Middle East Journal of Applied Sciences
ISSN 2077-4613

Volume : 08 | Issue :03 |July-Sept.| 2018
Pages: 736-748

Alleviation of Drought Stress on Chickpea (*Cicer acietrinum* L.) Plants by Foliar Application of Polyamine Compounds

[1]Magda A.F. Shalaby, M.A. Ahmed[2] and [2] El-Housini Ebtesam A.

[1]Botany Dept. and [2]Field Crop Research Dept., Agricultural and Biological Research Division, National Research Centre, 33 El Behouth St., (Former El Tahrir St.) 12622 Dokki, Giza, Egypt.

Received: 24 April 2018 / Accepted: 30 June 2018 / Publication date: 21 July 2018

ABSTRACT

Two field experiments were carried out to study alleviation of water stress on chickpea plants (*Cicer arietinum* L.) by foliar application with polyamines compounds i.e. putrescine and spermidine in private farm at New Salheyia Region, Sharkia Governorate during the winter seasons of 2015/16 and 2016/17 agricultural seasons. The main obtained results were:- 1- Growth characters; i.e. plant height, number and dry weight of each one from branches, leaves and pods/plant, leaves area /plant and LAI at 90 and 105 days after sowing were significantly decreased under the water stress conditions. Moreover, results indicated that chicpea plants appeared to be more sensitive to water stress during flowering stage followed by pod formation stage, wheras, the harmful effect caused at pod filling stage treatment was the lowest one. On the other hand, spraying chickpea plants with 100 mg/l putrescine , as well as, 100 mg / l spermidine seemed to be the most favorable treatments to increase growth attributes. 2-yield and its components, i.e. pods dry weight/plant, seed index, seed, straw and biological yields per plant and l or fed., crop index, as well as, harvest index were significantly affected by water stress treatments. Moreover, the all previous yield and its components except crop index and harvest index significantly decreased by skipping an irrigation at certain developmental growth stage. The results indicate that pods dry weight/plant, seed index, seed, straw and biological yields per plant and /or per fed. of chickpea plants appeared to be more sensitive to water stress during flowering stage followed by pod formation stage and pod filling stage, respectively. The results show clearly that foliar spraying with 100 mg/l putrecine and / or 100 mg/l spermidine harvested the greatest yield and its components of chickpea plants. On the other hand, the effect of polyamines compounds concentrations on crop index and harvest index faild to reach the significant levels at 5%. 3-The effect of the interaction between missing an irrigation at different stages of growth and putrescine and spermidine concentrations indicate clearly that chickpea plants cv.giza-30 was more sensitive to water stress at flowering stage compared with pods formation and pods filling stages, respectively, in addition, putrescine and spermidine as foliar application with 100 mg / l can be alleviate the harmful effect on growth characters and yield and its components of chickpea plants caused by water stress conditions under newly cultivated sandy lands.

Keywords: Alleviation, drought, stress, chickpea, polyamine compounds.

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crop grown and consumed all over the world; especially in the Afro-Asian countries. In Egypt it is ranked of the third after bean and lentil from the standby of its importance as legume crop. It is a good source of carbohydrate and protein, and its quality of protein is considered to be better than other pulses. Chickpea has significant amounts of all the essential amino acids except sulpher-containing amino acids, which can be complemented by cereals to the daily diet. Starch is the major storage carbohydrate followed by dietary fiber, oligosaccharides and simple sugars such as glucose and sucrose. It can be a very useful legume crop for incorporation into short- term rotation and for nitrogen fixation in soil and its fertility. Chickpea production is affected by different factors such as cultivars, soil fertility and irrigation.

Drought stress is one of the major biotic stress in agriculture worldwide, where, it impacts include growth, yield, membrane integrity, pigment content, osmotic adjustment, water relations and

Corresponding Author: Magda A.F. Shalaby, Botany Dept., Agricultural and Biological Research Division, National Research Centre, 33 El Behouth St., (Former El Tahrir St.) 12622 Dokki, Giza, Egypt.

photosynthetic activity. On the light of the present national water policy using chickpea cultivars produce high yield under suitable water regime, is greatly influenced by a number of factors especially foliar spraying with polyamine compounds in newly cultivated sandy soils under stress conditions. Thus, this work was carried out to investigate alleviation of water stress of chickpea (*Cicer arietinum* L.cv. Giza-3) plant by foliar application with polyamines compounds under water stress conditions in newly cultivated sandy lands.

Materials and Methods

Two field experiments were carried out in newly cultivated sandy land at New Salheyioa Region, Sharkia Governorate, during the two winter seasons of 2015/2016 and 2016/2017 to study allevation of drought stress on chickpea (*Cicer arietinum* L. c.v. Giza 30) plant by foliar application of polyamine compounds (i.e. putrescine and spermidine). The physical and chemical properties of the experimental soil sites (0-30 cm) were as follows: 9.68% clay, 1.60 silt, and 88.72% sand and loamy sand texture. Available N ppm was 10.60 and 11.09, available P ppm was 16.0 and 15.96, meanwhile, available K ppm was 78.0 and 75.0 in 2015/16 and 2016/17 seasons, respectively. On the other hand, the pH of the site of the experiment was 8.10 and 8.17 during the two growing seasons of this investigation, respectively. The mechanical and chemical analysis of the soil was done according to Champan and Pratt 1978). The experimental unit consisted of seven rows, four meter in length; and 20 cm apart.

Seeds of chickpea (*Cicer arietinum* L.cv.Giza-3) were planted on November 11th and 15th in 2015 and 2016; respectively, in hills 15 cm apart at a seeding rate 40 kg/fed., after inoculated with Rhizobium strains and irrigated just after sowing and after adding 31 kg P_2O_5/fed. as calcium super phosphate. Normal cultural practices were followed as usual in chickpea fields till harvest as recommended by Legume Research Department, Apicultural Research Centre, Giza, Egypt. The experimental design was split plot design with three replicates. Four irrigation treatments were assigned in the main plots, i.e normal irrigation without missing one irrigation as control treatment (I_1), missing one irrigation at 55 days after sowing(flowering stage ,I_2), missing one irrigation at 70 days after sowing (pod formation stage, I_3), and missing one irrigation at 85 days after sowing(pod filling, stage I_4). Seven rates of foliar application with putrescine and spermidine compounds (i.e, tap water as control treatment, 50 mg/l put., 75 mg/l put., 100 mg/l put., 50mg/l sper., 75 mg/l sper. and 100 mg/l sper.) were randomly distributed in the sub-plots. Putrescine($NH_2(CH_2)_3NH_2$) and spermidine ($NH_2(CH_2)_3NH\ (CH_2)_4\ NH_2$) were sprayed twice after 40 and 50 days from sowing, respectively.

