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THE EFFECT OF SALICYLIC ACID AND PHOSPHORUS SPRAYING ON MAIZE (*ZEA MAYS* L.) YIELD UNDER CONDITIONS OF INCOMPLETE IRRIGATION

Ali H. JASIM*, Kadhim M. HASSON, Haider M. RASHID
Agriculture College, Al-Qasim Green University, Iraq
**Corresponding author's e-mail address: ajasim11@gmail.com*
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ABSTRACT
A field experiment was carried out during the autumn season in 2013 in a farm located in Alhashimiya (20 km south east of Hilla), to study the effect of salicylic acid and phosphorus spraying on yield of maize under conditions of deficit irrigation. Split-split plot arrangement in randomized complete block design (RCBD) with three replications was used, operated irrigation treatments (A0 full irrigation, A1 deficit irrigation) in panels major plots , while concentrations of phosphorus (0, 1000 and 2000 mg.L^{-1}) panels the sub plot and concentrations of salicylic acid (0, 0.5 and 1 mM) panels the sub-sub plots. Maize grain (cv. Research 106) was seeded in 20-July/2013. The results showed that deficit irrigation led to reduce most of yield components (rows number, grain number, length and diameter of ear) significantly. Salicylic acid and phosphorous spraying led to remove or reduce this negative effect of water stress, in which P at 1000 mg.L^{-1} was superior in giving the highest rate of most yield components (ear length, rows number and weight of 500 grain). Salicylic acid 1 mM was superior in ear length and grain number.ear^{-1}. The interaction between the factors had a significant effect in most of traits studied.

KEY WORDS: *maize, deficit irrigation, phosphorous, salicylic acid.*

INTRODUCTION

Maize crop (*Zea mays* L.) is one of important grain crops in Iraq and the world, which ranks third after wheat and rice crop in terms of cultivated area and production (Huang *et al*., 2006). Nutrition plays an important role in increasing plant growth and yield (Abdul-Wakeel *et al.*, 2005; Ashley *et al.,* 2006; Ianovici *et al*., 2011). Phosphorus nutrient is needed by plants in relatively large quantities. Due to the exposure of phosphorus in Iraqi soils to booking process, so it began to add it as foliar fertilizer as well as adding to the soil. Foliar feeding be more effective when there are determinants of absorption mediated by the roots, such as drought (water stress) which is one of the most important environmental stresses that affect agricultural production in the world by causing reduction in growth and reduces the efficiency of the construction photosynthesis process as a result of the closing of the stomata, reduce processing CO_2 and delay germination and development of seedlings and mature plants (Ghooshchi *et al*., 2008; Khayatenezhad *et al.,* 2010; Rong, 2012). Salicylic acid (growth regulators), which is one of the antioxidants (non-enzymatic) that have role in scavenging oxygen species that effectively oxidized cells and enzymes and leading to inhibition of photosynthesis process (Hayat *et al.,* 2005), and also plays an important role in growth and development of the plant by

improving of ions and nutrients absorption (Khan *et al.,* 2003), prevents the representation of ethylene (Khan *et al.,* 2013), and has a role opposite to the effect of ABA. This study aims to study the effect of salicylic acid and phosphorus spraying in maize yield and the extent of its importance in reducing the harmful effects of water stress.

MATERIALS AND METHODS

A field experiment was carried out during the autumn season of 2013 in Al-Hashimiya, (20 km south of Babylon center) in sand soil (Table 1) in order to study the effect of spraying salicylic acid and phosphorus on yield of maize under deficit irrigation conditions. Split-split plots arrangement with randomized complete block design (RCBD) in three replications was used. Full irrigation (control) and deficit irrigation (cut one irrigation at vegetative phase), which coded A0 and A1 relatively, on main plots, and the sub-plots encompassing three concentrations of phosphorus B0, B1 and B2 (control and spraying 1000 and 2000 mg $P.l^{-1}$, respectively, and sub-sub plot included three concentrations of salicylic acid C0, C1 and C2 (control, and spraying 0.5 and 1.0 mM), respectively. Grain maize (cv. Buhooth 106) were seeded on ridges (75 cm apart and 25 cm between hills. The irrigation was done every 7 days. At harvest time, ear length and diameter, number per plant as average of ten randomized plants, 500 grain weight, grain yield, were calculated. The data were analyzed and the averages were tested by less significant differences.

