Mesopotamia Environmental Journal **ISSN 2410-2598**
Mesop. environ. j. 2015, Vol.1, No.2:pp. 8-17.

A study of maize (Zea mays L.) growth state under different environmental stress

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To cite this article:

Jasim, A. H.; Rashid, H. M. and Hassoun, K. M. A study of maize (Zea mays L.) growth state under different environmental stress , *Mesopotomia Environmental Journal,* , 2015, Vol. 1, No. 2, pp.8-17.

Abstract

A field experiment was carried out during autumn 2013 in a private farm at Al- Hashemia (20 km south east of Hilla), to study the effect of salicylic acid sprays and phosphorus in the growth of maize (Zea mays L.) under deficit irrigation conditions. Split-split plot arrangement in randomized complete block design with three replications were used . The irrigation treatments (A0, full irrigation and A1, deficit irrigation), were operated at main plot , while sub plot operated phosphorus concentrations B0, B1, B2 (without spray, spray phosphorus concentration of 1000 and 2000 mg $P.l^{-1}$), and salicylic acid concentrations C0, C1, C2 (without spray, 0.5 and 1.0 mM, respectively) in sub-sub plots. Maize seed (cv. Buhooth 106) were seeded in 20/7/2013 on ridges(70 cm) , and the data on vegetative growth were calculated and analyzed and the average were tested according to least significant difference. The most important results were summarized as follow: Deficit irrigation led to a significant increase in the number of days from planting until male and female flowering , and to reduce significantly all growth indicators (length and weight of root , plant height , number of leaves , chlorophyll content , leaf area and leaf area index). Salicylic and phosphorus spraying led to remove or reduce the negative impact of water stress. Spray phosphorus (1000 mg $P.l^{-1}$) was superior and gave the higher rate of growth indicators (root length , plant height , leaves number , chlorophyll content , leaf area and leaf area index*). Spraying of salicylic C2 acid (1 mM) was superior by giving a higher rate of plant height* , leaf area and leaf area index . The interaction between the factors had a significant effect in most of the studied characteristic.

Keywords; maize, salicylic acid, foliar P fertilizer, deficit water.

Introduction

Maize crop (Zea mays L.) is one of the important cereal crops in Iraq and the world, and ranks third after wheat and rice in terms of cultivated area and production [1]. Nutrition plays an important role in increasing growth and yield [2, 3]. Phosphorus is one of the macro-nutrients. Due to exposure of phosphorus in Iraqi soil to book and installation, it will be sprayed on plants as well as added to the soil, and that 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, causing the reduction in growth and reduces the efficiency of photosynthesis process and can slow down the crop and reduce biomass development [4, 5]. Modern techniques was used to minimize the effect of water stress by using growth regulators such as salicylic acid,

which is one of the antioxidants (non-enzymatic) that have a role in the scavenge kinds of active oxygen that oxidized cells and enzymes and leading to inhibition of photosynthesis [6]. It plays an important role in growth and evolution of plant by urging the absorption of ions and nutrients and to control the movement of stomata photosynthesis and construction [7] and prevents the representation of ethylene and its effect opposite to the inhibitory growth ABA [5].

Materials and Methods

A field experiment was conducted during the autumn season in 2013 at Al-Hashemia (20 km south east of Babylon) in silt-clay soil (Table 1) in order to study the effect of spraying salicylic acid and phosphorus in vegetative growth of maize under deficit irrigation conditions. Split-split plots arrangement in randomized complete block design (RCBD) with three replications. The main plots contained irrigation treatments (full irrigation and deficit irrigation by cutting one irrigation at vegetative stage), which were coded A0 and A1 respectively, sub-plots contained phosphorus treatments (control, 1000 and 2000 mg $P.l^{-1}$) which were coded B0, B1, and B2 respectively, sub-sub plots included salicylic acid treatments (control, 0.5 and 1.0 mM), which were coded C0 , C1 and C2 respectively. Maize grain (cv. Buhooth 106) was seeded on ridges (75 cm) and 25 cm apart. The plants was irrigated every 7 days, according to plant needed. The data was measured on root length and dry weight (as average of three randomized plants from each experimental unit and) , plant height (as average of ten plants from the level of the soil surface to the lower node of male flower, number of leaves, leaf area [8], leaf area index [9]. The results were analyzed and the average were compared with least significant difference.