Two samples of ten guarded plants were taken at random from each plot of the three replicates to measure growth parameters at 90 and 105 days after sowing to the laboratory; plant height cm number and dry weight of branches, leaves and pods/plant and leaves area/plant. Leaves area/plant cm^2 were determined according to Bremner and taha (1966), whereas, leaf area index (LAI) was determined according to Watson (1952). At harvest date, a random sample of ten guarded plant was taken from the middle rows of each plot to determine weight of pods/plant g, seed index 100 seeds/g and seed; straw and biological yields g/plant. Furthermore, seeds, straw and biological yields ton/fed. were collected from the whole area of each experimental unit and converted to ton per fed.. The crop index (seed yield/biological yield) and harvest index (seed yield/ straw yield) were calculated as Abdel-Gawad *et al*. (1987).

Chemical analysis:

Photosynthetic pigments content in chickpea green leaves (mg/g dry weight) were extracted by aqueous solution of 85% aceton and calculated using Wettstein formula (Wettstein,1957) at 90 days after sowing date. In addition, the dried seeds were finally ground and kept for carbohydrate and crude protein determination; using phenol-sulphoric acid method (Dubois *et al*.,1956) in case of carbohydrate percentages, meanwhile, case of crude protein determination the method described by A.O.A.C. (1980) was used , then, crude protein was estimated by multiplying total nitrogen by the factor 6.25.

Statistical analysis:

Combined analysis of the data for the two growing seasons was carried out as procedure outlined by Snedecor and Cochran (1990). For comparison between means L.S.D test was used.

Result and Discussion

A- Growth characters:

A-1. Effect of water stress:

Result illustrated in Table (1) indicate that missing one irrigation at flowering, pod formation, and/or pod filling stage significantly decreased plant height, number and dry weight of each one from branches; leaves and capsules/plant, as well as, leaves area/plant and LAI at 90 and 105 days after sowing. The negative significant effect in growth characters could be explained on the basis of the loss of which effects the rate of cell expansion and ultimate cell size loss of turgidity is probably the most sensitive process of water stress. Thus caused a decrement in growth rate, stem elongation and of leaf expansion. The depression in cell division and enlargement has been carefully discussed by Kramer and Boyer (1995). The results show clearly that water stressed plants even watered regulatory afterward did not recover to their normal behavior to complete the adverse effect caused by the exposure to drought conditions (Ahmed *et al.*, 2005). Furthermore, chickpea plants grown under drought conditions have a lower stomatal conductance in order to converse water. Consequently; CO_2 fixation is reduced and photosynthetic rate decreased, resulting in less assimilate production for growth plant (Ahmed *et al.,* 2015). In addition, Ahmed *et al.,* (2013), Kurdail *et al*. (2013) and Ahmed *et al.* (2015) found that skipping one irrigation at certain development growth stages of plant led to significant reduction in all growth characters. It is worthy that the most sensitive growth stage of chickpea to water stress are flowering stage; followed by pod formation, and pod filling, respectively. On the other hand, plant height, number of capsules and dry weight of capsules/plant increased with advancing plant age from 90-105 day after sowing, meanwhile, number and dry weight of each branches and/or leaves/plant, leaves area/plant and LAI decreased with advancing plant age from 90 to 105 days after sowing.

Our results are in full agreement with those reported by Abou El-Kheir *et al.* (2000), Singh and Kuhad (2005), Gao *et al*. (2008), Ghassemi-Golezani *et al.* (2008), Gunes *et al.* (2008), Mafakheri *et al*. (2010), Ahmed *et al.* (2013), Khodadadi (2013), Reza *et al.* (2013), Zaki *et al.* (2013) and Sadak (2016). On the other hands, such effects of drought on growth characters of the chickpea plant might be attributed to leach of water absorbed, inadequate uptake of essential elements, inhibition of meristemic activity and/or reduction in photosynthetic capacity under such unfavorable conditions (Ahmed *et al.* 2012, Ahmed *et al.* 2015 and Sadak, 2016).

A-2 Effect of polyamines compound concentrations:

Data detected in Table (1) observed that 50 mg/l put. significantly increased plant height, number and dry weight of each one from branches, leaves and capsules/plant, leaves are/plant and LAI at 90 and 105 days after sowing compared with control treatment (Tap water treatment).Increasing the concentration of put. up to 75 and 100 mg/l significantly increased growth parameters under study at 90 and 105 days age and the greatest mean values of these parameters were collected by foliar application with 100 mg/l put. compared with control, 50 and 75 mg/l put.

Regarding to foliar application with spermidine; results reported in Table(1) observed clearly that a marked stimulatory significant effect on plant height, number and dry weight of each one of branches; leaves and capsules/plant, leaves area/plant and LAI in comparison with control treatment. Moreover, increasing concentration of sper. up to 100 mg/l resulted the highest positive significant effect of polyamine on growth characters studied. In addition, the positive effect of polyamines on growth characters of chickpea plants can be due to that polyamines are considered now as a new class of growth substances and also well known for their anti- stress and anti- senescence effects where their acid neutralizing and antioxidant properties, as well as, to their membrane and cell wall

Table 1: Effect of missing one irrigation at different growth stage and polyamine compounds conc., on growth characters of chickpea plant. (Average of 2015/2016 and 2016/2017 seasons).

