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Effect of different levels and time of application of putrescine on quality and quantity of cotton grown under drought stress

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This study was conducted to investigated the effect of different levels and time of application under drought stress. The putrescine treatments were: without, 100 mg kg^{-1} at beginning of flowering, 160 mg kg^{-1} at the peak of flowering as well as 50 and 80 mg kg^{-1} twice at beginning of flowering and the peak of flowering. The irrigation treatment was: irrigation every 12 days and irrigation every 15 days (drought stress). The result indicate that drought stress significantly reduced all studied growth parameters, yield and its component, except earliness % and lint % the leaves, fiber properties and content of N, P, K, chlorophyll A and B and carotenoids. Earliness percentage was increased under drought stress, while line percentage did not affect. Application of putrescine all the above mentioned character, except first fruiting node and fiber properties which did not affected. In contrast earliness percentage was decreased as a result of putrescine application. The affective of putrescine is more pronounced when added at 80 mg kg^{-1} twice at beginning of flowering and at the peak of flowering, where cotton plants grown under drought stress when treated with these putrescine treatments exhibited quality and quantity of cotton equal that under full irrigation.

Keywords: drought stress, putrescine, growth, yield and its component, fiber properties and leaves chemical constituents.

INTRODUCTION

Cotton (*Gossypium barbadense* L.) is the most important crop for fiber production, it plays a key role in the Egyptian economic activity. Egyptian cotton has high quality around the world due to it is long fiber cotton, which makes it softer and stronger at the same time (Mehasen et at, 2012). In Egyptian cotton is known as a white gold, because it has an impact on Egyptian economic development, especially in past time. Nowadays much efforts have been made to get its position back among different types.

Many studies were conducted for observing plant biochemical and biophysical parameters of Egyptian strategic summer and winter crops (El Sharkawy et al, 2016 and El Sharkawy et al, 2013); however, few researches were conducted in water stress for Cotton. Deficit water is a common abiotic stress for cultivated cotton during the growing seasons, resulted many negative effects on quality and quantity of cotton. Cotton is considering sensitive plants for drought causing a significant reduction in yield, because deficit water affects the physiology of the plant (Iqbal et at. 2013). In addition, cotton is very response to quantity of irrigation water, consequently irrigation management is very complicated (Alishaha and Ahmadikhan, 2009). Sever water stress in early growth period to mid flowering stage resulted in slower growth, plant shrinkage, less nodes, prolific branches and reduction in leaf area index (Farooq et al, 2009).

Putrescine is a plolyamines having small ubiguitons nitrogenous compounds, which induse several plant growth and development processes (Farooq et al, 2009). It is classified as growth regulators and also, consider secondary messenger in signaling both ways (Kusano et al, 2008). Nayyar et al (2005) mentioned that putrescine having promotive effect on abiotic stress tolerance in plant. This positive effect is mainly due to its effect on regulation of cellular ionic environment maintenance of membrane integrity, protect of chlorophyll from loss and improve protein, nucleic acid and protective alkaloids (Sharma, 1999). Ahmed et al (2013) reported that putrescine application enhanced cotton growth, yield and yield components, and chemical constitutes and pigments.

The aim of this study was to investigate the mitigation effect of potassium and putrescine application on quality and quantity of cotton under water deficit conditions.

MATERIALS AND METHODS

This study was conducted at the seasons at the experimental farm of Seds Agricultural Research Station, Beni-Suef Governorate, Egypt, to study possibility of mitigate the negative effect of deficit water by using putrescine, the experimental site was located at longitude 31° 06 E, latitude 29° 04 N and at an altitude of 30-40 m above the mean sea level. The land cover map of Beni-Suef Governorate has been produced by (El Sharkawy and Kotb, 2018). The soil physical and chemical properties (according to A.O.A.C, 1985) were as follows: soil texture was clay, pH were 8.0 and 8.08, ECe were 1.36 and 1.27, soil organic matter were 2.1 and 1.9 %, and soil available N, P, and K were: N 26 and 24; P 15.1 and 17.6 and K 206 and 226 mg kg^{-1} in 2016 and 2017 seasons, respectively.

The experiment was laid out in split design in complete randomized block in four applications. The main plot consisted of irrigation treatment, i.e., every 12 days (without water stress) and every 15 days (deficits water), while sub plots were allocated with putrescine treatment, i.e,., 1- without putrescine, 2- foliar spraying of 100 mg kg^{-1} putrescine at beginning of flowering, 3- foliar spraying of 160 mg kg^{-1} putrescine at the peak of flowering, 4- foliar spraying of 50 mg kg^{-1} putrescine twice at beginning of flowering and at the peak of flowering, 5- foliar spraying of 80 mg kg^{-1} twice at beginning of flowering and at the peak of flowering.

