EFFECT OF POTASSIUM AND BORON ON DROUGHT TOLERANCE OF COTTON PLANTS

1- Vegetative growth and anatomical studies

Abd El- Dayem, H. M. and Faten, H. M. Ismaeil
Agriculture Plant Dep. Fac. of Agric Moshtohor- Benha University

ABSTRACT

Two pot experiments were carried out during 2005 and 2006 seasons at the Agricultural Botany Department, Faculty of Agriculture at Moshtohor, Benha University to study the effect of foliar spraying by potassium (125, 250 and 500 ppm.) and boron(5,25 and 50 ppm.)on cotton plants (Giza 67 cultivar)grown under soil moisture levels (20,40 and 60 %) of available soil moisture.

Plants were sprayed with potassium and boron three times: after complete germination, vegetative growth stage and before the flowering stage. Vegetative growth and Anatomical studies were done. The results obtained can be summarized as follows:-

The treatments with B at 25ppm and K at 500ppm with 60% of available soil moisture gave the highest values of vegetative growth compared with the control especially root length.

As for the anatomical, several alternations were existed with different applied treatments. All treatments gave the highest parameters in transfer sections of tap root, main stem and leaf blade. The best treatments were B at 25ppm and K at 500ppm with 60% of available soil moisture. As for stomatal number and dimensions (length and width) in the lower epidermis of leaf blade were affected by different applied treatments

INTRODUCTION

Cotton is the most important fiber crop in Egypt as well as in the world, and it is one of the bases of the economy of Egypt. Nevertheless, as the cotton acreage in Egypt decreased, there had to be way to increase cotton yield per unit area and area of cotton.

Water deficit or water stress occurred whenever the loss of water through both evaporation and mainly transpiration exceeds the rate of absorption. Such deficit was frequently reported under drought conditions on tomato by (Waister and Hudson, 1970 and Perepadya 1976) Water deficit was reporter to decrease plant growth (Swietlik *et al.*, 1982 a; Tan and Buttery, 1982; Swietlik and Miller 1983; Layne and Tan, 1984 and Proebsting *et al.*, 1984).

The effect of various soil moisture regimes on plant growth revealed that growth was affected by the amount of available water depleted before the soil rewatered. Growth is commonly used in reference to the height of plant or the quantity of some particular plant parts (Black, 1968). Water stress was found to affect particularly every aspect of plant growth. Plant growth was directly related to the amount of water applied (Horton *et al.*, 1982).

Drought tolerant plants classified into two groups i.e., those that postpone dehydration and those that tolerate dehydration postponement is accomplished by mechanisms which either reduce transpiration or increase water absorption thus preventing the cells of the plant from reaching detrimental: low cell water potentials. Dehydration, tolerance: involves processes which allow the plant to survive and / or grow after the cells actually have been exposed to water deficits and low cell water potential (Kramer, 1969).

In Egypt, most of the new reclaimed soils suffer from water deficit. This may affect growth, leaf mineral content and many other physiological characteristics. It is characterized by decrease in water content, osmotic potential and total water potential accompanied by loss of turgor, close of stomata and decrease in growth as well as decrease in the photosynthesis process.

Several evidences indicate that there are changes in the photosynthetic pigments and mechanism in the chloroplasts and those changes in the ultra structure may occur under water stress (Hale and Crcutt, 1979).

Potassium foliar spraying helps to water translocation in plant with nutrient elements due to increased plant growth and helps to opining and closing stomata.

Boron is one of the essential elements for plant growth and Boron deficiency found to effect plant growth because, B helps to translocation and accumulation of carbohydrates in borate complex (Ahmed, 2001).

MATERIALS AND METHODS:

This study was carried out at Experimental Station of Agricultural Botany Department, Faculty of Agriculture, Moshtohor, Benha University during 2005 and 2006 seasons.

This investigation aimed to study the response of cotton (*Gossypium barbadense* Mill.*)* plant Cultivar Giza 67 to foliar sprays with potassium (125, 250 and 500 ppm.) and boron (5, 25 and 50 ppm.) Under the different available soil water (A.W.), three levels (20, 40 and 60 %) pertaining the influence on some of their morphological and, photosynthetic pigments and Anatomical studies. Therefore, the factorial experiment were conducted each included its own investigated above-mentioned treatments to study.

Seeds were sown in March 15thduring 2005 and 2006 seasons in pots (30 cm. in diameter that were filled with 9 kg sand: clay soil mixture) like a completely randomized block design with five replicates for each treatment with mixture of sandy and clay soil (1:1 by volume). After emergence of seedlings, plants were sprayed with treatments (with 1ml/l of Tween 20 as a wetting and spreading agent) three times: after complete seedlings emergence, vegetative growth stage and before the flowering stage.

The following measurements were recorded:-

1-Morphological characters:-

The following different morphological characters were measured and/ or calculated at 100 days after sowing. The following characters were inspected:

-Root diameter (cm.) at the base of the tap root. -Root length (cm.).

-Stem diameter (cm.) at the third internodes from the bottom. –Stem length (cm.).

-Number of leaves/plant.

-Total leaf area (cm^2)/ plant following the method described by **Deriaux *et al***. (1973).

-Fresh and dry weight of root, stem and leaves.