TABLE 1. Some physical and chemical characteristics of the soil before planting

Characteristic	value	characteristic	value
salt	101 $g.kg^{-1}$ soil	N	34.91 $mg.kg^{-1}$ soil
silt	534 $g.kg^{-1}$ soil	P	11.98 $mg.kg^{-1}$ soil
clay	365 $g.kg^{-1}$ soil	K	214.5 $mg.kg^{-1}$ soil
Texture	Silt-clay	pH	7.6
Ec	4.5 dSm/m^{-1}		

RESULTS AND DISCUSSIONS

Table (2) showed that salicylic acid led to increase ear length and the treatment (C2) gave highest rate (16.86 cm) while control treatment (C0) gave the lowest rate (16.19 cm). This may be due the influence of salicylic acid being contributes in regulating physiological processes in the plant as the outward processing of SA can improve plant physiological efficiency, including photosynthetic rate, and enhance effective partitioning of accumulates from source to sink (Ghasemzadeh & Jaafar, 2013). These results agreed with the findings of Abd-Elwahad *et al.* (2006).

It is clear that phosphorous spraying led to increase the length of ears as B1 treatment gave the highest rate (17.14 cm) compared to control treatment (Bo), which gave 16.20 cm. This may be due to the role of phosphorus in the process of division, expansion and elongation of the cells, as well as its role in the revitalization of many of the enzymes responsible for the construction of synthetic materials that go into building the structure of the plant and its role in the process of hormonal balance, which are consistent with Amanulla & Zakirulla (2010). The treatment of deficit irrigation in the vegetative stage (A1) caused a reduction of ear length, which gave the lowest rate (16.15 cm) compared to the treatment of full irrigation (A0), which gave 16.88 cm. This may be due to water stress in the vegetative stage which led to reduce

production and transport of the outputs of photosynthesis process from the leaves to ears, and thus reducing its length. These results are consistent with Zarabi *et al.* (2011). The interaction between irrigation and phosphorus levels had a significant effect, which A0B1 gave the highest length (17.82 cm), while A1B0 gave the lowest rate (15.89 cm). The interaction between irrigation treatments, phosphorus and salicylic levels had significant effect and the combination A0B1C2 gave the highest ear length (17.99 cm), while A1B0C0 gave the lowest rate (15.74 cm).

TABLE 2. Effect of salicylic acid, phosphorus and deficit irrigation spray in the ear length (cm)

Treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	15.99	16.63	16.91	16.51
	P1	17.58	17.89	17.99	17.82
	P2	16.00	16.21	16.72	16.31
A2	P0	15.74	15.82	16.11	15.89
	P1	15.98	16.44	16.96	16.46
	P2	15.87	15.96	16.49	16.10
$LSD_{0.05}$		0.38			0.46
SA level		16.19	16.49	16.86	0.11 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	16.52	16.91	17.20	16.88.
	A1	15.86	16.07	16.52	16.15
$LSD_{0.05}$		NS			0.49
					P level
P level *SA	P0	15.86	16.22	16.51	16.20
	P1	16.78	17.16	17.47	17.14
	P2	15.93	16.08	16.60	16.20
$LSD_{0.05}$		NS			0.05