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	Silty-clay	pH	7.6
Ec	4.5 dSm/m^{-1}		

Results and Discussion

The results in table (2) showed that salicylic acid led to increased root length, and the high level(C2) was superior (32.95 cm) while control treatment (C0) gave the lowest rate (31.30 cm). This result was consistent with the findings of [10, 11]. It also showed that spraying of phosphorus led to increase root length , in which B1 treatment gave the highest (33.44 cm) compared to control (Bo) which gave 31.59 cm. The reason for this may be due to phosphorus effects as a key constituent of ATP and plays significant role in energy transformation in plant [12], and this leads to increased activity and root growth. These results are consistent with [13]. Deficit irrigation in vegetative stage (A1) caused increasing in root length and gave the highest rate of root length was 34.24 cm compared to full irrigation (29.89 cm). The reason may be due to the lack of water quantities in Vegetative Stage encouraged root cells to divide and elongation, thereby increasing root length to absorb the water from the depths of the soil and drought tolerance [14]. This result was agree with [14] and [15]. The interactions had no significant effect.

Table (3) showed that salicylic acid led to increase root dry weight , in which (C2) was superior (63.39 g) while the control treatment gave the lowest (52.96 g). It could be attributed to the role of salicylic acid in increasing cell division in apical root meristem and improve the accumulation of dry matter [16]. This results was agreed with [10, 11]. The results also showed that phosphorus led to increase root dry weight and the treatment B1 gave the highest rate (64.86 g) , which differed significantly from the treatment B2 (55.81 g) compared to control treatment (Bo), which gave 52.31 g. These results are consistent with [13]. Deficit irrigation gave lower root dry weight (43.26 g) compared to the treatment of full irrigation (72.06 g). This results due to that the lack in moisture tends to close the stomata and Limitation in gaseous exchange due to stomatal closure restricts, however, simultaneous carbon assimilation by the plant and thus growth [17], which reflected on the amount of material transported to the roots which caused decreases weight. Phosphorus led to a significant increase in dry weight of roots, and this may be due to its role in increasing the vegetative plant growth, such as height and thus increase the accumulation of dry matter. This result was agreed with [14]. The interactions had no significant effect.

Table 2: Effect of salicylic acid, phosphorus and deficit irrigation spray in the rate of root length (cm)

treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	28.12	29.51	30.93	29.52
	P1	29.89	31.04	33.75	31.56
	P2	27.86	28.12	29.78	28.59
A2	P0	32.78	34.26	33.96	33.67
	P1	35.95	34.88	35.11	35.32
	P2	33.17	33.91	34.14	33.74
$LSD_{0.05}$		NS			NS
SA level		31.30	31.95	32.95	1.16 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	28.62	29.56	31.49	29.89
	A1	33.98	34.35	34.40	34.24
$LSD_{0.05}$		NS			1.43
					P level
P level *SA	P0	30.45	31.89	32.45	31.59
	P1	32.94	32.96	34.43	33.44
	P2	30.52	31.02	31.96	31.16

$LSD_{0.05}$	NS	1.19

Table 3: Effect of salicylic acid, phosphorus and deficit irrigation spray in root dry weight (g)

treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	66.39	67.32	70.42	68.04
	P1	73.13	77.88	84.22	78.41
	P2	68.63	67.14	73.40	69.72
A2	P0	28.87	35.76	45.11	36.58
	P1	44.98	49.92	59.03	51.31
	P2	35.76	41.77	48.14	41.89
$LSD_{0.05}$		NS			NS
SA level		52.96	56.63	63.39	3.56 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	69.38	70.78	76.01	72.06
	A1	36.54	42.48	50.76	43.26
$LSD_{0.05}$		NS			3.68
					P level
P level *SA	P0	47.63	51.54	57.77	52.31
	P1	59.05	63.90	71.62	64.86
	P2	52.19	54.46	60.77	55.81
$LSD_{0.05}$		NS			2.41