Irrigation treatment	Polyamine compounds conc.mg/l	Plant height cm		No. of branches/ plant		No. of leaves / plant		No. of capsules / plant		Branches dry wt. g/ plant		Leaves dry wt. g/ plant		Capsules dry wt. g/ plant		Leaves area Cm^2/ pant		LAI	
		90	105	90	105	90	105	90	105	90	105	90	105	90	105	90	105	90	105
Normal irrigation (No missing irrigation)		80.39	90.84	15.59	13.29	183.07	173,43	48.94	65.32	5.10	4,29	6.56	5.16	12.37	16.85	662,62	601.42	2.21	2.00
Missing one irrigation at 55 days age		69.22	75.53	11.14	10.54	155.55	149.00	31.34	38.41	3.48	3.22	4.42	4.06	09.51	12.49	559.76	510.93	1.87	1.70
Missing one irrigation at 70 days age		74.89	84.92	13.36	11.43	175.00	166.00	41.85	54.07	3.88	3.40	4.91	4.58	10.07	13.28	601.00	547.61	2.00	1.83
Missing one irrigation at 85days age		76.85	86.89	14.30	12.07	178.83	168.04	45.64	55.55	4.40	3.84	5.33	4.92	10.96	14.67	620.42	560.44	2.07	1.87
L.S.D at 5%		1.86	1.55	0.19	0.34	2.27	1.24	1.39	1.01	1.15	0.21	0.18	0.20	0.52	00.47	9.25	3.76	0.04	0.03
	Tap water	70.22	80.63	12.12	10.72	168.05	156.38	36.24	49.56	3.61	3.-02	4.73	4.22	8.96	11.97	527.38	487.55	1.76	1.63
	50 Put.	71.94	82.64	12.51	11.04	170.10	160.83	39.43	51.60	3.87	3.44	4.95	4.46	9.79	12.92	547.71	515.00	1.83	1.72
	75 Put.	75.17	83.98	13.25	11.48	173.33	165.87	42.73	53.81	4.10	3.66	5.23	4.66	10.08	13.86	607.29	546.50	2.02	1.82
	100 Put.	76.66	87.14	14.58	12.42	175.93	167.25	44.50	54.61	4.37	3.85	5.52	4.76	10.98	14.18	646/76	569.58	2.16	1.90
	50 Sper.	74.96	84.19	13.25	11.56	171.88	161.75	41.86	52.56	4.20	3.71	5.20	4.63	10.83	13.71	604.70	548.10	2.02	1.83
	75 Sper.	76.81	85.95	14.24	12.38	174.50	166.25	45.16	54.81	4.52	3.94	5.59	4.90	11.58	15.32	655.05	596.00	2.18	1.99
	100 Sper.	81.61	87.31	15.22	13.21	178.00	170.50	46.25	56.48	4.85	4.21	5.95	5.13	1.99	17.34	687.75	625.5	2.29	2.09
L.S.D at 5%		1.51	1.23	0.14	0.16	1.49	1.38	0.56	00.71	0.18	0.22	0.15	0.11	01.11	1.09	3.57	2.24	0.04	0.07

stabilizing abilities (Velikova *et al*., 2000). Furthermore, polyamine compounds have been implica ted in a large range of growth and development processes such as cell division, simulation, support and development of flowers, buds, embryogenests, fruit set and growth, fruit ripening, plant morphogenesis and response to environmental stress (Qzturck and Demir, 2003). Moreover, Sood and Nagar (2003) indicated that peroxidase and cellulose activities were retarded by polyamines treatments and accelerated by polyamines biosynthetic inhibitors. Again polyamine inhibits senescence in plant (Sood and Nagar, 2003). Consequently; the filling period duration, effective filling period and filling rate increased and these processes caused a positive effect on growth attributes.

It is worthy to mention that our obtained results on the effect of polyamines compound concentration of growth characters of chickpea plant are in full agreement with the results obtained by Kakher *et al.* (2000), Sood and Nagar (2003), Abdel Haddy and Ahmed (2005), Ahmed *et al*. (2012), Shalaby and Salem |(2014), Ahmed *et al*. (2015),Ahmed *et al*. (2017) and Juzon *et al.* (2017).

A-3: Effect of the interaction between water stress and polyamine concentration:

The effect of the interaction between skipping an irrigation at certain different stages of chickpea plant growth and foliar spraying with different concentrations from polyamine compounds on plant height, number and dry weight of each one of branches; leaves and capsules/plant, leaves area/plant and LAI were significant, (Table 2). Moreover, data reported indicate clearly that foliar spraying with 100 mg/l put. and/or 100 mg/l sper. under normal irrigation i.e. without skipping one irrigation at any stages of growth harvested the greatest significant values from growth characters, whereas, foliar sprying with tap water on chickpea plant with missing one irrigation at flowering stage produced chickpea plants characterized by its lowest significant values of previous growth characters studied. Finally, data reported in Table (2), foliar spraying with 100 mg/l put. and/ or 100 mg/l sper. with skipping an irrigation can alleviate the harmful effect in growth parameters caused by water stress treatments followed by 75 and 50 mg/l put. and/or sper. .Generally, chickpea plants were more sensitive to water stress at flowering stage,in comparison with pod formation and pod filling, respectively.

B- Chemical constituents

B-1 Effect of drought stress

Table (3) indicate that skipping one irrigation at flowering stage, pod formation and pod filling stages of chickpea plants growth led to reduction in photosynthetic pigments content, i.e Chl.a ; Chl.b; Chl a+b and carotenoids per green leaves at 90 days after sowing, in total; carbohydrate and crude protein percentage per dry seeds at harvest date compared with normal irrigation (control plants) The differences between normal irrigation and missing one irrigation at flowering stage stage were significant, also, the differences between missing one irrigation in flowering stage and pod formation stage were significant, except in Chl a and crude protein percentage where the differences failed to reach the significant level at 5%. With respect of the differences between missing an irrigation at pod formation stages and pod filling stage; the differences were significant in the previous characters studied except in Chl.a that field to reach the significant level at 5% level. During this scientific work, our results examined that results of Gunes *et al.* (2008), who found that decreasing water availability under drought caused in reduces total nutrient uptake and frequently reduces concentrations of mineral nutrients in chickpea. It is worthy that our results are confirmed with results obtained by Ahmed *et al.* (2005), Gunes *et al*. (2008), Massacci *et al.* (2008) Juzon *et al*.(2013), Zaki *et al.* (2013) and Sadak *et al.*(2016). Also, the most sensitive growth stage for drought stress are flowering stage, followed by pod formation and pod filling, respectively.

B-2 Effect of polyamine compounds concentrations

It is clear from Table (3) that there were significant increase in photosynthtic pigments content (i.e. Chl.a , Chl.b ,Chl. a+b and carotenoids) per green leaves and each of total carbohydrate, as well

Table 2: Effect of interaction between missing one irrigation at different growth stages and polyamine compounds conc. on growth characters of chickpea plant (Average of 2015/2016 and 2016/2017 seasons).

