed that the effect of drought stress was not significant on 1000-kernel weight but the effect of salicylic acid spraying was significant ($p<0.01$). The highest value of 1000-kernel weight was observed in 1 Mm concentration of salicylic acid (304 gr) and the lowest one was observed in control (272 gr). Unlike our results, Sharafizad *et al*., [52] and Mamnouie *et al*., [36] found that drought stress at stage of grain filling could significantly decreased 1000 seed weight but Ali and Mahmoud [6] and Dawood *et al*., [17] reported that 1000-kernel weight of mungbean and sunflower was enhanced by application of salicylic acid. However, Karim and Khursheed [28] observed that the effect of salicylic acid application was not significant on 1000-kernel weight. According to the Mehrabian Moghadam *et al*., [38] drought stress via disordering in the absorption and translocation of nutrients decreases supplying of photosynthesis assimilations and consequently alters and reduces in yield components.

Data presented in table 3 indicated that the effect of drought stress on the number of row per ear (0.01) and the number of kernel per row ($p<0.05$) was significant but it was not significant for the mean of total kernel number. Also results revealed that salicylic acid application was significant ($p<0.01$) on the above traits. Furthermore, the interaction effect of drought stress and salicylic acid on the number of row per ear (0.01) and the number of kernel per row ($p<0.05$) but it was not significant for the mean of total kernel number. The maximum value of the number of row per ear was recorded for drought stress at 10-12 leaf stage and kernel set (13) and the lowest one was recorded for drought stress at flowering stage (12). 1 Mm concentration of salicylic acid had the highest number of row per ear (14) and control treatment had the lowest one (12). Regarding the significant interaction effect of drought stress and salicylic acid on the number of row per ear, the highest value was obtained in drought stress at flowering stage with application of 1 Mm concentration of SA (14) which had not significant difference with drought stress at 10-12 leaf stage and grain filling in different levels of SA and the lowest value was obtained in drought stress at tasseling stage with non application of SA (11). Crop sensitivity to drought pressure differs due to the stress degree, various associated factors of pressure, plant species and their developmental stages [19]. Abd El-Wahed [1] found that salicylic acid did not increase number of rows per ear.

Table 5. Correlation coefficients between corn kernel yield and dependent traits under drought stress and salicylic acid

Traits	Days to anthesis	Silking	ASI	Plant height	Ear height	Leaves no	Upper leaves no	Stem diameter	Leaf area
Days to anthesis	1								
Silking	-0.940**	1							
ASI	-0.188ns	0.511**	1						
Plant height	-0.283ns	-0.489**	-0.694**	1					
Ear height	-0.249ns	-0.425**	-0.599**	0.920**	1				
Leaves no	-0.142ns	-0.307ns	-0.528**	0.645**	0.633**	1			
Upper leaves no	-0.096ns	-0.231ns	-0.425**	0.601**	0.560**	0.458**	1		
Stem diameter	-0.362*	-0.486**	-0.486**	0.514**	0.498**	0.456**	0.450**	1	
Leaf area	-0.241ns	-0.458**	-0.713**	0.758**	0.676**	0.547**	0.694**	0.695**	1
Kernel yield	-0.070ns	-0.264ns	-0.584**	0.342*	0.168ns	0.240ns	0.463**	0.470**	0.657**
1000-kernel weight	0.045ns	-0.003ns	-0.121ns	0.151ns	0.178ns	0.100ns	0.272ns	0.089ns	0.179ns
Row no/ear	-0.160ns	-0.306ns	-0.480**	0.333*	0.195ns	0.315ns	0.478**	0.354*	0.542**
Kernel no/row	-0.015ns	-0.243ns	-0.662**	0.454**	0.308ns	0.290ns	0.552**	0.441**	0.694**
Mean total kernel no	0.041ns	-0.122ns	-0.455**	0.384*	0.228ns	0.224ns	0.517**	0.337*	0.627**
Ear diameter	-0.127ns	-0.301ns	-0.547**	0.423*	0.283ns	0.273ns	0.546**	0.404*	0.704**
Cob diameter	-0.219ns	-0.221ns	-0.085ns	-0.205ns	-0.410*	-0.128ns	0.026ns	0.158ns	0.115ns
Kernel depth	-0.051ns	-0.236ns	-0.550**	0.527**	0.457**	0.339*	0.570**	0.370*	0.705**
Ear length	-0.130ns	-0.339*	-0.648**	0.552**	0.396*	0.374*	0.623**	0.440**	0.763**

***, *, ns: Significant at 1 and 5 % probability levels and non significant, respectively.*

Table 5. Continue

Traits	Kernel yield	1000-kernel weight	Row no/ear	Kernel no/row	Mean of total kernel no	Ear diameter	Cob diameter	Kernel depth	Ear length
Kernel yield	1								
1000-kernel weight	0.294ns	1							
Row no/ear	0.681**	0.141ns	1						
Kernel no/row	0.732**	0.146ns	0.820**	1					
Mean of total kernel no	0.706**	0.434**	0.657**	0.776**	1				
Ear diameter	0.780**	0.424**	0.817**	0.859**	0.864**	1			
Cob diameter	0.474**	0.200ns	0.203ns	0.127ns	0.185ns	0.340*	1		
Kernel depth	0.648**	0.374*	0.790**	0.865**	0.849**	0.934**	-0.019ns	1	
Ear length	0.699**	0.168ns	0.834**	0.949**	0.770**	0.864**	0.113ns	0.875**	1