2-Anatomical studies

The samples of tap root were taken from 10 cm. after base root. Stem and leaf samples were taken from the 3rd internode from the top of the main stem at 15 days after the second spray (90 days after sowing) from the best treatments(B at 25ppm and K at 500ppm) and the control under two levels of available soil water(20 &60%). The vegetative specimens were taken then killed and fixed in FAA (5ml. formalin, 5ml. glacial acetic acid and 90ml. ethyl alcohol 70%), washed in 50% ethyl alcohol, dehydrated in series of ethyl alcohols 70,90,95 and 100%. The samples infiltrated in xylene, embedded in paraffin wax with a melting point of 60-63^{o}C, sectioned to 20 microns in thickness *(***Sass 1951),** stained with the double stain method (fast green and safranin), cleared in xylene and mounted in Canada balsam **(Johanson, 1940***).* Sections were read to detect histological manifestation of noticeable responses resulted from other treatments.

Hence, leaf stomatal characteristics i.e., stomatal density (No. of stomata per leaf area unit/360µ and stomatal pore dimensions (length and width) for the lower leaf surface of blade were determined from impressions of the leaf surface of blade on transparent fingernail polish according to methods described by **Stoddard (1965), Manning *et al*. (1977) and Laz (1999)**. The transparent impressions were fixed on glass slides and the median portion of each one examined by microscope furnished with a phase contract system, always using the same power of magnification., then average of each treatment was calculated.

The prepared section were microscopically examined, counts and measurements (µ) were taken using a micrometer eye piece. Average of readings from 3 slides/treatment were calculated.

RESULTS AND DISCUSSION

A-Vegetative growth characteristics:-

1- Specific effect of available soil water percentage:-

Data in Table (1) show that water stress decreased length, diameter and fresh weight of root especially 20 % available soil water compared with the other available soil water levels. The same results were cleared in the stem and leaf parameters especially, stem length and leaf area /plant (97.53 and 123.33 cm, respectively).

2-Specific effect of foliar spraying by K and B concentrations:-

Potassium and boron spraying increased vegetative growth in cotton plants compared with control. Root length, root diameter and fresh weight of root were increased from 40.78cm., 1.27cm. and 23.39g/plant, respectively with K at 125ppm to 48.67cm., 1.50cm. and 27.92g/plant, respectively with K at 500ppm**(Table,1)**. Meanwhile, boron levels highly increased the root characters especially B at 25ppm (51.22, 1.56 cm. and 29.38 g/ plant, respectively).

The same levels of K and B increased the stem and leaf characters compared with the control. B at 25ppm increased stem length and fresh weight of stem(128.07 cm. and 38.75 g/ plant, respectively) followed by B at 50ppm and K at 500 ppm. The leaves area /plant and fresh weight of leaves are increased from 111.59 cm. and 32.40g with control to 176.10cm and 52.39 g/plant with spraying of B at 25ppm followed by K at 500ppm (176.07cm. and 50.48g/ plant).

3- Interaction effect (spraying K or B and available soil water percentage):-

Data in **Table (1)** show the effect of foliar spraying with K and B levels on drought tolerances of cotton plants. B at 25ppm significantly increased the vegetative growth followed by K at 500ppm compared with control under different available soil water levels especially, under 60% A.W.

It is well known that potassium acts to balance the effect of nitrogen and enhances the cold endurance of crops and slow down the efflux of photosynthetic products from leaves to root. In addition, there is a close correlation between potassium content and growth rate in plants **(El-Taweel, 1999).**

Although the possibility that these mineral nutrients have a direct effect on the biosynthesis of CYT can not be disanissed, it is much more likely that they act indirectly via root growth and the induction of root primordial. The close positive correlation between the number of root primordia and leaf area in tomato plants **(Marschner, 1995)** is presumably related to CYT production.

B-dry matter of root, stem and leaves:-

1- Specific effect of available soil water percentage:-

Data in **Table (2)** show that water stress decreased dry weight of root, stem and leaves especially under 20 % available soil water compared with the other available soil water levels.

2-Specific effect of foliar spraying by K and B levels:-

Boron levels increased dry weight of root, stem and leaves of cotton plants compared with control. **(Table,2)**. Especially, B at 25ppm followed by B at 50 ppm. The total dry weight / plant are increased with B spraying at 25ppm (55.94g/ plant) followed by B at 50 ppm (54.29 g/plant) compared with control (38.65 g/plant).

Table (1): Effect of K and B on root, stem and leaf characteristics of cotton plants under drought condition at 100 days after sowing during 2005 and 2006 seasons.