Irrigation treatment	Polyamine compounds conc.mg/l	Plant height cm		No. of branches/ plant		No. of leaves / plant		No. of capsules / plant		Branches dry wt. g/ plant		Leaves dry wt. g/ plant		capsules dry wt. g/ plant		Leaves area cm2/ pant		LAI	
		90	105	90	105	90	105	90	105	90	105	90	105	90	105	90	105	90	105
Normal irrigation (No missing irrigation)	Tap water	73.91	85.79	13.67	11.75	178.9	163.5	42.25	59.40	4.25	3.49	5.80	4.63	10.07	14.35	566.0	512.0	1.89	1.71
	50 Put.	76.70	88.90	14.20	12.5	180.4	171.5	47.20	61.33	4,67	4.08	6.18	5.00	11.50	15.00	580.70	547.0	1.94	1.82
	75 Put.	80.67	90.6	15.00	13.00	182.7	174.0	51.75	67.50	5.00	4.32	6.63	5.18	11.92	16.41	647.90	583.0	2.16	1.94
	100 Put.	81.85	93.8	17.33	14.00	186.0	177.0	53.20	69.00	5.50	4.62	7.00	5.30	13.00	17.90	691.33	600.0	2.30	2.00
	50 Sper.	79.80	90.00	15.00	12.75	181.5	173.0	50.20	62.00	5.00	4.19	6.34	5.21	12.00	16.00	685.00	602.0	2.28	2.01
	75 Sper.	82.25	91.80	16.70	14.00	184.0	175.0	53.00	68.00	5.28	4.57	6.70	5.33	12.60	18.00	717.30	675.0	2.39	2.25
	100 Sper.	87.5	95.00	17.20	15.00	186.0	180.0	55.00	70.00	6.00	4.78	7.28	5.50	15.48	20.29	750.25	691.0	2.50	2.30
Missing one irrigation at 55 days age	Tap water	65.17	71.33	09.80	10.00	151.5	145.0	25.20	34.25	2.85	2.63	4.03	3.75	08.05	10.15	481.72	451.2	1.61	1.50
	50 Put.	66.00	73.65	10.00	10.00	152.0	147.0	28.00	36.80	3.20	3.01	4.21	3.86	08.72	11.72	509.13	467.0	1.70	1.56
	75 Put.	68.00	75.00	11.00	10.25	155.3	150.0	30.00	38.00	3.37	3.14	4.36	4.00	08.93	12.01	575.29	506.0	1.92	1.69
	100 Put.	70.00	76.75	12.00	10.67	157.0	151.0	31.80	39.75	3.50	3.26	4.50	4.11	09.41	13.00	605.00	539.3	2.02	1.80
	50 Sper.	69.80	75.00	11.00	10.50	155.0	146.0	33.00	38.00	3.64	3.31	4.28	4.00	09.88	12.40	536.80	501.0	1.79	1.67
	75 Sper.	72.00	78.00	11.50	11.00	158.0	149.0	35.40	39.17	3.81	3.46	4.57	4.18	10.52	13.88	591.4	549.0	1.97	1.83
	100 Sper.	73.60	79.00	12.67	11.33	160.0	155.0	36.00	42.90	4.00	3.75	5.01	4.56	11.03	14.25	619.00	563.0	2.06	1.88
Missing one irrigation at 70 days age	Tap water	70.00	81.50	12.00	10.33	170.0	157.0	38.00	51.00	3.50	2.97	4.32	4.00	08.56	11.13	520.00	483.0	1.73	1.61
	50 Put.	71.00	83.00	12.50	10.67	172.0	161.0	40.00	53.00	3.64	3.18	4.51	4.34	09.18	12.07	537.00	515.0	1,79	1.72
	75 Put.	75.0	84.00	13.00	11.00	175.0	169.0	41.67	54.00	3.90	3.39	4.74	4.50	09.27	13.00	601.00	539.0	2.00	1.80
	100 Put.	76.0	88.00	14.00	12.00	179.0	170.0	43.00	54.67	4.10	3.50	4.98	4.63	10.00	13.46	645.00	575.0	2.15	1.92
	50 Sper.	73.25	85.00	13.00	11.00	174.0	163.0	41.25	54.00	3.91	3.37	5.00	4.50	10.41	12.57	586.00	541.3	1.95	1.80
	75 Sper.	74.00	81.85	14.00	12.00	175.0	170.0	44.00	55.80	4.00	3.52	5.33	4.97	11.23	14.39	642.00	570.0	2.14	1.90
	100 Sper.	85.0	79.80	15.00	13.00	180.0	172,0	45.00	56.00	4.11	3.88	5.50	6.09	12.04	16.33	676.00	610.0	2.25	2.03
Missing one irrigation at 85 days age	Tap water	71.80	82.25	13.00	10.80	171.8	160.0	39.50	53.60	3.82	3.00	4.75	4.51	09.17	12.24	541.80	504.0	1.81	1.68
	50 Put.	74.0	87.50	13.33	11.00	176.0	163.8	42.50	55.25	3.97	3.50	4.91	4.62	09.76	12.87	564.00	531.0	1.88	1.77
	75 Put.	77.0	65.17	14.00	11.67	180.3	170.5	47.50	55.75	4.13	3.78	5.17	4.95	10.19	14.00	605.00	558.0	2.02	1.86
	100 Put.	78.8	66.00	15.00	13.00	181.7	171.0	50.00	55.00	4.38	4.00	5.58	5.00	11.20	16.24	645.70	564.0	2.15	1.88
	50 Sper.	77.0	68.00	14.00	12.00	177.0	165.0	43.00	56.00	4.26	3.98	5.18	4.80	11.02	13.86	611.00	548.1	2.04	1.83
	75 Sper.	79.0	70.00	14.75	12.50	181.0	171.0	48.00	56.25	5.00	4,22	5.75	5.11	11.98	15.00	669.50	590.0	2.23	1.97
	100 Sper.	80.33	69.80	16.00	13.50	184.0	175.0	48.00	57.00	5.27	4.41	6.00	5.42	13.41	18.49	706.00	638.0	2.35	2.13
L.S.D at 5% level		2.57	2.09	72.00	0.27	2.53	2.35	0.95	1.21	0.31	0.37	0.26	0.19	1.89	1.85	6.07	3.81	0.07	0.12

as well as, crude protein percentages of chickpea dry seeds due to foliar application with polyamine compounds. These results may be due to increase in growth and yield which in turn reflected positively on chemical constituents of chickpea levels and seeds, respectively (Tables 1 and 5).Moreover, foliar application with 50 mg/l put. significantly enhanced photosynthetic pigments content per green leaves, as well as, total carbohydrate and crude protein percentages per dry seeds compared with control treatment (Tap water treatment). Increasing put. concentration up to 75 and 100 mg/l Put. caused significant increment in the previous chemical constituents studied in this study, also, the greatest mean values of these previous chemical constituents were obtained by foliar application with 100/l put. compared with control, 50 and 75 mg/l put., respectively. Regarding, spermidine treatments, chemical constituents were significantly increased by foliar application with spermidine, also, the highest significant values from Chl.a, Chl.b; Chl.a+b; and carotenoids per green leaves and total carbohydrate, as well as, crude protein per chickpea dry seeds were obtained with 100 mg/l Sper. treatments compared with six polyamine compounds under study (Table 3).