***, *, ns: Significant at 1 and 5 % probability levels and non significant, respectively.*

Table 6. Stepwise regression between kernel yield and dependent traits under drought stress and salicylic acid

Entered trait	Regression coefficient	Standard error	t	F value
Ear diameter	309.03	69.53	0.61	52.69**
Cob diameter	422.49	163.09	0.66	4.76**
ASI	-437.58	192.24	0.71	5.18**

***, *, ns: Significant at 1 and 5 % probability levels and non significant, respectively.*

Data recorded in table 7 illustrated clearly that drought tension at kernel set stage (28.06) and flowering stage (22.59) had the maximum and minimum number of kernel per row. In addition, 1 Mm concentration of SA and control treatment (29 and 20) had the highest and lowest number of kernel per roe, respectively. Considering the significant interaction effect of drought tension and SA, drought pressure at 10-12 leaf stage with 1 Mm application of SA (32) and drought pressure at flowering with non application of SA (13) had the maximum and minimum kernel no/row, respectively.

Average total number of kernels at both drought pressure and salicylic acid application except for control treatment did not show significant differences, statistically.

Pandy and Maravili [45] reported that drought tension at different growth stages of maize reduced kernel no/row. Corn has high sensitivity to drought stress 2 weeks before and after pollination which reduces the number of kernels of ear [2].

Effect of drought stress on plant height, ear height, leaf area except for ear length ($p<0.05$) was not significant and effect of SA application and its interaction with drought stress on the above traits was significant ($p<0.01$). Bideshki and Arvin [12] found that drought stress reduced plant height and leaf area of garlic and salicylic acid application ameliorated these features in drought and normal conditions. Plant growth reduction under drought condition was ascribed to the adverse effect of drought on the pressure of cell turgor, expansion rate of cell, reduction in the activity of plant cells metabolic [7], decrease in photosynthesis and disturbance in the nutrients accumulation [56]. The doses of salicylic acid which enhanced plant height in drought and normal conditions could have better performance since the amounts of sugar shoot which is translocated at seed filling stage to compensate for limited photosynthesis in drought condition depends on plant height and having a shorter height can limit this case [63].

The longest ear was related to the drought stress at kernel set stage (14 cm) and the shortest one was recorded for the flowering stage (12 cm). The effect of foliar application of salicylic acid on ear length revealed that the longest ear was related to the 1 Mm concentrations on SA (14 cm) and the shortest one was related to the control treatment (11 cm). The interaction effect of SA and drought stress indicated that drought pressure at 10-12 leaf stage with 1 Mm concentration of SA has the longest ear (15 cm) and the shortest one was related to the drought pressure at flowering stage with non application of SA (8 cm).

1 Mm concentration of salicylic acid had the maximum plant height (119 cm) and control treatment had the minimum one (103 cm). Regarding the interaction effect of drought stress and salicylic acid on plant height, the maximum height was observed in drought stress at 10-12 leaf stage with 1 Mm concentration of SA (126 cm) and the minimum plant height was recorded for drought stress at 10-12 leaf stage with non application of SA (92 cm). Mehrabian Moghaddam *et al*., [38] indicated that all the concentrations of SA increased plant height. They found that drought stress throughout reduction in cell growth (reduction in cell division and cell size) at vegetative growth caused decrease in plant height. Shakirova *et al*., [51] showed that salicylic acid enhanced cell division in meristem of wheat seedling and ameliorated plant growth. Sadeghipour and Aghaei [47] found that plant height of common bean was decreased by the drought pressure and application of salicylic acid enhanced it. Umebese *et al*., [60] reported that the positive effect of SA on tomato stem height was due to the capability of this compound to stimulate antioxidant reactions that preserve the plant from perilous effects of drought pressure and develop in mitosis and cell elongation. Also, Maity and Bera [35] in vigna radiate and Khan *et al*., [30] in mungbean stated that the affirmative effect of salicylic acid was because of the function of SA in increasing biochemical and physiological processes or enhancing in the activity of N, P, K and Ca in antioxidant enzymes and the content of glutathione. Khandaker *et al*., [31] found that application of SA at low concentrations caused increment in soybean, maize and wheat plants growth but at higher concentrations decreased the growth of tomato, lupine, wheat and maize plants.

For the ear height, 1 Mm concentration of SA (60 cm) and control treatment (50 cm) had the highest and lowest ear, respectively. Drought stress at 10-12 leaf stage with 1 Mm concentration of SA (62 cm) and non application of SA at 10-12 leaf stage (39 cm) had the highest and lowest ear.