Treatments		Root			Stem			Leaf		
		Length (cm)	Diameter (cm)	Fresh Weight g/plant	Length (cm)	Diameter (cm)	Fresh Weight g/plant	No. of leaves/ plant	Leaf area/ plant (cm^2)	Fresh weight g/plant
Specific effect of available soil water %										
A.W. %		Mean of 2005 and 2006								
20% A.W.		38.57	1.17	22.13	97.53	1.32	29.23	19.24	123.33	39.91
40% A.W.		44.24	1.35	25.18	114.66	1.56	34.18	22.81	157.20	47.33
60% A.W.		49.38	1.51	28.33	119.40	1.62	35.58	23.33	164.15	48.29
L.S.D. 0.05		4.774	0.145	2.738	11.948	0.552	3.439	2.255	16.927	4.668
Specific effect of K and B concentrations										
Element con.		Mean of 2005 and 2006								
K at 125 ppm		40.78	1.27	23.39	106.14	1.45	31.68	22.11	129.63	45.89
K at 250 ppm		43.00	1.37	24.67	107.50	1.47	33.69	22.33	139.47	46.33
K at 500 ppm		48.67	1.50	27.92	121.93	1.62	36.34	24.33	176.07	50.48
B at 5 ppm		39.55	1.23	22.69	98.89	1.35	29.47	19.33	145.27	40.10
Bat 25 ppm		51.22	1.56	29.38	128.07	1.74	3857	25.22	176.10	52.39
B at 50 ppm		50.33	1.49	28.43	123.90	1.69	36.91	24.55	164.83	50.95
Control		34.89	1.06	20.01	87.28	1.18	25.99	15.78	111.59	32.40
L.S.D. at 0.05		4.866	0.149	2.840	12.816	0.667	3.728	2.438	17.610	5.06
Interaction effect (spraying K or B X available soil water %**)**										
Element con.	A.W.%*	Mean of 2005 and 2006								
K at 125 ppm	20%	32.33	1.00	18.55	80.83	1.10	24.13	26.00	181.89	44.99
	40%	38.67	1.23	22.18	109.30	1.50	32.68	35.00	244.85	60.57
	60%	51.33	1.57	29.45	128.30	1.77	38.24	35.33	247.16	61.14
K at 250 ppm	20%	40.33	1.23	23.14	100.80	1.37	30.05	30.00	209.87	51.91
	40%	44.00	1.37	25.24	110.00	1.50	32.78	31.67	221.56	54.81
	60%	44.67	1.37	25.62	111.70	1.53	33.27	32.00	223.87	55.38
K at 500 ppm	20%	44.00	1.37	25.24	117.50	1.57	35.01	33.33	233.17	57.87
	40%	46.67	1.43	26.77	138.30	1.80	41.22	37.67	263.53	65.19
	60%	55.33	1.70	31.74	110.00	1.50	32.78	32.00	223.87	55.39
B at 5 ppm	20%	36.33	1.15	20.84	90.83	1.23	27.07	27.33	191.19	47.29
	40%	38.33	1.20	21.99	95.83	1.30	28.56	29.00	202.88	50.19
	60%	44.00	1.33	25.24	110.00	1.53	32.78	31.67	221.56	54.81
B at 25 ppm	20%	46.67	1.43	26.77	116.70	1.60	36.00	33.00	230.86	57.11
	40%	50.67	1.53	29.06	126.70	1.75	37.74	35.00	245.90	60.83
	60%	56.33	1.73	32.32	140.80	1.87	41.96	37.67	280.12	69.29
B at 50 ppm	20%	42.67	1.27	24.48	106.70	1.45	31.78	31.00	216.87	53.65
	40%	55.33	1.62	30.40	132.5	1.83	39.48	36.33	254.16	62.87
	60%	53.00	1.60	30.40	132.5	1.80	39.48	36.33	261.25	64.62
Control	20%	27.67	0.80	15.87	69.34	0.93	20.61	24.00	167.90	41.53
	40%	36.00	1.10	20.65	90.00	1.23	26.82	25.00	174.90	43.26
	60%	41.00	1.27	23.52	102.50	1.38	30.54	28.34	198.68	49.15
L.S.D. 0.05		5.349	0.1659	3.124	14.09	0.1659	4.056	2.931	28.032	6.580

*** A.W.= available soil water**

The same results were recorded with K treatments. Foliar spraying with K at 500ppm increased the total dry weight / plant (53.07g /plant) compared with the control.

3- Interaction effect (spraying K or B and available soil water %):-

Table (2) shows that B at 25ppm significantly increased the total dry weight / plant followed by K at 500ppm compared with control under different available soil water levels especially, under 60% A.W. Total dry weight/plant were significantly increased from 44.14g/plantwith control to 61.52g/plant with B at 25ppm. and 59.42g /plant with K at 500 ppm under 60 % A.W.

Table (2): Effect of K and B on dry matter partitioning of cotton plants under drought condition at 100 days after sowing during 2005 and 2006 seasons.