Egyptian cotton (Gossypium barbadense, C.V. Giza 95) seeds were sown in 20 and 27 March in both seasons, respectively. The nitrogen and potassium fertilizers as ammonium nitrate (33.5 % N) at rate of 180 kg N ha^{-1} and potassium sulphate (48 % K) at rate of kg ha^{-1} were added in two equal doses at before second and third irrigation, while phosphorus fertilizer as calcium superphosphate (6.5 P) was added before planting during land preparation. Other cultural practices were carried out as recommended for cotton production in district.

The cotton plants at harvest were randomly taken from the mid of plot measured some growth parameters, i.e., plant height (cm), first fruiting node and number of fruiting branches as well as some yield and yield component, namely, number of open bolls $plant^{-1}$, boll weight (g), seed index (g), earliness percentage, lint percentage and seed cotton yield (t ha^{-1}). Also some fiber properties, i.e., fiber length (mm), micronaire reading and pressly index were measured according to A.S.T.M. (1979).

Also, representative leaves sample were randomly taken from the top fourth node leaves at 15 days after full flowering stage to determine N, P, and K concentration (%) according to the methods of A.O.A.C. (1985) as well as chlorophyll A and B according to Arnon (1949) and carotenoids according to rolbelen (1957).

The result was subjected to the statistical analysis according to snedecor and Cochran (1980). The least significant differences at 0.05 level was used to compare between treatment means.

RESULTS AND DISCUSSION

1- Growth parameters

Data in table 1 show the effect of irrigation and putrescine treatment on cotton growth parameters. The results indicate that plants exposed to drought stress at 25 % (irrigation every 15 days) comparing with optimum irrigation (irrigation every 12 days) had a significant negative effect on plant height, first fruiting node and number of fruiting branches $plant^{-1}$. In this conction, farooq et al., (2009) mentioned that drought severely affects cotton growth and development due to its effect on the rate of cell division and elongation, leaf area, root and stem growth, decreasing stomatal conductance and water use efficiency, consequently makes

Table (1) Effect of foliar spraying of putrescine at different levels and time of application on growth parameters of cotton plant grown under deficit water.

Irrigation intervals	Putrescine levels (mg kg^{-1}) and time of application	Plant height (cm)		First fruiting node		No. of fruiting branches $plant^{-1}$	
		2016	2017	2016	2017	2016	2017
12 days	without	122.6	126.5	8.7	8.9	15.4	15.9
	100 mg kg^{-1} at beginning of flowering	125.1	128.3	8.7	8.9	15.6	16.1
	160 mg kg^{-1} at the peak of flowering	126.9	130.8	8.6	8.8	15.8	16.3
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	130.2	134.0	8.7	8.9	16.1	16.5
	80 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	133.7	137.5	8.7	8.9	16.3	16.6
Mean		127.7	131.4	8.7	8.9	15.8	16.3
15 days	without	115.7	118.1	9.2	9.3	12.8	13.0
	100 mg kg^{-1} at beginning of flowering	121.6	124.7	9.1	9.3	13.6	13.9
	160 mg kg^{-1} at the peak of flowering	125.0	128.9	9.1	9.2	13.7	14.1
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	129.0	132.7	9.2	9.3	13.9	14.2
	80 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	133.6	137.3	9.2	9.3	14.0	14.3
Mean		125.0	128.8	9.2	9.3	13.6	13.9
Mean of putrescine	without	119.2	122.3	9.0	9.1	14.1	14.5
	100 mg kg^{-1} at beginning of flowering	123.4	126.5	8.9	9.1	14.6	15.0
	160 mg kg^{-1} at the peak of flowering	126.0	129.9	8.9	9.0	14.8	15.2
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	129.6	133.4	9.0	9.1	15.0	15.4
	80 mg kg-1 twice at beginning of flowering and at the peak of flowering	133.7	137.4	9.0	9.1	15.2	15.5
L.S.D. at 0.05 levels	A	1.25	1.16	0.03	0.03	0.16	0.15
	B	1.01	1.00	NS	NS	0.12	0.12
	AB	1.67	1.63	NS	NS	0.36	0.33

photosynthesis very sensitive to drought. Furthermore, Farooq et al., (2012) stated that nutrients require water for absorption and translocation, therefore as water decrease, nutrients uptake does. These results agree with many investigators on cotton plant such as Hanafy et al .,(2013).