Table (3) showed that salicylic acid led to increase ear diameter and the treatment (C2) gave the highest rate (4.77 cm), while control treatment gave the lowest rate (4.26 cm). This may be due to improve plant growth under conditions of water stress by regulating the physiological operations and reduce cellular membranes oxidation, thus improving the permeability and absorption of nutrients and this helps to increase the dry matter accumulated in ears, thus increasing its weight and diameter. These results agreed with Abd-Elwahad *et al* (2006). Phosphorous led to increase ear diameter, and B1 treatment gave the highest rate (4.92 cm) compared to (4.21 cm) in control treatment (Bo). It may be due to increasing photosynthesis process, and then increase cell size and the speed of division, which leads to increase leaf area, thereby increasing ear diameter. These results agreed with Grazia et al. (2003). Deficit irrigation (A1) caused a reduction in ear diameter and it gave the lowest rate (4.39 cm) compared to full irrigation (4.70 cm). It may be due to the lack of water in the vegetative phase which led to reduce leaf area and reflected in reducing radiation interceptor and the rate of photosynthesis as well as reduction the absorption and transport of nutrients due to water stress and the melting of the elements associated with the lack of root growth and the weakness of all these reasons, reduced the amount of dry matter and transferred to ears. These results are consistent with Khaksar *et al.* (2013). The interaction between irrigation and

phosphorus levels had significant effect, in which A0B1 gave the highest rate (5.22 cm), while A1B0 gave the lowest rate (4.20 cm).

TABLE 3. Effect of salicylic acid, phosphorus and deficit irrigation spray in ear diameter

Treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	4.09	4.26	4.31	4.22
	P1	4.98	5.30	5.38	5.22
	P2	4.27	4.74	5.03	4.68
A2	P0	3.98	4.24	4.38	4.20
	P1	4.26	4.71	4.89	4.62
	P2	4.03	4.37	4.68	4.36
$LSD_{0.05}$		NS			0.10
SA level		4.26	4.60	4.77	$0.11=LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	4.44	4.76	4.90	4.70
	A1	4.04	4.44	4.65	4.39
$LSD_{0.05}$		NS			0.02
					P level
P level *SA	P0	4.03	4.25	4.34	4.21
	P1	4.62	5.00	5.13	4.92
	P2	4.15	4.55	4.85	4.52
$LSD_{0.05}$		NS			0.09

Table (4) showed that salicylic acid led to increase ears number, which treatment (C2) gave the highest rate (1.22 earns) while control (C0) gave the lowest rate (1.07). These results agreed with (El-Khalall, 2009). The results showed that phosphorous led to increase ears number and B1 treatment gave the highest rate (1.20 ears) and the treatment B2 gave (1.15) compared to control (1.09). This may be due to the role of phosphorus in giving plant superiority in the growth and spread of the roots, which reflected in good plant hormonal balance and improve plant nutrition reflected in increasing ears number. These results are consistent with the results of Masood *et al*. (2011). The interactions had no significant effect on this trait.

Table (5) showed that salicylic acid led to increase rows number per ear significantly and the treatment (C2) gave the highest (16.06 rows), while control treatment gave the lowest rate (15.59 row). This is due to superiority in leaf area and dry roots weight (unpublished data) that leads to increase the efficiency of photosynthesis, in addition to the ability of salicylic acid in reducing free radicals which is generated due to water stress, and increase the effectiveness of enzymes by increasing antioxidants, especially enzymes shared the process of photosynthesis. These results are consistent with the findings of Zamanineijad *et al.* (2013). The results showed that phosphorous spraying led to increase rows number per earn, and B1 treatment gave the highest rate (16.15 rows) compared to control (15.58 rows). The reason for this may be due to the role of phosphorus in promoting plant growth in the early stages of plant age (Amanulla & Zakirulla, 2010). These results are consistent with Ghasmi *et al*. (2013). The treatment of deficit irrigation (A1) caused a reduction in rows number, which gave the lowest rate (15.54 rows) compared to full irrigation (A0), which gave 16.11 a rows. It may be due to the negative impact of the lack of moisture in the vegetative growth and nutritional status of the

plant, which was reflected in the reduced number of rows per ear. These findings are consistent with Khaksar *et al.* (2013). The interaction between the irrigation treatments and phosphorus concentrations had a significant effect, which A0B1 gave the highest rate of rows number per ear (16.50 rows), while A1B0 gave the lowest rate (15.38 row).