Treatments		Root dry weight (g/plant)	stem dry weight (g/plant)	leaves dry weight (g/plant)	Total dry weight (g/plant)	Dry weight % related to the control
Specific effect of available soil water %						
A.W. %		**Mean of 2005 and 2006**				
20% A.W.		**11.16**	**14.60**	**17.84**	**43.60**	**100.00**
40% A.W.		**12.93**	**17.07**	**20.03**	**50.03**	**100.00**
60% A.W.		**13.84**	**17.77**	**20.60**	**52.21**	**100.00**
L.S.D. 0.05		**0.334**	**0.187**	**0.361**	**2.047**	
Specific effect of K and B concentrations						
Element con.		**Mean of 2005 and 2006**				
K at 125 ppm		**11.69**	**15.82**	**19.59**	**47.10**	**121.86**
K at 250 ppm		**12.32**	**16.00**	**19.05**	**47.37**	**122.56**
K at 500 ppm		**13.94**	**18.16**	**20.97**	**53.07**	**137.31**
B at 5 ppm		**11.33**	**14.72**	**17.89**	**43.94**	**113.69**
Bat 25 ppm		**14.68**	**19.26**	**22.00**	**55.94**	**144.73**
B at 50 ppm		**14.57**	**18.44**	**21.28**	**54.29**	**140.46**
Control		**9.99**	**12.98**	**15.68**	**38.65**	**100.00**
L.S.D. at 0.05		**1.415**	**1.856**	**1.447**	**5.407**	
Interaction effect (spraying K or B X available soil water %**)**						
Element con.	**A.W.%***	**Mean of 2005 and 2006**				
K at 125 ppm	**20%**	9.27	12.05	15.86	37.18	113.15
	40%	11.08	16.32	21.35	48.75	124.27
	60%	14.71	19.10	21.55	55.36	125.42
K at 250 ppm	**20%**	11.56	15.01	18.20	44.77	136.24
	40%	12.61	16.37	19.32	48.30	123.12
	60%	12.80	16.62	19.52	48.94	110.87
K at 500 ppm	**20%**	13.37	17.49	20.40	51.26	155.99
	40%	15.85	20.59	22.98	59.42	151.46
	60%	12.61	16.37	19.52	48.50	109.88
B at 5 ppm	**20%**	10.41	13.52	16.67	40.60	123.55
	40%	10.98	14.27	17.69	42.94	109.45
	60%	12.61	16.37	19.32	48.30	109.42
B at 25 ppm	**20%**	13.37	17.98	20.13	51.48	156.66
	40%	14.52	18.85	21.46	54.83	139.76
	60%	16.14	20.96	24.42	61.52	139.37
B at 50 ppm	**20%**	12.23	15.87	18.91	47.01	143.06
	40%	15.19	19.72	22.16	57.07	145.47
	60%	16.29	19.72	22.76	58.77	133.14
Control	**20%**	7.93	10.29	14.64	32.86	100.00
	40%	10.31	13.40	15.25	39.23	100.00
	60%	11.74	15.25	17.15	44.14	100.00
L.S.D. 0.05		1.57	2.026	2.962	5.540	

Generally, all boron and potassium treatments increased drought tolerance in cotton plants under study in 2005 and 2006 seasons especially, B at 25ppm and K at 500ppm.

C-Anatomical studies:

1-In transfer sections of tap root:-

Data in **Table (3) and Fig.(1)** clearly indicate that the root diameter of cotton plant under the control treatment was decreased due to water stress from 2298.80 micron (60% A.W.) to 2073.60 micron (20% A.W.). Meanwhile, it was highly increased by all treatments of the K and B foliar spraying especially B at 25ppm under 20% A.W.(3425.40 micron) and under 60% A.W.(3191.60 micron) followed by K at 500 ppm under 60% A.W. The same result recorded in number and thickness of cortex layer. Meanwhile, the other characters (thickness of phloem, thickness of secondary xylem tissues, No. of the xylem rows, thickness of widest xylem vessel and wall thickness of widest xylem vessel) are increased with Bat 25ppm under 60% A.W. and under 20%A.W. followed by K at 500ppm under 60% A.W.

Table (3): Effect of K and B on histological features of the tap root (T.S.) of cotton plants under drought condition(cross section).

Treatments / Characters (micron)	A.W.%* (20%)			A.W.%* (60%)		
	K at 500ppm	B at 25ppm	control	K at 500ppm	B at 25ppm	control
Root diameter.	2439.00	3425.40	2073.60	2455.20	3191.60	2298.80
Thickness of periderm layers.	**288.80**	**315.00**	225.50	297.00	388.00	280.00
No. of periderm layers	10.00	14.00	10.00	12.00	14.00	9.00
Mean thickness of periderm layers.	28.88	22.50	22.55	24.75	27.71	31.11
No. of cortex layers.	11.00	16.00	11.00	11.00	12.00	9.00
Cortex layers thickness.	344.8	540.00	275.00	288.00	360.00	270.00
Mean thickness of Cortex layers.	31.34	33.75	25.00	26.18	25.71	30.00
Thickness of phloem layers	108.00	132.30	85.30	117.00	135.00	90.00
Thickness of secondary xylem layers	441.00	585.00	320.50	486.00	657.00	378.00
No. of the xylem rows	22.00	21.00	14.00	17.00	21.00	16.00
Xylem vessels no. in the row.	9.00	5.67	4.00	5.75	6.67	4.00
Thickness of widest xylem vessel.	83.60	89.10	70.50	88.80	103.50	76.50
Wall thickness of widest xylem vessel	14.40	15.30	12.80	15.30	15.30	10.60
Parenchymatous pith thickness.	-	-	90.00	-	-	90.00
Thickness of primary xylem.	36.90	51.30	40.50	39.60	55.80	41.40

*** A.W.= available soil water**

2-In transfer sections of main stem:-

Data in **Table (4) and Fig. (2)** revealed that the stem diameter, mean thickness of collenchyma layers, thickness of cortical parenchyma layers and phloem thickness were highly increased in stems treated by B at 25ppm under 60 %A.W. compared with the other treatments.

On the other hand, epidermal cell thickness, thickness of cambium layers, thickness of secondary xylem tissues, No. of the xylem rows, thickness of widest xylem vessel and wall thickness of widest xylem vessel were significantly increased in stems treated by B at 25ppm under 20 %A.W.(15.30, 60.10, 586.18, 137.00,58.50 and 15.30 micron(μ), respectively) compared with the other treatments. Also, treatment of K at 500ppm under 20&60 %A.W. increased the parameter of stem sections compared with control.