Concerning putrescine treatments, the result show that main affect of putrescine reveal that, regardless level and time of application, all studied growth parameters except fisrt fruiting node were significantly improved due to putrescine treatments comparing with no putrescine. It could be arranged the effect of putrescine on growth parameters as the following descending order: 80 mg kg^{-1} foliar spraying of putrescine twice at beginning of flowering and at the peak of flowering > 50 mg kg^{-1} foliar spraying of putrescine twice at beginning of flowering and at peck of flowering > 160 mg kg^{-1} at the peak of flowering > 100 mg kg^{-1} at beginning of flowering > without putrescine. It is obvious to notice that the most effective putrescine treatments on cotton growth was 80 mg kg^{-1} foliar spraying of putrescine twice. The positive effect of putrescine on growth parameters under drought stress may be due to puterscine involved in many of plant growth and development processes, such as cell division, vascular differentiation, root initiation and shoot formation (Galston and Sawhney, (1990). These results are similar to obtained by Talaat et al., (2015) and Shaimaa et al.,(2018).

As for the interaction between treatments, the obtained data show that the studied growth parameters, except first fruiting node were significantly responded to the interaction between irrigation and putrescine treatments. Plant height and number of fruiting branches $plant^{-1}$ under drought stress when treated with putrescine at rate of 80 mg kg^{-1} twice at beginning of flowering plant at peak of flowering were statistically equal to those received full irrigation and treated with 80 mg kg^{-1} twice at beginning of flowering at the peak flowering. This is mainly due to putrescine stimulated growth by increasing auxins, gibberllins and cytokinins, which accompanied by activity reaction in response to abiotis stress (EL-Bassiouny and Bekheta, 2005). On the other hand, the plants under drought stress in absence of putrescine exhibited the lowest growth parameters. These results are in line with those obtained by Hussein et al., (2013) and Karimi (2016) and for maize, and cotton plants, respectively.

2-Yield and its components and fiber properties

The Yield and its components as well as fiber properties of cotton plants grown under drought stress and different levels and time of application represented in Tables 2 – 3. The result reveal that number of open bolls $plant^{-1}$, boll weight, seed index, seed cotton yield and fiber properties were significantly decreased when exposed the plants for drought stress (irrigation every 15 days), while earliness percentage increased. On the other hand, lint percentage did not affect by irrigation treatments. In this connection, LV et al., (2009) reported that flowering and the stage of forming bolls is the most important period of cotton, induce drought stress during this stage will seriously influence cotton and fiber productivity. Furthermore, the delays in boll cracking and leaf senescence under full irrigation have positive effect on extending the period of boll – filling, consequently improve seed and fiber quality (Mittal et al., 2015). In contrast, Riboni et al., (2013) pointed out that drought stress tends to induce early flowering due to on elaborate network of floral signaling pathways. In addition, soeda et al (2005) clear that drought stress may change the direction of the metabolism precess by accelerating the surose translocalion from leaves to seeds. These result are similar to those obtained by yagmur et al., (2014) and Luo et al., (2016).

For the effect of putrescine, data in Tables 2 and 3 reveal that number of open bolls $plant^{-1}$ boll weight, seed index and seed cotton yield were significantly increased by putrescine application, while earliness percentage decrease. On the other hand, lint percentage and fiber properties did not respond to putrescine application. Spraying 80 mg kg^{-1} putrescine twice at beginning of flowering and at the peak of flowering gave the highest values of cotton yield and its component the positive effect of putrescine on yield and its component for cotton may be due to putrescine is involved in many physiological activities in plant such as growth, senescence and abiotic stress responses (Tiburcio et al., 2014). Also, Ahmad et al., (2012) mentioned that polyamines imigate drought stress through osmotic adjustment. In addition, Ashraf et al.,(2011) indicated that enhancement in yields with foliar spraying of polyamines may be due to their ability to maintain the turgor pressure of cells in plant under drought stress conditions. These result are in a good agreement of those obtained by Ahmed et al .,(2013) and Ahmed et al., (2017).

