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Stay-Green Response in Maize Hybrids and Cultivars Through SA Application

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ABSTRACT
An experiment was carried out on farm in Ramadi/Anbar, Iraq to study the response of stay-green leaves of maize genotypes sprayed by salicylic acid (SA) under limited irrigation. SA levels: 0, 100, 200, and 300g/l used SA main-plots while maize genotypes were set sub-plots in a split-plot arrangement with RCBD of three replicates. Results showed that the hybrids B73× Ik8 and AGR3×AGR11, and the cultivars Maha gave best values of most traits studied. Plants treated with 300mg/l SA gave increases in sinking, number of functional leaves, leaf area, kernels/row, kernel weight, and grain yield. Values of the interaction of the three mentioned genotypes with 300mg/l SA gave higher plant height, and grain yields in both spring and fall plantings in 2020. It can be concluded that using SA application SA (300mg/l) as growth regulator is useful to enhance growth and grain yield of some maize genotypes.

Keywords: *Zea mays* L., growth regulator, leaf duration

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INTRODUCTION
Maize (*Zea mays* L.) is ranking the third after wheat and rice in the world production. Maize grains are being used in animal feed, breakfast cereals, and many industries. Maize could be used as petroleum alternative for automobile fuel, and named as, King of crops (Khan et al 2003). The production and productivity of maize have been increased in the world, but due to continuous, human population increase, and animal farms increases, this crop is still in short especially in Iraq. The area planted with crop in Iraq in 2019 estimated as 128800 ha with a productivity of 3.67 t/ha (Directorate of Agricultural Statistics 2016). One of the important factors of low productivity is the use of less productivity hybrids coincided with poor soil and crop management practices. Maize high yielding hybrid ore not always available in Iraq besides low management practices (Haseeb et al 2018).
Growth regulators are being used nowadays to mitigate some of abiotic streets on crops-one of There is SA ($C_6H_4(OH)CO_2H$). The SA is a plant growth regulator has many physiological activities in plant growth, and enhancing efficiency of photosynthesis, beside its role in salt and heat stresses (Hayat and Ahmed 2007; Arfan et al 2007; Gharib and Hegazi 2010). These activities could be due to its negative effect on reactive oxygen species (ROS) as an antioxidant enzyme (Kadiogula et al 2011) .SA has another value in plant growth by inhibitor ABA (Rai et al 1986) and depressing production of ethylene (Leslie and Romani 1988). SA effects on plant growth parameters and yield counts a plant species used and SA levels applied (Horvath et al 2015; Poor et al 2019). The use of SA is directed to it role in mitigation some of abiotic stress on plants, and This could be much cleaner if a good producing hybrid are used. This research was set up to shed some light on the response of some maize genotypes to levels of SA applied on plants.

MATERIALS AND METHODS
This experiment was conducted in 2019 in spring and fall planting season in Ramadi/Anbar, Iraq. The land was ploughed, risked and fertilized with 320 kg/ha of DAP. The soil them divided into plants of 3×3m. When seeds parted, and the plants were about 25 cm high. 100kg/ha of urea was added, and the second addition was at an thesis. The maize generation use were three pollution cultivars (Maha, Rabie and Safa) with three hydrates (B73×Ik8, AGR3×AGR11 and A105×NA17). Four concentration of SA were applied; 0, 100, 200 and 300 mg/l. Two applications were used the first after 30 days from emergence, and the second 15 days after. The design used was RCBD in a split-plot arrangement of three replications. Levels of SA were main plots and genotypes a sub-plot. Each plot consisted of 4 rows of 75cm and 25cm within row. Data were recorded on 10 randomly taken plants from each experimental unit. Field data, such as flowering, plant height, leaf area, and yield and yield components were tabulated and statistically analyzed according to the design used and as shown in tables.

RESULTS AND DISCUSSION
50% silking:
Table 1 shows the significant differences among maize genotypes, SA levels and infection in 50% silking. SA3 gave more acceptable silking percent which is fit with tasseling in planting seasons. This means that SA promoted silking via its role as an auxin to enhance photosynthesis which led to early silking (Al-Sheikhli and Yaemur 2019). The hybrid B73×Ik8 gave the best optimum day of silking in both seasons. Other differences among open pollinated cultivars and hybrids can be noticed in the Table. The combination treatment B73×Ik8 with 5A3 gave better value of 50% silkng in both spring (65.75 days) and in the fall planting (54.36 days). However, the effect of SA in reducing days required for silking was clear and significant although the differences were not many days out still important to be closer to tasseling.