Boron deficiency is associated with a range of morphological alterations and changes in differentiation of tissues, similar to those induced by either subraoptimal levels of IAA. As lignification and xylem differentiation are unique to vascular plants, which is also true, in principle, for the boron demand, a key role of boron in IAA metabolism and in regulation of lignin biosynthesis and xylem differentiation had been proposed **(Marschner, 1995)**.

Enhanced cell division in a radial direction with a distinct proliferation of cambial cells and impaired xylem differentiation are also features typical of the subapical shoot tissue of boron-deficient plants **(Marschner, 1995).**

3-In transfer sections of leaf blade:-

The obtained results regarding the increase in thickness of both cuticle and epidermis layers exhibited in leaf anatomical structure of cotton grown under water stress (**Table,5 & Fig.3**) i.e., severe irrigation regime (20 % A.W.).

The obtained results are in general agreement with findings of **El-Hadeedy, (1984); Hassan *et al*., (1984); Draz, (1986); Ahmed (1990); and Al-Khateeb, (1996).** Moreover, the decrease in mesophyll thickness (palisade & spongy thickness) and both (diameter & wall thickness) of xylem vessel induced by drought condition was supported by the findings of **El-Hadeedy, (1984) and Ahmed (1990)**.

Sprayed with B at 25ppm followed by K at 500 ppm resulted in an obvious increase with regard to the response of leaf mesophyll thickness (palisade & spongy tissues), it was quite evident that each tissue followed its own trend. Whereas B & K

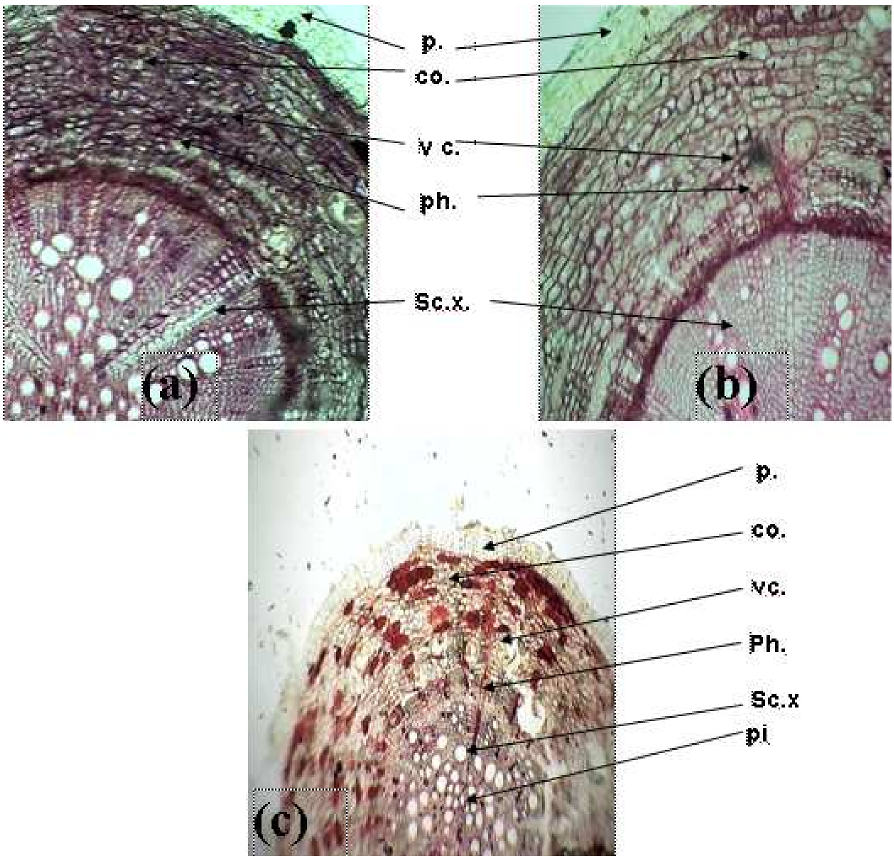

Fig.(1):- Effect of K and B on histological features of the root(T.S.) of cotton plants under drought Condition (20% soil moisture level) (100 x).

a-K at 500 ppm. b-B at 25 ppm. c- Control

Where: p.= periderm tissue, co.= cortex tissue, v.c.= vascular cylinder, ph.= phloem tissue and sc. x.= secondary xylem tissues pi= pith.

Table (4): Effect of K and B on histological features of the main stem (T.S.) of cotton plants under drought condition.

Treatments / Characters (micron)	A.W.%* (20%)			A.W.%* (60%)		
	K at 500 ppm	B at 25 ppm	control	K at 500ppm	B at 25 ppm	control
Stem diameter.	3037.84	3181.66	2511.50	3310.20	3811.20	2510.80
Parenchymatous pith thickness.	1081.80	1093.50	980.00	1359.00	1710.00	1020.00
Epidermal cuticle thickness.	13.85	15.30	10.87	11.70	13.60	9.90
Epidermal cell thickness.	16.20	18.00	15.16	26.10	25.20	19.80
No. of periderm layers	5.00	6.00	4.00	4.00	4	4.00
Thickness of periderm layers.	117.90	118.80	68.18	90.00	103.50	66.60
Mean thickness of periderm layers.	23.58	19.80	17.54	22.50	25.87	16.65
No. of cortex layers.	7.00	7.00	4.00	6.00	10.00	6.00
Cortex layers thickness.	145.20	158.40	90.00	161.10	193.50	84.60
Mean thickness of Cortex layers.	20.74	22.63	22.50	15.00	19.35	14.10
Thickness of phloem in the vascular cylinder..	70.20	87.30	60.30	98.10	110.70	67.5
Thickness of cambium layers in the vascular cylinder.	56.67	60.10	30.90	48.60	55.10	35.50
Thickness of xylem in the vascular cylinder.	558.00	586.18	490.34	540.00	549.00	486.00
No. of xylem rows in the vascular cylinder.	135.00	137.00	100.00	130.00	131.00	120.00
Xylem vessels no. in the row.	14.00	14.67	12.00	12.50	13.50	11.50
Thickness of widest xylem vessel in vascular cylinder.	57.60	58.50	50.40	53.10	55.80	44.10
Wall thickness of widest xylem vessel in vascular cylinder.	12.60	15.30	11.00	11.70	13.50	10.80