Regarding the interaction affect, the data show that all studied yield and yield components were significantly affected by the interaction between irrigation and putrescine treatments, except lint percentage. Sprayed cotton plant grown under drought stress with 80 mg kg^{-1} putrescine twice at beginning of flowering and at the peak of flowering gave statistically values of yield and its components equal to those supplied with full irrigation and treated with putrescine. In this respect, Gupta et al., (2011) and Ahmed and Sadak (2016) reported that putrescine increased plant tolerance to abiotic stress due to regulating stomatal closure and decreasing water losing through transpiration, hence reflect on amelioration of relative water content these result is in line with those obtained by Almaghrabi (2012) and Aydin et al .,(2015).

3- Leaf chemical content

Cotton plants grown under full irrigation treatment showed a significant increment in N, P, and K content as well chlorophyll A, chlorophyll B and carotenoids as shown in table 4. Comparing with the optimum water level, decrease the irrigation intervals to every 15 days decreased the abovementioned chemical composition of cotton levels by about 3.4, 8.6, 2.5, 1.9, 1.8, and 6.3% in the first seasons, respectively. Similar trend were obtained in the second season.The reduction in chemical constituents of cotton leaf as a result of drought stress may be due to drought reduces nutrient uptake by roots and their transport from roots to shoots (Helal et al., 2013). Also, Ahmed et al., (2016) and Karimi (2016) pointed out that pigments in plant leaf decreased under drought stress, which are mainly due to the membrane disintegration and damage chloroplasts by overproduction of reactive oxygen species.

In addition, Jul et al., (2018) indicated that the decline in chlorophyll under drought stress may be due to the diminished biosynthetic pathway or oxidation during drought stress. These results are in conformity with those obtained by Ahmed et al .,(2017) and Jul et al., (2018) for nutrient content and Shallan et al., (2012) and Shaimaa et al., (2018) for leaf pigments.

Respecting putrescine treatments, the results indicate that, regardless of level and time of application, as well as leaf pigments content were increased as a result of foliar spraying of putrescine. Its noticeable that the highest values of these constituents resulted from added putrescine at rate of 80 mg kg^{-1} twice at beginning of flowering and at the peake of flowering, while the no putrescine treatment exhibited the lowest ones. In this conection, El–Bassiouny et al., (2008) indicated that the positive effect of putrescine on leaves pigments may be due to putrescine might retard the chlorophyll, distruction and or enhance their biosynthesis or stabilize the thylakoid membrance. In addition, putrescine has many physiological precesses in enhancing the pigments content, which it was accompanied by an increase in endogenous cytokinins, where cytokinins stimulate pigments biosynthesis and differentiation (Xie et al., 2004). These results are in line with those obtained by Helal et al., (2013) and Ahmed et al., (2017) for N, P and K and Nassar et al .,(2003) and Shallan et al., (2012).

As for the interaction affect, the data reveal that both nutriecnt and pigments contents in cotton leaves were significantly affected by the interaction between irrigation and putrescine treatments. Watered cotton plants every 15 days when sparyed with 80 mg kg^{-1} putrescine twice at beginning of flowering and at the peak of flowering exhibited highest nutrient and pigment content statistically equal to those under full irrigation and received 80 mg kg^{-1} putrescine twice and both beginning and peak of flowering.

Table (2) Effect of foliar spraying of putrescine at different levels and time of application on yield and yield components of cotton plants grown under deficit water.