TABLE 4. Effect of salicylic acid, phosphorus and deficit irrigation spray in ear number

Treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	1.00	1.10	1.14	1.08
	P1	1.19	1.25	1.28	1.24
	P2	1.11	1.12	1.33	1.18
A2	P0	1.02	1.12	1.17	1.10
	P1	1.07	1.19	1.22	1.16
	P2	1.04	1.15	1.20	1.13
$LSD_{0.05}$		NS			NS
SA level		1.07	1.15	1.22	0.05 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	1.10	1.15	1.25	1.17.
	A1	1.04	1.15	1.19	1.13
$LSD_{0.05}$		NS			NS
					P level
P level *SA	P0	1.01	1.11	1.15	1.09
	P1	1.13	1.22	1.25	1.20
	P2	1.07	1.13	1.26	1.15
$LSD_{0.05}$		NS			0.07

TABLE 5. Effect of salicylic acid, phosphorus and deficit irrigation spray in rows number.ear^{-1}

Treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	15.52	15.83	16.00	15.78
	P1	16.04	16.43	17.03	6.50**1**
	P2	15.92	16.08	16.21	16.07
A2	P0	15.14	15.43	15.58	15.38
	P1	15.63	15.83	15.98	15.81
	P2	15.30	15.41	15.61	15.44
$LSD_{0.05}$		NS			0.19
SA level		15.59	15.83	16.06	0.36 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	15.82	16.11	16.41	16.11
	A1	15.35	15.55	15.72	15.54
$LSD_{0.05}$		NS			0.25
					P level
P level *SA	P0	15.33	15.63	15.79	15.58
	P1	15.83	16.13	16.50	16.15
	P2	15.61	15.74	15.91	15.75
$LSD_{0.05}$		NS			0.10

Table (6) showed that salicylic acid led to increase grain number per row which the treatment (C2) gave the highest rate (46.24 grains), while the control gave the lowest rate (40.35 grains). It is attributed to its effect in increasing chlorophyll, sytokinins and growth.

Salicylic acid role in maintaining the process of photosynthesis and increase the representation of CO_2 under stress conditions by increasing the production of antioxidants and reduce flower abortion. These results are consistent with the findings of Bayat & Sepehr, (2012). The treatment of deficit irrigation (A1) caused a reduction in grain number per row, which gave the lowest rate (39.47 grains compared to full irrigation (47.01 grains). The reason for this is that grains number decreased significantly when the plant exposed to water stress, because of water stress affects the nutritional status and hormonal balance of the plant which will reflect negatively on the process of flower fertilization and grains number. These findings are consistent with (Khaksar *et al.,* 2013). The interactions had no significant effect on this trait.

TABLE 6. Effect of salicylic acid, phosphorus and deficit irrigation spray in grain number.row^{-1}

Treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	42.92	44.73	46.93	44.86
	P1	45.89	47.05	48.06	47.00
	P2	44.96	45.99	56.56	49.17
A2	P0	33.00	37.97	40.87	37.28
	P1	36.75	43.15	43.98	41.29
	P2	38.59	39.88	41.02	39.83
$LSD_{0.05}$		NS			NS
SA level		40.35	43.14	46.24	3.29 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	44.59	45.92	50.52	47.01
	A1	36.11	40.33	41.96	39.47
$LSD_{0.05}$		NS			4.66
					P level
P level *SA	P0	37.96	41.35	43.90	41.07
	P1	41.32	45.10	46.02	44.15
	P2	41.77	42.93	48.79	44.50
$LSD_{0.05}$		NS			NS

Table (7) showed that salicylic acid led to increase weight of 500 grains and the treatment (C2) gave the highest rate (128.06 g), while control treatment gave the lowest rate (124.98 g). This is attributed to the role of salicylic acid in increasing chlorophyll content, which led to increasing the representation of CO_2 and the production of dry matter and regulate its distribution from the source (leaves) to the sink (seeds). These findings are consistent with the findings of the Abd-Elwahad *et al.* (2006) and Zamaninejad *et al.* (2013). The results showed that spraying phosphorous led to increase weight of 500 grains and the treatment B1 gave the highest weight (129.38 g) compared to control (123.91 g). This can be attributed to the direct impact in leaf area, which lead to increase the ability of the plant to carry out the process of photosynthesis, which is reflected in increasing grain weight (Abdel- Fattah *et al.,* 2012). The interactions had no significant effect on this trait.