Our results are in agreement with those obtained by Martin- Tanguy(1997), Oztruk and Demir (2003), and Ahmed *et al.* (2012).

Table 3: Effect of missing one irrigation at different growth stages and polyamine compound on chemical constituents of chickpea plants (Average of 2015/2016 and 2016/2017 seasons).

Irrigation treatment	Polyamine compounds conc.mg/l	Photosynthetic pigments content per green leaves mg/gm dry wt.				Total carbohydrates % per dry seeds	Crude protein % per dry seeds
		Chl. a	Chl. b	Ch.la + chl. b	Carotenoids		
Normal irrigation (No missing irrigation)		2.68	2.03	4.71	1.48	69.13	25.30
Missing one irrigation at 55 days age		2.35	1.74	4.09	1.29	67.13	24.51
Missing one irrigation at 70 days age		2.40	1.81	4.21	1.33	68.09	24.61
Missing one irrigation at 85 days age		2.49	1.89	4.38	1,40	68.81	24.82
L.S.D at 5% level		0.12	0.07	0.08	0.05	0.26	0.12
	Tap water	2.37	1.80	4.17	1.21	67.58	24.44
	50 Put.	2.43	1.81	4.24	1.33	67.83	24.63
	75 Put.	2.47	1.85	4.32	1.38	67.94	24.76
	100 Put.	2.50	1.87	4.37	1.41	68.46	24.92
	50 Sper.	2.50	1.89	4.39	1.40	68.43	24.85
	75 Sper.	2.53	1.92	4.45	1.43	68.80	24.94
	100 Sper.	2.57	196	4.53	1.47	69.00	25.15
L.S.D at 5% level		0.02	0.03	0.05	0.01	0.13	0.11

B-3 Effect of the interaction between water stress and polyamine concentrations

The effect of the interaction between water stress and polyamine compounds concentration on photosynthetic pigments content (i.e.Chl. a ; Chl. b ;Chl. a+b and carotenoids)per green leaves, also, total carbohydrate and crude protein percentages per dry seeds at harvest date; were significant (Table 4).Data illustrated in the same table indicated that foliar spraying with 100 mg/l put. and or 100 mg/l sper. under normal treatments gave the greatest significant values from all chemical constituents studies, whereas, foliar application with tap water under treatment with skipping one irrigation at flowering stage of chickpea plants gave the lowest significant values from chemical constituent studied herein, Consequently data in Table (4) show clearly that foliar spraying with 100 mg/l put. and/or 100 mg/l sper. under missing one irrigation at different growth stages can alleviate the harmful effect caused by water stress compared with foliar spraying with 50 and 75 mg/l Put. and Sper. respectively. Generally chickpea plants were more sensitive to water stress at flowering stage in comparison with pod formation and pod filling growth stages, respectively

Table 4: Effect of the interactions between missing one irrigation at different growth stages and polyamine compounds conc. on chemical constituents of chickpea plant (Average of 2015/2016 and 2016/2017 seasons)

Irrigation treatment	Polyamine compounds conc.mg/l	Photosynthetic pigments content per green leaves mg/g dry wt.				Total carbohydrates, % per dry seeds	Crude protein % per dry seeds
		Chl. a	Chl.b	Chl. a+ b	Carotenoids		
Normal irrigation (No missing irrigation)	Tap water	2.47	1.93	4.40	1.28	68.10	25.00
	50 Put.	2.63	1.98	4.61	1.42	68.30	25.12
	75 Put.	2.68	2.05	4.73	1.50	68.53	25.28
	100 Put.	2.75	2.08	4.83	1.54	69.29	25.53
	50 Sper.	2.70	2.03	4.73	1.49	69.68	25.20
	75 Sper.	2.73	2.06	4.79	1.51	69.92	25.33
	100 Sper.	2.79	2.11	4.90	1.61	70.07	25.65
Missing one irrigation at 55 days age	Tap water	2.30	1.70	4.00	1.15	66.69	24.11
	50 Put.	2.32	1.71	4.03	1.23	66.89	24.31
	75 Put.	2.35	1.73	4,08	1.28	67.00	24.50
	100 Put.	2.38	1.76	4.14	1.30	67.29	24.69
	50 Sper.	2.35	1.73	4.08	1.32	67.13	24.56
	75 Sper.	2.36	1.74	4.10	1.35	67.29	24.65
	100 Sper.	2.40	1.80	4.20	1.37	67.30	24.77
Missing one irrigation at 70 days age	Tap water	2.33	1.75	4.08	1.18	67.63	24.13
	50 Put.	2.35	1.76	4.11	1.31	67.92	24.54
	75 Put.	2.39	1.80	4.19	1.33	68.04	24.61
	100 Put.	2.40	1.82	4.22	1.38	68.29	24.70
	50 Sper.	2.40	1.80	4.20	1.35	68.00	24.65
	75 Sper.	2.45	1.85	4.30	1.36	68.22	24.67
	100 Sper.	2.47	1.89	4.36	1.40	68.51	25.00
Missing one irrigation at 85 days age	Tap water	2.39	1.78	4.17	1.22	67.90	24.50
	50 Put.	2.41	1.80	4.21	1.36	68.11	24.55
	75 Put.	2.45	1.81	4.26	1.39	68.20	24.66
	100 Put.	2.46	1.83	4.29	1.41	68.98	24.77
	50 Sper.	2.56	2.00	4.56	1.44	67.90	25.00
	75 Sper.	2.57	2.01	4.58	1.49	69.77	25.12
	100 Sper.	2.60	2.03	4.63	1.52	69.82	25.17
L.S.D at 5% level		0.03	0.05	0.09	0.02	0.22	0.19

C-yield and its components

C-1 Effect of water stress:

Data reported in Table (5) show clearly that skipping one irrigation at flowering; pod formation; and /or pod filling stage significantly decrement capsules dry wt./plant, seed index, seed; straw and yield/plant and/or, fed., as biological yield per plant and / or /fed. The negative significant effect in the previous yield and its component could be attributed on the basis of the loss of which effects the rate of cell expansion and ultimate cell size. Lose of turgidity is probably the most sensitive process of water stress. Thus caused a decrease in growth rate, stem elongation and leaf expansion. The depression in cell division and enlargement has been carefully discussed by Kramer and Boyer (1995). The results show clearly that water- stressed plants even watered regulatory afterward did not recover to their normal behavior to complete the adverse effect caused by the exposure to drought conditions (Ahmed *et al.,* 2005). In addition, chickpea plants grown under water stress conditions have a lower stomatal conductance in order to converse water. Thus, CO_2 fixation is reduced and photosynthetic rate decreased, resulting in less assimilate production for plant growth(Ahmed *et al*.,2005).Moreover, Ahmed *et al.,* 2013),Kurali *et al*.(2013), and Ahmed *et al.*(2015) found that skipping one irrigation at different developmental growth stage of the plant led to significant reduction in cell growth characters. It is worthy that the significant decrement in growth character of chickpea plants (Table 1), and photosynthetic pigments content per green leaves (Table 2) caused by water stress in this study can be a reason for the significant decrement in those previous yield

Table 5: Effect of missing one irrigation at different growth stages and polyamine compounds conc. on yield its components of chickpea plant (Average of 2015/2016 and 2016/2017 seasons)

Irrigation treatment	Polyamine compounds conc.mg/l	Capsules dry wt. g/plant	Seed index 100 seed/g	Seed yield g/plant	Straw yield g/plant	Bio yield g/plant	Seed yield Ton/fed.	Straw yield Ton/fed.	Bio yield Ton/fed.	Crop index	Harvest index
Normal irrigation (No missing irrigation)		28.54	22.97	20.71	27.71	48.42	1.24	1.790	3.030	0.41	0.69
Missing one irrigation at 55 days age		22.30	19.31	14.67	21.05	35.72	0.831	1.024	1.855	0.45	0.81
Missing one irrigation at 70 days age		24.72	20.21	15.76	24.29	40.05	0.943	1.293	2.236	0.42	0.73
Missing one irrigation at 85 days age		26.46	21.90	18.86	25.31	44.17	1.129	1.607	2.736	0.41	0.70
L.S.D at 5% level		1.32	0.53	0.78	0.64	1.36	0.040	0.12	0.07	0.01	0.02
	Tap water	21.91	19.43	15.09	22.44	37.53	0.900	1.260	2,16	0.42	0.71
	50 Put.	23.02	19.88	15.99	23.47	39.46	0.964	1.325	2.229	0.42	0.73
	75 Put.	24.72	20.29	16.65	24.35	41.00	1.010	1.409	2.419	0.42	0.72
	100 Put.	26.71	20.84	18.32	25.34	43.66	1.060	1.473	2.533	0.42	0.72
	50 Sper.	24.58	21.61	17.06	24.42	41.48	1.080	1.411	2.491	0.43	0.77
	75 Sper.	27.10	22.29	18.79	25.60	44.39	1.110	1.528	2.638	0.42	0.73
	100 Sper.	30.51	23.34	20.63	26.55	47.18	1.130	1.598	2.728	0.41	0.71
L.S.D at 5% level		1.19	0.71	1.31	1.00	1.08	0.010	0.03	0.08	n. s	n. s

components, also. Again results in Table (5) show clearly that the most sensitive growth stage of chickpea to water stress are flowering stage, followed by pod formation and pod filling in the end of the lest of sensevity growth stages.

Generally, our obtained results are confirmed with results indicated by Abo El-Kheir *et al.*(2000), Sing and Kuhad (2005), Gao *et al.*(2008), Ghassemi-Golezani *et al.,*(2008), Gunes *et al.*(2008), Mafakheri *et al.*(2010), Ahmed *et al*(2013), Khodadadi (2013), Reza *et al.,*(2013), Znki *et al.,* and Sadak (2016).. Also, such effects of drought on yield and its components of chickpea plant might be due to leach of water absorbed, in adequate uptake of essential elements, inhibition of meristimic activity and/or reduction in photosynthetic capacity under such unfavorable conditions (Ahmed *et al.,*2012, Ahmed *et al.,*2015 and Sadak, 2016).

With respect of each of crop index and harvest index Table(5) show that skipping one irrigation at flowering stage gave the highest significant values from these to parameters, followed by skipping one irrigation at pod formation; skipping one irrigation at pod filling and normal irrigation, respectively.

C-2 Effect of polyamines compound concentrations:

Table (5) indicate that foliar application with 50 mg/l put. caused a significant increment in capsules dry weight/plant, seed yield/plant, straw yield/plant, biological yield /plant, seed yield/fed., straw yield/fed., and biological yield/fed., and insignificant increase in seed index and harvest index; compared with control treatment (Tap water). Another increase in put. concentration up to 75 and 100 mg/l significantly increased pods dry weight/plant, seed index, as well as, seed; straw and biological yields per plant and/or fed. and the highest mean values of these previous yield attributes were harvested by foliar application with 100 mg/l put. in comparison with control, 50 and 75 mg/l put.

With respect of foliar spraying with spermidine; data illustrated in Table (5) show that capsules dry weight, seed index, seed yield/fed., straw yield/plant, biological yield/plant, seed yield/plant, straw yield/fed and biological yield/fed. were increased significantly according to spermidine treatments compared with control treatment (Tap water).Furthermore, increasing spermidine concentration up to 100 mg/l caused a positive significant effect on the previous yield parameters studied.

The positive effect of polyamine compounds on yield components of chickpea plants may be due to that these compound are considered now as a new class of growth substances and also well known for their anti-stress and anti-senescence effects where their acid neutralizing and antioxidant properties, as well as, to their membrane and cell wall stabilizing abilities (Velikova *et al.,* 2000). In addition, polyamine compounds have been implicated in large of growth and development processes such as cell division, simulation, support and development of flowers, buds embryogenesis, fruit set and growth, fruit ripening, plant morphogenesis and response to environmental stress (Ozturk and Demir, 2003). Also, Sood and Nagar (2003) found that peroxidase and cellulose activities were restarted by polyamine treatment and polyamine biosynthetic inhibitors and senescence of plant inhibitions. Consequently, the filling period duration, effective filling period and filling rate increased and those processes caused a positive effect on yield and its components.

Regarding the effect of polyamine compounds concentrations on crop index and harvest index; the effect failed to reach the significant levels at 5% level.

Our results regarding the effect of polyamine compounds concentration on yield and its components of chickpea plant are in good harmony with results of kakher *et al*. (2000), Sood and Nagar (2003), Abdel Haddy and Ahmed (2005), Ahmed *et al.*(2012), Shalaby and Salem (2014), Ahmed *et al.* (2015), Ahmed *et al.* (2017) and Juzon *et al.* (2017).