Irrigation intervals	Putrescine levels (mg kg^{-1}) and time of application	No. of open bolls $Plant^{-1}$		Boll weight (g)		Seed index (g)		Earliness (%)		Lint (%)		Seed cotton yield (t ha^{-1})	
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
12 days	without	17.5	16,4	2.14	2.35	8.77	8.47	81.5	80.2	40.2	41.6	4.22	4.11
	100 mg kg^{-1} at beginning of flowering	18.2	17.5	2.20	2.41	8.93	8.63	81.4	80.4	40.1	41.7	4.34	4.23
	160 mg kg^{-1} at the peak flowering	18.9	18.0	2.26	2.46	9.25	8.95	81.0	80.1	40.3	42.0	4.36	4.27
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	20.2	20.0	2.32	2.52	9.40	9.31	81.7	80.0	40.6	41.6	4.45	4.35
	80 mg kg^{-1} twice a t beginning of flowering and at the peak of flowering	21.5	21.3	2.40	2.55	9.53	9.43	81.6	80.4	40.1	41.5	4.53	4.46
Mean		19.3	81.7	2.26	2.46	9.18	8.96	81.4	80.2	40.3	41.7	4.38	4.28
15 days	without	12.6	13.9	1.85	1.93	8.01	7.78	89.6	87.1	40.3	41.6	3.03	2.96
	100 mg kg^{-1} at beginning of flowering	16.6	16.0	2.08	2.19	8.54	8.36	86.3	84.6	40.5	41.5	3.46	3.40
	160 mg kg^{-1} at the peak of flowering	17.3	16.8	2.16	2.27	8.93	8.78	85.9	83.1	40.3	41.7	4.02	3.98
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	19.5	19.0	2.29	2.45	9.13	9.01	84.3	82.3	40.5	41.8	4.22	4.16
	80 mg kg^{-1} twice a t beginning of flowering and at the peak of flowering	21.3	21.2	2.38	2.54	9.53	9.41	83.8	81.0	40.7	41.3	4.52	4.48
Mean		17.5	17.4	2.15	2.82	8.83	8.67	86.0	83.6	40.5	41.6	3.85	3.80
Mean of putrescine	without	15.1	15.2	2.00	2.14	8.39	8.13	85.60	83.7	40.3	41.6	3.63	3.54
	100 mg kg^{-1} at beginning of flowering	17.4	16.8	2.14	2.30	8.74	8.50	83.85	82.5	40.3	41.6	3.90	3.82
	160 mg kg^{-1} at the peak of flowering	18.1	17.4	2.21	2.37	9.09	8.87	83.50	81.6	40.3	41.9	4.19	4.13
	50 mg kg^{-1} twice at beginning of f lowering and a t the peak of flowering	19.9	19.2	2.32	2.49	9.27	9.16	83.00	81.2	40.6	41.6	4.35	4.26
	80 mg kg-1 twice at beginning of flowering and at the peak of flowering	21.4	21.3	2.39	2.55	9.53	9.42	82.70	80.7	40.4	41.4	4.53	4.47
L.S.D. at 0.05 levels	A	1.12	1.05	0.04	0.04	0.11	0.10	1.47	1.36	NS	NS	0.36	0.34
	B	0.96	0.93	0.03	0.04	0.10	0.09	1.12	1.11	NS	NS	0.31	0.30
	A	1.56	1.32	0.06	0.06	0.14	0.12	1.57	1.49	NS	NS	0.45	0.43

Table (3) Effect of foliar spraying of putrescine at different levels and time of application of some fiber properties of cotton plant grown under deficit water.

Irrigation intervals	Putrescine levels (mg kg^{-1}) and time of application	Fiber length (mm)		Micronaire reading		Fiber strength (g tex^{-1})	
		2016	2017	2016	2017	2016	2017
12 days	without	29.30	30.10	3.67	3.71	9.78	9.73
	100 mg kg^{-1} at beginning of flowering	29.41	30.11	3.65	3.70	9.80	9-81
	160 mg kg^{-1} at the peak of flowering	29.35	30.05	3.69	3.70	9.90	9.85
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	29.39	30.07	3.67	3.74	9.86	9.83
	80 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	29.36	30.12	3.65	3.75	9.92	9.89
Mean		29.36	30.09	3.67	3.72	9.85	9.82
15 days	Without	27.65	28.36	3.36	3.41	9.11	9.10
	100 mg kg^{-1} at beginning of flowering	27.39	28.31	3.41	3.43	9.10	9.08
	160 mg kg^{-1} at the peak of flowering	27.42	28.54	3.35	3.39	9.06	9.07
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	27.55	28.52	3.42	3.46	9.08	9.05
	80 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	27.46	28.36	3.39	3.50	9.12	9.10
Mean		27.49	28.42	3.39	3.44	9.09	9.08
Mean of putrescine	Without	28.48	29.23	3.52	3.56	9.45	9.42
	100 mg kg^{-1} at beginning of flowering	28.40	29.21	3.53	3.57	9.45	9.45
	160 mg kg^{-1} at the peak of flowering	28.39	29.36	3.52	3.55	9.48	9.46
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	28.47	29.30	3.55	3.60	9.47	9.44
	80 mg kg-1 twice at beginning of flowering and at the peak of flowering	28.41	29.24	3.52	3.63	9.52	9.50
L.S.D. at 0.05 levels	A	0.72	0.79	0.16	0.17	0.33	0.32
	B	NS	NS	NS	NS	NS	NS
	AB	NS	NS	NS	NS	NS	NS

Table (4) Effect of foliar spraying of putrescineat different levels and time of application on chemical and pigments in leaves of cotton plant grown under deficit water.