Table 1. Effect of SA levels and maize genotypes on 50% silking (day).

Genotypes (G)	Spring season					Fall season				
	Salicylic acid (SA) mg/l					Salicylic acid (SA) mg/l				Means (G)
	SA0 0	SA1 100	SA2 200	SA3 300	Means (G)	SA0 0	SA1 100	SA2 200	SA3 300	
Maha	68.94	68.35	67.37	64.98	67.41	56.12	56.10	56.08	55.32	55.91
Rabie	70.75	68.74	67.88	65.25	68.16	59.64	58.47	57.95	58.64	58.68
Safa	73.61	72.86	72.38	69.34	72.05	61.34	60.45	58.84	59.21	59.96
B73 x IK8	67.62	66.48	66.13	65.75	66.49	56.24	56.18	55.54	54.36	55.58
AGR3xAGR11	69.24	67.26	68.26	70.54	68.82	56.42	56.18	55.73	54.65	55.75
A105 x NA17	71.65	70.15	69.81	71.42	70.75	59.37	56.18	57.94	58.87	58.09
Means SA	70.30	68.97	68.64	67.88		58.19	56.18	57.01	56.84	
L.S.D 1%	G	SA	G×SA			G	SA	G×SA		
	1.11	**1.59**	**2.22**			**1.04**	**1.02**	**2.08**		

Plant height

Results in Table 2 show that plant height was increasing as SA levels increased in both spring and fall plantings. However, it is known in our climate that time of silking is longer in spring than in fall planting. While plants are taller in fall than in spring planting. Plant height increased by SA application is attributed to the enhancement of photosynthesis and lead to call division (Farahbakhsh, H., and Saiid 2011; Zamaninejad 2013). Plant height in general in not a constant key to high grain yield in maize, since we can notice the differences in plant heights and plant grain yields shown in Table 7. The different among maize genotypes in plant heights were reported by other researchers (Ibrahim et al 2016; Saedpanah et al 2016).

Table 2. Effect of SA levels and maize genotypes on plant height (cm).

Genotypes (G)	Spring season					Fall season				
	Salicylic acid (SA) mg/l					Salicylic acid (SA) mg/l				Means (G)
	SA0 0	SA1 100	SA2 200	SA3 300	Means (G)	SA0 0	SA1 100	SA2 200	SA3 300	
Maha	168.45	150.21	154.65	167.25	160.14	165.72	152.65	155.74	170.59	161.18
Rabie	160.67	162.56	180.45	184.52	172.05	167.35	171.42	178.85	188.33	176.49
Safa	148.96	163.69	169.74	181.43	165.96	155.61	165.94	175.68	185.78	170.75
B73 x IK8	150.96	154.95	167.89	168.48	160.57	155.45	155.36	168.34	169.35	162.13
AGR3xAGR11	155.34	159.64	162.46	170.94	162.10	156.23	158.67	166.15	171.45	163.13
A105 x NA17	164.95	169.78	175.89	178.15	172.19	167.35	179.34	182.76	184.76	178.55
Means SA	158.22	160.14	168.51	175.13		161.29	163.90	171.25	178.38	
L.S.D 1%	G	SA	G×SA			G	SA	G×SA		
	7.65	**10.3**	**15.30**			**6.41**	**8.74**	**12.82**		

Number of functional leaves:

Plant functional leaves have a trend of increasing as SA levels increasing in both seasons (Table 3). In general, the higher the SA level, the higher the number of functions on leaves in both seasons. The effect of SA was so clear in delaying ageing of leaves; this will keep the activities to the time of harvest. Maize genotypes showed significant differences in this trait too. The means of functional leaves in fall planting was higher than in spring planting. This probably explains some of the higher grain yield of maize in the fall (Lee and Tollenaar 2007). The interaction was significant, and the hybrids B73×Ik8 and AGR3× AG11 had higher functional levels per plant. Other researchers found similar results (Habibpor et al 2016; El-Katony et al 2019).