C-3 Effect of the interaction between water stress and polyamine concentrations

Table (6) observed that the interaction between skipping one irrigation at different development growth stages of chickpea plant and foliar application with different concentration from polyamine compounds on capsules dry weight / plant, seed index, seed yield/plant, straw yield/plant, biological yield/plant., seed yield/fed., straw yield/fed., biological yield/fed. caused a significant effects on these previous yield components. On the other hand, the effect on crop index and harvest index failed to

Table 6: Effect of interaction between missing one irrigation at different growth stages and polyamine compounds conc. on yield and its componentsof chickpea plant (Average of 2015/2016 and 2016/2017 seasons)

Irrigation treatment	Polyamine compounds conc.mg/l	Capsules dry wt. g/plant	Seed index 100 seed/g	Seed yield g/plant	Straw yield g/plant	Bio yield g/plant	Seed yield Ton/fed.	Straw yield Ton/fed.	Bio yield Ton/fed.	Crop index	Harvest index
Normal irrigation (No missing irrigation)	Tap water	25.18	21.45	18.07	25.14	43.21	1.097	1.563	2.660	0.41	0.70
	50 Put.	26.08	21.90	19.32	26.10	45.42	1.178	1.640	2.818	0.42	0.72
	75 Put.	27.91	22.16	19.36	27.81	47.17	1.250	1.761	3.011	0.42	0.71
	100 Put.	29.52	22.91	21.20	28.40	49.60	1.268	1.938	3.206	0.40	0.65
	50 Sper.	27.19	23.14	20.46	27.12	47.58	1.257	1.750	3.007	0.42	0.72
	75 Sper.	30.12	24.06	22.36	28.92	51.28	1.299	1.900	3.199	0.41	0.68
	100 Sper.	33.78	25.18	24.19	30.50	45,69	1.320	2.010	3.330	0.40	0.66
Missing one irrigation at 55 days age	Tap water	18.67	17.82	12.51	18.10	30.61	0.791	0.905	1.696	0.47	0.87
	50 Put.	19.85	18.14	13.40	19.75	33.15	0.815	0.938	1.753	0.46	0.87
	75 Put.	21.36	18.58	14.08	20.44	34.52	0.832	0.986	1,818	0.46	0.84
	100 Put.	24.17	19.10	16.30	21.56	37.86	0.849	1.024	1.873	0.45	0.83
	50 Sper.	20.29	19.74	13.69	21.30	34.99	0.827	1.000	1.827	0.45	0.83
	75 Sper.	23.96	20.00	15.12	22.84	37.96	0.846	1.096	1.942	0.44	0.77
	100 Sper.	27.80	21.80	17.61	23.39	41.00	0.857	1.218	2.075	0.41	0.70
Missing one irrigation at 70 days age	Tap water	20.81	18.40	13.60	22.86	36.46	0.840	1.160	2.000	0.42	0.72
	50 Put.	22.10	18.64	14.09	23.85	37.94	0.865	1.230	2.095	0.41	0.70
	75 Put.	23.97	19.21	15.18	24.00	39.18	0.914	1.318	2.232	0.41	0.69
	100 Put.	26.11	19.43	16.57	25.20	41.77	0.975	1.320	2.295	0.42	0.74
	50 Sper.	24.71	21.40	15.00	24.09	39.09	0.945	1.276	2.230	0.43	0.75
	75 Sper.	26.18	22.00	17.14	24.85	41.99	1.000	1.364	2.364	0.42	0.73
	100 Sper.	29.13	22.39	18.77	25.19	43.96	1.054	1.385	2.439	0.43	0.76
Missing one irrigation at 85 days age	Tap water	22.96	20.03	16.17	23.65	39.82	0.872	1.430	2.302	0.38	0.61
	50 Put.	24.05	20.85	17.13	24.16	41.89	0.998	1.490	2.488	0.40	0.67
	75 Put.	25.64	21.22	17.96	25.14	43.10	1.024	1.570	2.594	0.39	0.65
	100 Put.	27.02	21.93	19.20	26.18	45.38	1.136	1.609	2.745	0.41	0.71
	50 Sper.	26.11	22.17	19.08	25.16	44.24	1.286	1.618	2.904	0.44	0.79
	75 Sper.	28.13	23.08	20.53	25.78	46.31	1.290	1.750	3.040	0.42	0.74
	100 Sper.	31.30	24.00	21.94	27.12	49.06	1.300	1.780	3.080	0.42	0.73
L.S.D at 5% level		2.02	1.21	2.23	1.70	1.84	0.02	0.05	0.14	n.s	n.s

reach the significant level at 5% . Furthermore, foliar spraying with 100 mg/l put. and/or 100 mg/l sper. under normal irrigation (i.e. without missing one irrigation) gave the highest significant value from capsules dry wt./plant, as well as, seed; straw and biological yields per plant and/or fed., meanwhile, foliar application with tap water on chickpea plants under skipping one irrigation at flowering stage conditions produced chickpea plants had the lowest significant values from the previous yield and its components deleted. Generally, data in Table (6) indicate that foliar spraying with 100 mg/l put. and/or 100 mg/l sper. under missing one irrigation can alleviate the harmful effect on yield and its components caused by water defect treatments; followed by 75 and 50 mg/l put. an/or sper., respectively. Finally chickpea plant was more sensitive to water stress at flowering stage in comparison with pod formation and pod filling, respectively.

References

A.O.A.C., 1980.Official Methods of Analysis. 20th Ed. Association of Official Analysis Chemists, Arlington, Virginia, U.S.A., No 984.

Abdel- Gaead, A., K.A. El- Shouuny, S.A. Saleh and M.A. Ahmed, 1987. Partition and migration of dry matter in newly cultivated wheat varieties. Egypt. J. Agron., `2:1-16.

Abdel- Hady, M.S.S. and M.A. Ahmed, 2005. Effect of putrescine and spermidine on growth and productivity of two wheat cultivars derived from field experiments and *in Vitro*. Egypt. J. Agric. Res., 2: 691-709.

Abo El-Kheir, M.S.A., A.A. Abo Ellil and H.A. El-Zeiny, 2000. Effect of water stress at different growth stages of three faba bean cultivars. J. Agric. Sci. Mansoura Univ., 25:1485-1493.

Ahmed, Amal G., Magda H. Mohamed, M.S. Hassanein, Nabila M. Zaki, S.F. El-Habbasha, M.M. Tawfic and Manal F. Mohamed, 2015. Effect of water regime and potassium fertilization on productivity of two chickpea (*Cicer arietinum* l.) cultivars. Inter.J. of Chem Tech Res., 8:1509-1519.