***A.W.= available soil water**

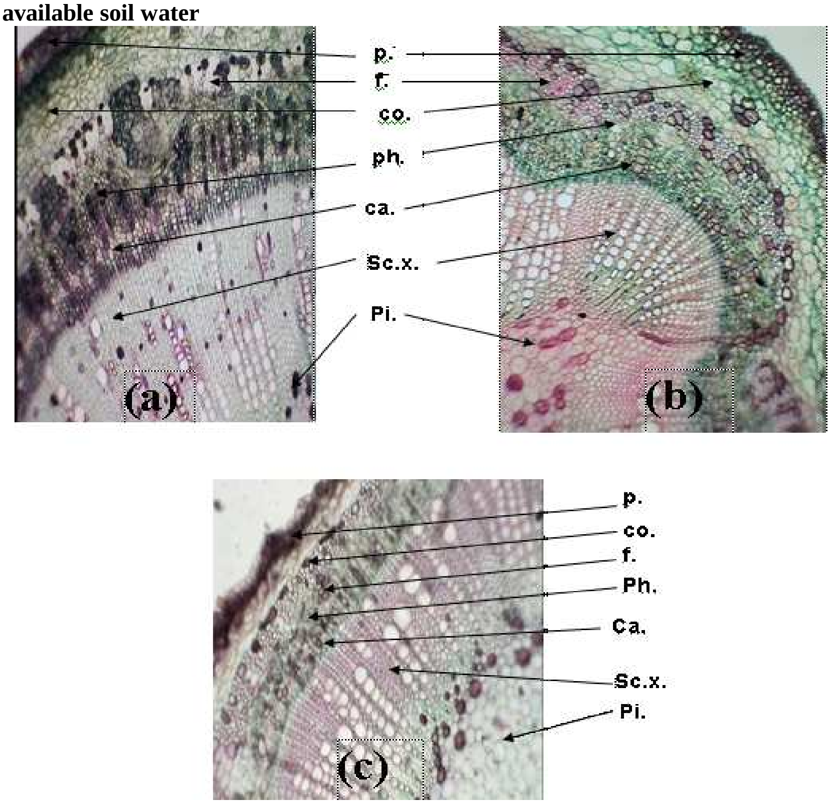

Fig.(2):- Effect of K and B on histological features of the tap root(T.S.) of cotton plants under drought Condition (20% soil moisture level) (150 x).
a-K at 500 ppm. b-B at 25 ppm. c- Control
Where: p.= periderm tissue, co.= cortex tissue, f.= fiber layer, ph.= phloem tissue, ca.=cambium tissue, sc. x.= secondary xylem tissue and pi= pith tissue.

sprays resulted in an increase in thickness of upper epidermal layer. On the other hand, the response of spongy tissue thickness to K spray indicated increase in leaves compared with to that of unsprayed water stressed (control)..

Potassium foliar spraying on cotton plants resulted obviously in decreasing xylem tissue thickness in leaf midrib as compared to Boron foliar spraying **(Table,5).**

As for the number of xylem rows in leaf vascular bundle of water stressed cotton plants in response to B and K foliar spraying, **Table (5)** it could be generally concluded that B at 25ppm and K at 500 ppm had increased it to 28 and 27 rows, respectively on number of xylem rows in midrib compared with the unsprayed water stressed ones(18 rows)under 20% A.W. Referring the diameter and wall thickness of xylem vessel, data obtained as shown from **Table (5**) displayed that B and K foliar spray resulted in an increase in both characteristics. On the other hand, the rate of increment in wall thickness of xylem vessel was more pronounced rather than that exhibited in its diameter, especially with K at 500ppm under 20% A.W.

An increase in thickness of either xylem or phloem tissue ensures improvement of translocation into and outside leaves for inorganic solutes and organic synthates, respectively. This conclusion also ensures the essentiality of increasing the cross sectional area of phloem **(Canny, 1973 and El- Desouky *et al*, 2001).**

Table (5): Effect of K and B on histological features of the leaf blade (T.S.) of cotton plants under drought condition.