Irrigation intervals	Putrescine levels (mg kg^{-1}) and time of application	N %		P %		K%		Chlorophyll A (mgg-1),dw		Chlorophyll A (mgg-1), dw		Cartenoids (mgg-1), dw	
		2016	201 7	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
12 days	without	2.10	2.08	0.30	0.29	2.80	2.76	3.10	3.08	2.13	2.11	0.55	0.54
	100 mg kg^{-1} at beginning of flowering	2.2	2.20	0.33	0.32	2.82	2.78	3.17	3.15	2.18	2.16	0.59	0.57
	160 mg kg^{-1} at the peak of flowering	2.35	2.32	0.35	0.34	2.84	2.80	3.20	3.19	2.22	2.21	0.63	062
	50 mg kg^{-1} twice at beginning of flowering and at the peak o f flowering	2.43	2.40	0.37	0.35	2.87	2.83	3.23	3.20	2.25	2.24	0.68	0.66
	80 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	2.51	2.48	0.38	0.36	2.89	2.86	3.27	3.25	2.29	226	0.74	0.73
Mean		2.32	2.30	0.35	0.33	2.84	2.81	3.19	3.17	2.21	2..20	0.64	0.62
15 days	without	2.86	1.83	0.27	0.25	2.53	2.50	2.85	2.84	2.00	1.98	0.47	0.56
	100 mg kg^{-1} at beginning of flowering	2.19	2.16	0.31	0.30	2.76	2.73	3.14	3.13	2.14	2.13	0.56	0.55
	160 mg kg^{-1} at the peak of flowering	2.28	2.24	0.33	0.31	2.81	2.79	3.17	3.15	2.20	2.18	0.60	0.59
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	2.39	2.36	0.35	0.33	2.85	2.82	3.21	3.18	2.23	2.20	0.66	064
	80 mg kg^{-1} twice at beginning g of flowering and at the peak o f flowering	2.50	2.47	0.36	0.35	2.88	2.85	3.25	3.24	2.28	2.26	0.73	0.72
Mean		2.24	2.21	0.32	0.31	2.77	2.74	3.13	3.10	2.17	2.15	0.60	0.59
Mean of Putrescine	without	2.98	1.96	0.29	0.27	2.67	2.63	2.98	2.96	2.07	2.05	0.51	0.50
	100 mg kg^{-1} at beginning of flowering	2.21	2.18	0.32	0.31	2.79	2.76	3.16	3.14	2.16	2.15	0.58	0.56
	160 mg kg^{-1} at the peak of flowering	2.32	2.28	0.34	0.33	2.83	2.80	3.19	3.17	2.21	2..20	0.62	0.61
	50 mg kg^{-1} twice at beginning of flowering and at the peak of flowering	2.41	2.28	0.36	0.34	2.86	2.83	3.22	3.19	2.24	2.22	0.67	0.65
	80 mg kg-1 twice at beginning of flowering and at the peak of flowering	2.51	2.48	0.37	0.36	2.89	2.86	3.27	3.25	2.29	2.26	0.74	0.73
L.S.D. at 0.05 levels	A	0.04	0.04	0.02	0.02	0.05	0.05	0.03	0.03	0.02	0.03	0.01	0.01
	B	0.03	0.02	0.02	0.02	0.03	0.03	0.02	0.03	0.02	0.03	0.01	0.01
	AB	0.06	0.05	0.03	0.03	0.06	0.06	0.04	0.04	0.03	0.04	0.02	0.02

On the other hand, the plant irrigated at drought stress without putrescine application achieved with low nutrient and pigment contents these results are similar to many investigators such as Shallan et al., (2012) and Ahmed et al., (2016) who reported that spraying cotton plants with different levels of putrescine under deficit water enhanced chemical contents of cotton leaves.

CONCLUSION

It can be concluded the foliar application of putrescine at rate of 80 mg kg^{-1} twice at beginning of flowering and the peak of flowering to cotton plant resulted in improvements in growth, yield and its component, fiber properties and nutrient and pigment contents during drought stress. Therefore, it can irrigated cotton plants every 15 days and foliarily application with 80 mg kg^{-1}putrescine twice at both beginning and peak of flowering, which yielded quality and quantity of cotton equal to irrigated with full irrigation (irrigated every 12 days). This means that the possibility to save about 2 irrigation by using putrescine.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Abd El-Hafeez and Abdel-Gayed designed and performed the experiments and also wrote the manuscript. All authors read and approved the final version.

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