Table 3. Effect of SA levels and maize genotypes on number of functional leaves

Genotypes (G)	Spring season					Fall season				
	Salicylic acid (SA) mg/l					Salicylic acid (SA) mg/l				Means (G)
	SA0 0	SA1 100	SA2 200	SA3 300	Means (G)	SA0 0	SA1 100	SA2 200	SA3 300	
Maha	12.52	12.73	13.29	13.51	13.01	13.00	13.98	14.23	14.42	13.91
Rabie	10.81	10.85	11.14	11.46	11.07	11.46	12.07	13.32	13.52	12.59
Safa	11.03	11.26	11.68	11.88	11.46	12.09	12.65	12.75	12.89	12.60
B73 x IK8	12.74	12.84	13.23	13.61	13.11	13.49	13.78	14.46	14.78	14.13
AGR3xAGR11	12.46	12.65	12.92	13.49	12.88	13.39	13.64	14.39	14.72	14.04
A105 x NA17	11.25	11.54	11.44	12.17	11.60	12.52	12.73	13.61	13.73	13.15
Means SA	11.80	11.98	12.28	12.69		12.66	13.14	13.79	14.01	
L.S.D 1%	G	SA	G×SA			G	SA	G×SA		
	1.06	**0.87**	**2.12**			**1.10**	**1.01**	**2.20**		

Plant leaf area: Table 4 shows the results of plant leaf area for maize genotypes as increasing by SA application. SA3 gave the wider plant leaf area in both seasons. On the other hand, maize genotypes were also different, and these genotypes have reacted differently to SA levels. However, the magnitude of response to SA effect was different among maize genotypes. High leaf area of B73×Ik8 was the best with SA3, since it gave 0.542 and 0.571 m²/plant in spring and fall planting, respectively. SA effects in increasing leaf area could be due its impact on ethylene production and enhancing antioxidant acting against reactive oxygen species produced due to stress (Cruz 2008), besides its role in increasing cytosol and retains water in leaves which lead to better growth (Arfan et al 2007; Hayat and Ahmed 2007; Gharib and Hegazi 2010), and this is with agreement with Hayat and Ahmed (2007); Hussein et al (2007); Molazem et al (2014).

Table 4. Effect of SA levels and maize genotypes on plant leaf area (cm²)

Genotypes (G)	Spring season					Fall season				
	Salicylic acid (SA) mg/l					Salicylic acid (SA) mg/l				Means (G)
	SA0 0	SA1 100	SA2 200	SA3 300	Means (G)	SA0 0	SA1 100	SA2 200	SA3 300	
Maha	0.451	0.479	0.512	0.536	0.495	0.478	0.492	0.501	0.538	0.502
Rabie	0.378	0.398	0.402	0.462	0.410	0.384	0.439	0.441	0.423	0.422
Safa	0.367	0.381	0.426	0.461	0.409	0.345	0.373	0.443	0.446	0.402
B73 x IK8	0.454	0.477	0.524	0.542	0.499	0.468	0.478	0.502	0.571	0.505
AGR3xAGR11	0.417	0.456	0.513	0.532	0.480	0.457	0.459	0.500	0.589	0.501
A105 x NA17	0.394	0.410	0.416	0.474	0.424	0.412	0.411	0.415	0.458	0.424
Means SA	0.410	0.434	0.466	0.501		0.424	0.442	0.467	0.504	
	G	SA	G×SA			G	SA	G×SA		
L.S.D 1%	**0.038**	**0.071**	**0.076**			**0.082**	**0.040**	**0.164**		

Kernels/row: Kernels/row of maize genotypes reacted to SA leaves are shown in Table 5. Increased SA leaves coincided with increased number of kernels/rows of maize genotypes. The higher the concentration gave the higher number in both seasons. The best values of kernels/row were of B73×Ik8 in both seasons, since it gave 38.42 and 38.96 kernels/row respectively. However, some genotypes had somewhat similar values, SA levels increased chlorophyll activity and leaf area, them resulted in high number of kernels/row (Tantawy et al 2016; Jasim et al 2017; Tahjib-Ul-Arif et al 2018).

Table 5. Effect of SA levels and maize genotypes on kernels/row

Genotypes (G)	Spring season					Fall season				
	Salicylic acid (SA) mg/l					Salicylic acid (SA) mg/l				Means (G)
	SA0 0	SA1 100	SA2 200	SA3 300	Means (G)	SA0 0	SA1 100	SA2 200	SA3 300	
Maha	29.31	30.14	33.25	35.19	31.97	31.45	32.13	32.89	38.76	33.81
Rabie	24.62	25.65	27.62	26.75	26.16	23.61	24.16	25.65	24.89	24.58
Safa	25.95	24.74	28.15	30.13	27.24	27.74	26.72	26.38	31.73	28.14
B73 x IK8	30.58	31.26	36.37	38.42	34.16	31.48	33.59	37.26	38.96	35.32
AGR3xAGR11	29.91	32.78	34.08	37.85	33.66	29.75	34.12	34.87	37.91	34.16
A105 x NA17	23.65	25.36	27.49	27.61	26.03	25.34	23.82	30.26	28.79	27.05
Means SA	27.34	28.32	31.16	32.66		28.23	29.09	31.22	33.51	
	G	SA	G×SA			G	SA	G×SA		
L.S.D 1%	**3.18**	**2.01**	**6.36**			**3.91**	**4.51**	**7.82**		