Treatments / Characters	A.W.%* (20%)			A.W.%* (60%)		
	K at 500 ppm	B at 25 ppm	control	K at 500 ppm	B at 25 ppm	control
Thickness of midrib of leaf.	1003.50	1118.50	657.00	1098.00	1269.00	1057.50
Thickness of blade.	303.94	322.17	175.85	315.00	356.75	183.60
Upper epidermal cuticle thickness.	14.40	15.30	11.50	11.70	13.50	10.80
Lower epidermal cuticle thickness.	12.34	12.67	9.90	10.80	11.15	8.10
Upper epidermal thickness.	23.40	25.10	18.88	27.00	27.90	20.70
Lower epidermal thickness.	15.30	18.00	8.50	20.70	21.60	10.80
No. of palisade tissue layers.	1.00	1.00	1.00	1.00	1.00	1.00
Palisade tissue thickness.	147.60	150.30	86.40	124.20	137.70	89.10
No. of spongy tissue layers.	7.00	7.00	5.00	6.00	7.00	5.00
Spongy tissue thickness.	99.90	100.80	40.67	120.60	144.90	44.10
Mean of spongy tissue thickness.	12.98	14.40	8.13	20.10	20.70	8.82
No. of collenchyma layers below the upper epidermis at midrib.	3.00	3.00	3.00	3.00	3.00	3.00
Thickness of collenchyma layers below the upper epidermis at midrib.	90.00	95.85	63.00	78.28	80.15	72.90
Mean thickness of collenchyma layers below the upper epidermis at midrib.	30.00	31.95	63.00	78.28	80.15	72.90
No. of collenchyma layers above the upper epidermis at midrib.	4.00	4.00	4.00	4.00	4.00	3.00
Thickness of collenchyma layers above the upper epidermis at midrib.	103.50	105.30	83.70	100.10	100.80	50.40
Mean thickness of collenchyma layers above the upper epidermis at midrib.	25.87	26.32	20.92	25.02	25.20	16.80
Length of midrib vascular bundle.	477.00	531.00	358.50	500.10	540.00	378.00
Width of midrib vascular bundle.	733.50	783.00	450.00	702.00	756.00	432.00
Thickness of phloem in v. bundle	140.40	149.80	111.60	148.50	153.90	117.00
Thickness of xylem in vascular bundle.	336.60	381.20	246.90	351.60	386.10	261.00
No. of xylem rows in vascular bundle.	27.00	28.00	18.00	25.00	26.00	16.00
No. of vessels in the xylem row.	13.00	14.00	10	11.50	12.00	8.00
Thickness of widest xylem vessel in vascular bundle	38.34	40.50	29.18	36.00	38.00	28.00
Wall thickness of widest xylem vessel in vascular bundle	13.50	14.40	9.87	10.80	12.60	9.00

*** A.W.= available soil water**

4- Stomatal parameters:

In this respect number of stomata per leaf area unit (360 μ) and stomatal dimensions (length & width) were the investigated stomatal characteristics in response to water stress. It is quite evident as shown from data presented in **Table (6) and Fig. (4)** that the response of stomatal density (No. of stomata per leaf area unit/360-μ) to two investigated irrigation regimes was approximately absent. However, raising the determining limits of irrigation regime(available soil water%) from 20 to 60 % induced a worthless increase in leaf stomatal density of cotton plants.

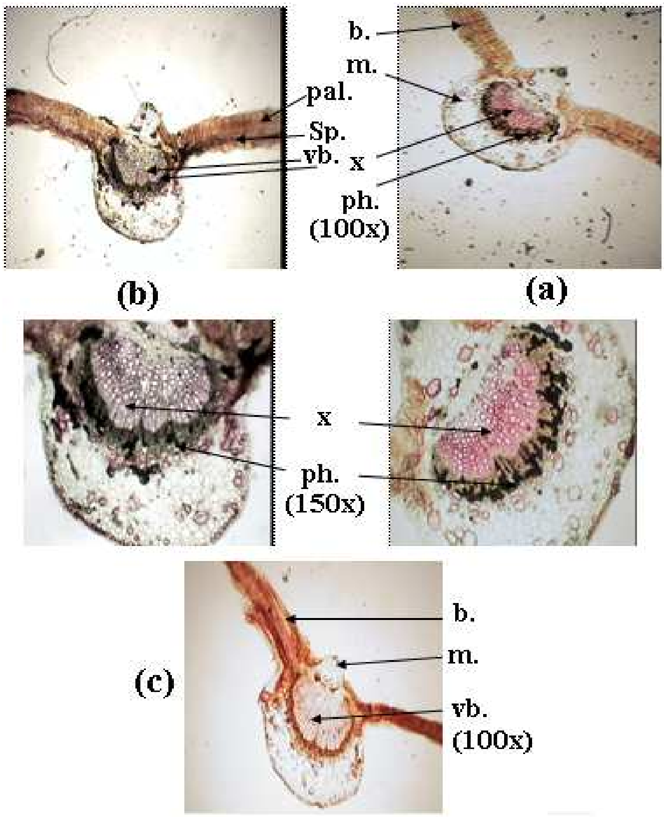

Fig.(3):- Effect of K and B on histological features of the leaf blade (T.S.) of cotton plants under drought Condition (20% soil moisture level) (100 x and 150x).
a-K at 500 ppm. b-B at 25 ppm. c- Control

Where: b.= blade, m.= midrib of leaf, pal.=palisade tissue, sp.=spongy tissue, vb.=vascular bundle, x= xylem tissue, ph.= phloem.