Table (4) showed that salicylic acid caused an increase in plant height , in which C2 gave the highest rate (210.78 cm) , while the control treatment (C0) gave the lowest (176.79 cm). The increase in plant height can be attributed to the positive impact of salicylic acid by increasing the representation of CO2 and products of photosynthesis and increase the absorption of nutrients, that is reflected in increasing the division and elongation stem cells [7]. This result was agreed with [18]. The results showed also that phosphorus led to increase plant height , and B1 treatment gave the highest rate (204.56 cm), while B0 treatment gave the lowest rate (178.49 cm). This result attributed to the role of phosphorus in increasing

root growth, which speeds up the water and nutrient absorption as well as participation in energy compound . This results was agreed with [19]. The deficit irrigation treatment caused a reduction of plant height and it gave the lowest rate of plant height (164.90 cm) compared to the treatment of full irrigation (A0) which gave 223.09 cm. The reason for this due to that vegetative growth stage is the active phase of growth and expansion and division of cells which are affected by water stress (deficit irrigation).This result was consistent with [20]. The interaction between the irrigation and phosphorus levels had a significant effect and A0B1 combination gave the highest rate of plant height (236.81 cm), compared with A1B0, which gave the lower rate (159.15 cm). The interaction between salicylic acid and irrigation treatments had a significant effect and A0C2 gave the highest rate (243.92 cm) , while the lowest rate (154.09 cm) from A1C0.

Table 4: Effect of salicylic acid, phosphorus and deficit irrigation spray in plant height (cm)

treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	177.32	195.93	220.23	197.83
	P1	208.76	240.15	261.53	236.81
	P2	212.36	241.50	249.99	234.62
A2	P0	148.93	162.34	166.18	159.15
	P1	159.89	166.94	190.10	172.31
	P2	153.46	159.63	176.63	١٦٣,٢٤
$LSD_{0.05}$		NS			2.34
SA level		176.79	194.42	210.78	4.16 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	199.48	225.86	243.92	223.09.
	A1	154.09	162.97	177.64	164.90
$LSD_{0.05}$		4.95			2.56
					P level
P level *SA	P0	163.13	179.14	193.21	178.49
	P1	184.33	203.55	225.82	204.56
	P2	182.91	257.57	213.31	198.93
$LSD_{0.05}$		NS			1.69

Table (5) showed that salicylic acid at 1 mM (C2) caused increasing plant leaf number (15.95) compared to control (15.20). The reason may be due to the role of salicylic acid in the formation of chlorophyll and carotenoid pigment and accelerate the process of photosynthesis, or by adverse the effect of the growth inhibitor ABA [21]. This result was agreed with [18]. Phosphorus caused increasing plant leaf number , and B1 treatment gave the highest rate (15.92) compared to control (Bo), which gave 15.34. The changes in the number of leaves by adding phosphorus can be attributed to the role of phosphorus in increasing growth and division of meristem cells. Deficit irrigation caused a reduction of plant leaf number and gave the lowest rate (5.07) compared to full irrigation (A0), which gave 16.22. It may be due to the apparent decrease in plant height (table 4) and lower leaf area, which led to reduction of leaf number. This result was consistent with [22].

Table 5: Effect of salicylic acid, phosphorus and deficit irrigation spray in plant leaf number

treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	15.49	16.04	16.12	15.88
	P1	16.04	16.70	16.83	16.52
	P2	15.83	16.43	16.53	16.26
A2	P0	14.31	14.81	15.31	14.81
	P1	14.88	15.50	15.61	15.33
	P2	14.69	15.24	15.34	15.09
$LSD_{0.05}$		NS			NS
SA level		15.20	15.78	15.95	0.15 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	15.78	16.39	16.49	16.22
	A1	14.62	15.18	15.42	15.07
$LSD_{0.05}$		NS			0.029
					P level
P level *SA	P0	14.90	15.42	15.71	15.34
	P1	15.46	16.10	16.22	15.92
	P2	15.26	15.83	15.93	15.67
$LSD_{0.05}$		NS			0.22