Kernel weight: The weight of kernel a represented by 1000 kernel weight is shown in Table 6. Maize genotypes had significant differences in their response to SA levels. The higher level of SA the higher the value of kernels weight. The effect of SA in photosynthesis and growth lead to have higher kernels weight (Hayat and Ahmed 2007). The hybrids B73×Ik8 gave higher kernels weight in both seasons. The interaction of maize genotypes with SA levels was also significant. Similar results have been reported by other researchers (Ghazi 2017; Haseeb et al 2018).

Table 6. Effect of SA levels and maize genotypes on

Genotypes (G)	Spring season					Fall season				
	Salicylic acid (SA) mg/l					Salicylic acid (SA) mg/l				Means (G)
	SA0 0	SA1 100	SA2 200	SA3 300	Means (G)	SA0 0	SA1 100	SA2 200	SA3 300	
Maha	263.36	258.98	292.14	301.27	278.94	271.37	269.98	294.21	330.26	291.46
Rabie	221.67	227.64	259.72	273.94	245.74	243.56	256.75	257.83	286.53	261.17
Safa	204.68	200.33	216.84	232.42	213.57	201.63	191.16	238.45	276.41	226.91
B73 x IK8	260.45	270.75	287.68	304.33	280.80	273.51	287.35	304.39	334.68	299.98
AGR3xAGR11	250.25	271.36	280.94	299.87	275.61	258.62	278.92	296.28	332.94	291.69
A105 x NA17	195.34	223.57	255.57	263.31	234.45	200.33	215.34	267.36	268.56	237.90
Means SA	232.63	242.11	265.48	279.19		241.50	249.92	276.42	304.90	
	G	SA	G×SA			G	SA	G×SA		
L.S.D 1%	**31.11**	**37.81**	**62.22**			**25.91**	**29.38**	**51.82**		

Plant grain yield:

Plant grain yield is the final target of researchers and farmers. Table 7 shows the results of maize genotype grain yields as influenced by SA levels applications. SA levels, maize genotypes, and their interactions were all significate in both seasons. SA3 gave best plant grain yields in both seasons; 162.9 and 171.9 g/plant, respectively. The hybrid B73 × IK8 gave 157.9 g in spring, while it gave 172.9 g/plant in fall planting. Other maize genotypes were still different in this trait. On the other hand, some hybrid (B73 × IK8) reacted differently with SA levels giving 216.5 and 231.2 g/plant, respectively. This response of maize genotypes to SA in attributed to its effects on leaf area and leaf area duration, as we have seen in previous tables. These results were similar to those reported before (Ibrahim et al 2016; Said and Hamd-Alla 2018).

Table 7. Effect of SA levels and maize genotypes on plant grain yield (g/plant)

Genotypes (G)	Spring season					Fall season				Means (G)
	Salicylic acid (SA) mg/l					Salicylic acid (SA) mg/l				
	SA0 0	SA1 100	SA2 200	SA3 300	Means (G)	SA0 0	SA1 100	SA2 200	SA3 300	
Maha	102.48	127.62	157.93	201.37	147.35	109.68	125.87	179.86	210.18	156.40
Rabie	78.69	90.33	102.42	109.36	95.20	86.33	93.56	113.37	115.17	102.11
Safa	69.12	81.61	94.85	121.63	91.80	76.59	90.45	98.64	127.55	98.31
B73 x IK8	110.26	1.9831	2.6571	6.4912	157.85	112.59	149.72	198.15	231.16	172.91
AGR3xAGR11	106.57	114.34	144.24	200.23	141.35	111.74	125.43	167.89	211.78	154.21
A105 x NA17	82.79	97.62	112.95	128.32	105.42	95.64	93.12	129.45	135.41	113.41
Means SA	91.65	107.25	130.84	162.90		98.76	113.03	147.89	171.88	
L.S.D 1%	G	SA	G×SA			G	SA	G×SA		

CONCLUSION

Maize genotypes of aper-pollinated and hybrids responded differently to SA levels and that improved agronomic traits and finally plant grain yield. SA of 300 mg/l had significant effects in delaying leaf ageing and increased deration of green leaves. This lead to enhance photosynthesis and more metabolites moved from source to sink.

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