TABLE 7. Effect of salicylic acid, phosphorus and deficit irrigation spray in weight of 500 grain

treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	121.37	123.81	125.32	123.50
	P1	126.88	128.98	131.26	129.04
	P2	125.72	127.00	127.26	126.66
A2	P0	122.94	123.70	126.32	124.32
	P1	126.89	132.00	130.28	129.72
	P2	126.09	127.17	127.92	127.06
$LSD_{0.05}$		NS			NS
SA level		124.98	127.11	128.06	1.84 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	124.66	126.60	127.95	126.40
	A1	125.31	127.62	128.17	127.03
$LSD_{0.05}$		NS			NS
					P level
P level *SA	P0	122.15	123.75	125.82	123.91
	P1	126.88	130.49	130.77	129.38
	P2	125.90	127.08	127.59	126.86
$LSD_{0.05}$		NS			1.32

Table (8) showed that salicylic acid led to increase grain yield which the treatment (C2) gave highest rate (9.09 $t.ha^{-1}$) compared to control treatment (7.89 $t.h^{-1}$). This is attributed to the increase in chlorophyll content, which leads to increase photosynthesis process, which reflected in increasing ear rows number (Table 5), as well as improve and increase vegetative growth which enhance chances of catching the largest amount of sunlight and thus produce a greater amount of dry matter (Khan, 2003), which reflected positively in increased grain yield. This result agreed with Zamanineijad *et al.* (2013). Phosphorus caused increases in grain yield, which B1 treatment gave the highest rate (9.16 $t.ha^{-1}$) compared to control (Bo) which gave 7.97 $t.ha^{-1}$. This may be due to the increase in ear-length, number of rows and $grains.ear^{-1}$ as well as heaviest grain weight (Amanullah *et al.,* 2009). These findings are consistent with Ghisemi *et al.* (2013). It is clear that the treatment of deficit irrigation (A1) caused a reduction of grain yield, which gave the lowest rate (7.84 $t.ha^{-1}$) compared to full irrigation (A0) which gave 9.29 $t.ha^{-1}$. This is attributed to exceed rows number and grain number per ear as components of yield, in addition to the availability of water in sufficient quantities causing increase the accumulation of dry matter. These results were agreed with Yilmaz *et al.* (2010). The interactions had no significant effect on this trait.

TABLE 8. Effect of salicylic acid, phosphorus and deficit irrigation spray in grain yield

treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	8.05	8.75	9.34	8.71
	P1	9.32	9.96	10.22	9.83
	P2	8.99	9.38	9.60	9.32
A2	P0	6.22	7.42	8.02	7.22
	P1	7.28	9.00	9.16	8.48
	P2	7.49	7.81	8.19	7.83
$LSD_{0.05}$		NS			NS
SA level		7.89	8.72	9.09	0.27 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	8.79	9.36	9.72	9.29
	A1	7.00	8.08	8.46	7.84
$LSD_{0.05}$		NS			0.63
					P level
P level *SA	P0	7.14	8.08	8.68	7.97
	P1	8.30	9.48	9.69	9.16
	P2	8.24	8.59	8.89	8.57
$LSD_{0.05}$		NS			0.37

CONCLUSIONS

It will be concluded that deficit irrigation in the vegetative growth stage caused a significant reduction in most of yield components. Spraying of Salicylic acid and P had a positive effect in removing or reducing the negative effect of water stress. P at 1000 $mg.L^{-1}$ and salicylic acid at 1 mM were superior.

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