Data presented in table 1 revealed that the maximum value of leaf area was observed in salicylic acid with 1 Mm concentration (372 cm2) and the minimum leaf size was observed in control treatment (326 cm2). The interaction effect of SA and drought stress showed that drought stress at 10-12 leaf stage with 1 Mm concentration of SA and non application of SA (402 and 308 cm2) had the maximum and minimum leaf size, respectively. Decrease in leaf size, expansion and stomatal closure are one of the primary reactions to drought pressure which subsequently lead to decrease in photosynthesis [40]. SA reduces the deleterious effect of drought tension via increasing the antioxidant compounds and enhancing the antioxidant enzymes activity and stimulating the synthesis of new proteins as well [9]. Foliar application of phenolic compounds such as salicylic acid, hydrogen peroxide, ethylene and nitric oxide, has huge potential in ameliorating tolerance of drought tension [64,61]. Salicylic acid application develops photosynthetic capacity in spring wheat and barley under drought pressure [8,16]. It was reported by Maity and Bera [35] that SA application enhanced rate of assimilation that showed increment in the content of chlorophyll and the activity of leaf hill reaction. It was indicated by the Mardani *et al*., [37] that increment in salicylic acid concentration considerably enhanced leaf area in cucumber. Khan *et al*., [29] found that 5-10 mol/L foliar application of salicylic acid enhanced 8 and 13% the rates of photosynthetic and it increased maize leaf area. So that, leaf area was enhance up to 74.94 % [19]. Gharib [22] reported that lower concentrations of SA enhanced photosynthetic activity in basil and marjoram that increased number of leaves and leaf area.

Data recorded in table 2 showed that the effect of drought pressure on total leaf number, the number of upper leaves and stem diameter was not significant. But application of salicylic acid had significant effect ($p<0.01$) on the above traits. So that SA application of 1 Mm concentration had the maximum total leaf number (16.07), the number of upper leaves (6.37) and stem diameter (21.13 mm) and control treatment (15.32, 6, 20.07 mm) had the minimum ones, respectively. However, Sure *et al*., [59] found that drought pressure decreased the number of leaf per plant. They claimed that SA increased the number of leaf. Hussein *et al*., [26] stated that foliar application of SA increased stem diameter. Al-Hakimi [4] announced that salicylic acid causes increment in lignin of cell wall which could be a factor of increasing in stem diameter of plants under drought condition. Orabi *et al*., [43] in cucumber and Khodary [33] reported that foliar application of salicylic acid enhanced leaf area, total number of leaves, plant height and root dry matter.

According to the obtained results the effect of drought stress on ear diameter and kernel depth was not significant, statistically but it was significant on cob diameter ($p<0.01$). Also, the effect of salicylic acid on ear diameter and kernel depth was significant ($p<0.01$). The thickest ear height was recorded for drought stress at 10-12 leaf stage (23 mm) and the thinnest one was recorded for kernel set (22 mm). 1 Mm application of SA resulted in thickest ear (41) and maximum kernel depth (9 mm) and the lowest values was obtained from non application of SA (37 and 7 mm), respectively.

The results of analysis of variance showed that the effect of drought stress was not significant on days to anthesis, days to siliking and ASI. Furthermore, effect of SA was not significant except for ASI.

CONCLUSION

The results of this experiment showed that the effect of drought stress treatments on all the traits except for kernel yield, kernel row no per ear, kernel no per row, cob diameter and ear length was not significant. In fact, the maximum values of drought stress treatments were related to the 10-12 leaf stage. It means that the application of drought stress in this stage reduced kernel yield, kernel row no per ear, kernel no per row, cob diameter and ear length. In addition, by application of salicylic acid all the traits except for days to anthesis, days to siliking and cob diameter had the significant differences, statistically and maximum values of salicylic acid treatments were related to the 1 Mm concentration which modified the effects of drought. The interaction effect of drought and salicylic acid in plant height, ear height, leaf area, kernel row no per ear, kernel no per row and ear length was significant. So, it was concluded that in drought stress, it's better to use salicylic acid for modifying the effects of drought on corn at 10-12 leaf stage with 1 Mm concentration of SA.

Traits correlation

The results of simple correlation revealed that the kernel yield had the maximum correlation with ear diameter (0.78**) and minimum with plant height (0.34*). kernel yield had a positive and significant correlation with kernel no per row, mean total number of kernel, ear length, kernel row no per ear, leaf size, kernel depth, cob diameter, stem diameter, upper leaves no and plant height. The highest correlation coefficients were observed for ear diameter ($r = 0.78^{**}$), kernel no per row ($r = 0.73^{**}$), mean total number of kernel ($r = 0.71^{**}$) and ear length ($r = 0.70^{**}$). Kernel yield had a negative and significant correlation with ASI. Abd El-Wahed [1] reported grain yield had significant and positive correlation with plant height, stem diameter and ear length. Moosavi [39] announced that there was a significant correlation between number of seed per ear and seed yield. Grain in row had highest correlation with grain in ear (974**), and then with grain yield (943*) [11].

Stepwise regression

The first trait which was entered to the model was ear diameter which justified about 60 percent of yield changes. Afterwards, cob diameter was entered to the model which along with previous trait justified about 65 percent of yield changes. And finally ASI was entered which accompanying with previous traits justified 70 percent of yield changes. Hence, it could be concluded that selection based on ear diameter, cob diameter and ASI is more appropriate.

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