Table (6) showed that salicylic acid led to increase leaf area and (C2) gave the highest rate (566.5 cm2), while control treatment (C0) gave the lowest leaf area (488.3 cm2). This result may be due to the role of salicylic acid in increasing the efficiency of photosynthesis by increasing pigments such as chlorophyll and carotenoids and maintain the integrity of the membranes plasma, which is reflected positively in increasing leaf area [22]. It is agreed with [18]. Phosphorus led to increase leaf area and B1 gave the highest rate (562.3 cm2) compared to control (Bo), which gave 498.9 cm2. This can be attributed to the role of phosphorus in the composition of cell membranes. The deficit irrigation treatment (A1) caused a reduction of leaf area as it gave the lowest rate (466.4 cm2) compared to the full irrigation (601.4 cm2). The reason may be attributed to the loss of turgor which affects the rate of cell division and enlargement [24]. The interactions had not significant effect.

Table (7) showed that salicylic acid led to increase leaf area index , and the treatment (C2) gave high rate (5.12), while control treatment (C0) gave the lowest leaf area index (4.27). The reason may be due to the role of salicylic acid in stimulating the photosynthesis process by maintaining the common enzymes in this process and the permeability of plant membranes and thus increase leaf area [7].

Table 6: Effect of salicylic acid, phosphorus and deficit irrigation spray in leaf area (cm^2)

treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	482.1	580.3	594.4	552.3
	P1	603.4	636.5	660.6	633.5
	P2	593.1	624.0	638.6	618.6
A2	P0	396.8	457.4	482.3	445.5
	P1	441.2	506.0	526.3	491.2
	P2	413.5	477.3	496.8	462.5
$LSD_{0.05}$		NS			NS
SA level		488.3	546.9	566.5	25.26 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	559.5	613.6	631.2	601.4.
	A1	417.2	480.2	501.8	466.4
$LSD_{0.05}$		NS			28.64
					P level
P level *SA	P0	439.5	518.8	538.4	498.9
	P1	522.3	571.3	593.4	562.3

	P2	503.3	550.6	567.7	540.6
$LSD_{0.05}$		NS			20.02

These results are consistent with [25]. Phosphorous spraying led to increase leaf area index and the treatment B1 gave the highest rate (5.01) compared to control treatment (Bo), which gave 4.39. It can be attributed to phosphorus role in increasing the effectiveness of meristems and to increase the number of leaves which led to increase total leaf area comparison to plant land area, as well as increased metabolic activities including the process of photosynthesis, leading to increase leaf cells and size . Deficit irrigation caused reduction in leaf area index and gave the lowest rate (4.02) compared to full irrigation (A0) which gave 5.50 . The reason may be due to water stress during the vegetative growth stage reduces the elongation of leaves and its expansion as a result of the loss in pressure bulge hanging on the walls of the cells from the inside and the outside, and as a result of this loss of growth affected its elongation, which negatively affects in increasing leaf area and leaf area index [26]. This result was consistent with [27] . The interaction between the irrigation and salicylic acid had a significant effect , in which A0C2 gave the highest rate of leaf area index (5.80), while A1C1 gave the lowest rate (4.25).

Table 7: Effect of salicylic acid, phosphorus and deficit irrigation spray in leaf area index

treatments		SA level			Irrigation * P level
irrigation	P level	S0	S1	S2	
A1	P0	4.78	5.4	5.25	5.06
	P1	5.31	5.99	6.18	5.82
	P2	5.43	5.53	5.98	5.64
A2	P0	3.23	3.97	4.12	3.77
	P1	3.54	4.38	4.69	4.20
	P2	3.38	4.41	4.51	4.10
$LSD_{0.05}$		NS			NS
SA level		5.12	4.88	4.27	0.21 =$LSD_{0.05}$
					Irrigation
Irrigation * SA	A0	5.17	5.52	5.80	5.50
	A1	3.38	4.25	4.44	4.02
$LSD_{0.05}$		0.32			0.37
					P level

P level *SA	P0	4.00	4.50	4.68	4.39
	P1	4.42	5.18	5.43	5.01
	P2	4.40	4.97	5.24	4.87
$LSD_{0.05}$		NS			0.18

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