Ahmed, Amal G., Nabila M. Zaki. Magda H. Mohamed, M. M. Tawfik and M. M. Hassanein, 2013. Growth and yield of two chickpea cultivars (*Cicer arietinum* l.) to skipping one irrigation. Middle East J. Agric. Res., 2:146-151.

Ahmed, H.H.A., E. Darwish and M.G. Alobaidy, 2017. Impact of putrescine and 24- epibrassinolide on growth, yield and chemical constituents of cotton (*Gossypium barbadense* L.) plant grown under drought stress conditions. Asian J. of Plant Sciences, 16: 9-23.

Ahmed, M.A., M.K.A. Ahmed and Magda A. F. Shalaby, 2005. Allevation of water stress effects on wheat by Mepiquat chloride. Inter. J. of Agric & Biol., 7. 451-546.

Ahmed, M.A., Magda A. F. Shalaby and M. S. A. Abdallah, 2012. Growth and productivity of wheat as affected by putrescine and spermidine under water stress conditions. J. of Appl. Sci. Res., 8: 5068-5074.

Ahmed, M.A., Magda A.F. Shalaby and M.B.A. El-Komy, 2015. Allevation of water stress effects on corn by polyamine compounds under newly cultivated sandy soil conditions. Inter. J. of Chem Tech Res., 8:497-508.

Bremner, P.M. and M.A. Taha, 1966. Studies in potato agronomy: Effect of variety, seed size and sparing on growth, development and yield. J. Agric. Sci. 66:241-252.

Champan, H.D. and R.F. Fratt, 1978. Methods Analysis for Soil, Plant and Water. Univ. of California, Division Agricultural Science, pp:16-38.

Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers and F. Smith, 1956.Colorimetric method for determination of sugars and related substances," Analytical Chemistry, 28. 350-356.

Gao, W.R., X.S.H. Wang, Liu. P., J.G.Li and H. Ma. Zhang, 2008. Comparative analysis of ESTs in response to drought stress in chickpea (*Cicer arietinum* L.) Bioch. Bioph. Res. Commu,,376:578-583.

Ghassemi- Golezani, K., B. Dalil., A.D. Muhammadi- Nassab and S. Zehtab-Salmasi, 2008. The response of chickpea cultivars to field water defict. Not. Bot. Hor. Agro. Cluj-Napoca,36:25-28.

Gunes, A., A. Inal, M.S. Adak, E.G. Bagci, N. Cicer and F. Eraslan, 2008. Effect of drought stress implemented at pre - or post- anthesi stage some physiological as screening criteria in chickpea cultivars Russ. J. Plant Phys., 55: 59-67.

Juzon, K., I.C. Mysza, I. Marcinska, M. Dziuuka, P. Waligorski, and E. Shrzypek, 2017. Polyamines in yellow lupin *(Lupinus luteus* L.) tolerance to soil drought. Acta Physiol Plant, 39:202-212.

Kakhar, R.K., P.K. Nagar, P.S. Ahuja and Ahuja and Rai, 2000. Polyamines and plant morphogenesis. Biol. Plant., 43: 1-11.

Kramer, P. J. and J.S. Bayer, 1995. Water Relation of plants and Soil. Academic Press., New York.

Kurdali, F., M. Al-Chammaa and A. Mouasess, 2013. Growth and nitrogen fixation in silicon and/or potassium fad. Chickpea grown under drought and well watered conditions. J. Stress Physio, Bioch., 9:385-406.

Mafakheri A., B. Siosemardeh, P.C. Baharannajad and Y. Sohrabi, 2010. Effect of drought stress on yield, proline and chlorophyll contents in three chickpea varieties. Aust. J. Crop Sci. 4: 580-585.

Martin-Tanguy, J., 1997. Conjugated polyamines and reproductive development: biochemical, molecular and physiological approaches. Physiologia Plantarum, 100:675-688.

Massacci, A., S.M. Nabiev, L. Pietrosanti, S.K. Nematov, T.N. Chernikova, K. Thor and J. Leipner, 2008. Response of the photosynthetic apparatus of cotton (*Gossypium hirsutum*) to the onset of drought stress under field conditions studied by gas- exchange analysis and chlorophyll fluorescence imaging. Plant Physiol. Biochem., 46:189-195.

Oztruk, L. and Y. Demir, 2003. Effect of putrescine and ethephon on some oxidative stress enzyme activities and protein content salt stressed spinach leaves. Plant Growth Regulators, 40: 89-95.

Reza, T., M.H. Ensafi, N. Baghebbani, E. Karami and K. Mohammadi, 2013. Physiological response of chickpea (*Cicer arietinum*) genotyprs to drought stress. Environ. Exper. Bio., 11: 9-15.

Rhodadadi, M., 2013. Effect of drought stress on yield and water relative content in chickpea. I. J. Agron. Plant. Prod. 4:1168-1172.

Sadak, Mervat. Sh., 2016. Mitigation of drought stress on fenugreek plant by foliar application of trehalose. Inter. J. of Chem Tech Res., 9:147-155.

Shalaby, Magda A.F. and A. K.M. Salem, 2014. Growth and productivity of barley cv. Giza- 129 cultivar as affected by putrescine and spermidine under water stress conditions. Life Science J. 11.666-671.

Singh, N. and M.S. Kuhad, 2005. Role of potassium in alleviating the effect of water stress on yield and seed quality in chickpea (*Cicer arietinum* L.) Bull Nat. Inst. Ecol. 15:219-225.

Snedecor, G.W and G.W. Cochran, 1990.Statistical Methods. 8th Ed Iowa State Univ. Press Ames, Iowa, U.S.A.

Sood, S. and P.K. Nahar, 2003. The effe4ct of polyamines on leaf senescence in two diverse rose species. Plant Growth Regulators, 39:155-160.

Wettstein, D., 1957. Chlorophyll Letal und der Submikroscopische Farmwechsell der Plastiden. Exptl. Cell. Res., 12: 427-433.

Velikova, V., I. Yordannw and A. Edrea, 2000. Oxidative stress and some axodant system in acid-rain treated bean plants. Protective role of exogenous polyamine. Plant Sci., 115: 59-66.

Watson, D.J., 1952. The physiological basis of variation in yield. Adv. Agron., 4:101-145.

Zaki, Nabila M., Amal G. Ahmed, Magda H. Mohamed, M.M. Tawfik and M.S. Hassanein, 2013. Effect of skipping one irrigation and potassium fertilization on growth and yield of chickpea plants. World Appl. Sci. J., 27: 557-561.