As for the dimensions of stomatal pore, it was too clear to be detected that both length and width of stomatal pore were more sensitive to water stress. Whereas, under severer irrigation regime (20% available water) leaves of cotton plants characterized by their shorter stomatal dimensions (length & width) as water stressed compared to the analogous ones under the lighter irrigation regime (60 % A.W.). The rate of change i.e., decrease in stomatal pore dimensions under water stress. Such response of stomatal pore dimensions to irrigation regime could be considered as a real powerful mechanism for regulating water loss and consequently reducing the harmful influence of further water stress **(Table, 6).**

Generally, the present results of stomatal characteristics in response to water stress are in harmony with those previously found by **Hassan *et al*., (1984); Draz, (1986), Ahmed (1990)**

Table (6): Effect of K and B on stomatal Characters of lower epidermis of the leaf blade of cotton plants under drought condition.

Treatments / Characters (micron)	A.W.%* (20%)			A.W.%* (60%)		
	K at 500ppm	B at 25ppm	control	K at 500ppm	B at 25ppm	control
Number of opining stomata.	**1.00**	**1.00**	**3.00**	**2.00**	**2.00**	**6.00**
Number of closing stomata.	4.00	3.00	2.00	6.00	5.00	4.00
Total number of stomata.	5.00	4.00	**5.00**	8.00	7.00	**10.00**
Length of stomata.	27.90	28.80	24.30	29.70	30.60	19.80
Width of stomata.	20.70	22.50	**18.80**	21.60	25.20	17.70
Length of stomatal pore.	16.20	14.40	18.00	18.90	19.80	18.15
width of stomatal pore.	8.10	6.30	**11.70**	10.80	9.90	13.50

*** A.W.= available soil water**

and Osman (2004) especially, pertaining the response of stomatal dimensions. Moreover, findings of the same authors were to some extent in partial agreement, with the present result of stomatal density. This shift in response between findings of the aforesaid investigators and present study may be due to variations in either characteristics (especially heritable ones) of different plant materials used in each case or between limits of drought conditions under every experiment.

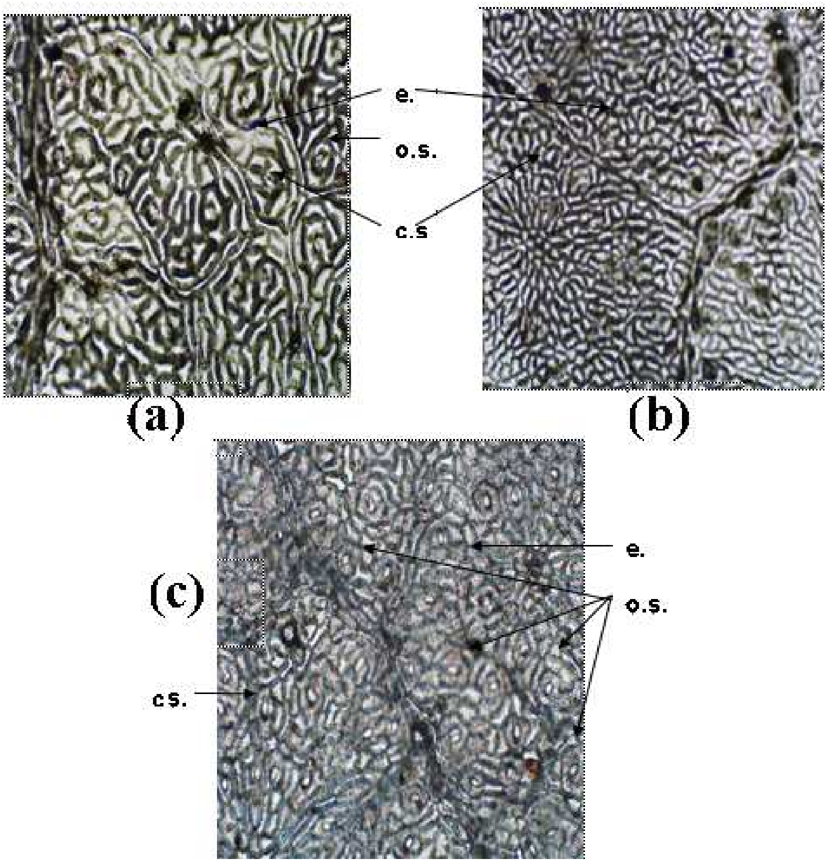

Fig.(3):- Effect of K and B on stomatal characters of the lower epidermis of leaf blade of cotton plants under drought Condition (20% soil moisture level) (100 x).

a-K at 500 ppm. b-B at 25 ppm. c- Control

Where:- e.= epidermis cells, o.s.= opining stomata and c.s.=closing stomata.

As for the stomatal dimensions (length and width) it is quite evident that an obvious decrease was resulted by B and K foliar spraying. Such decrease was clearly observed in both stomatal length and width for cotton plant. Boron at 25% and potassium at 500ppm increased drought tolerance on cotton plant via to decreased the number of stomata per leaf area unit (360 μ), stomatal dimensions (length & width) and stomatal pore dimensions(length& width). On the other hand, the same treatment increased number of closing stomata from 3 and 4 stomata, respectively compared with control (2 stomata) under 20% A.W. per leaf area unit (360 μ)

In most plant species, K^+ has the major responsibility for turgor changes in the guard cells during stomatal movement. An increase in K^+ concentration in the guard cells results in the uptake of water from the adjacent cells and a corresponding increase in turgor in the guard cells and thus stomatal opining. When the soil water supply is limited, loss of turgor and wilting are typical symptoms of potassium deficiency. The lower tolerance of potassium-deficient plants to drought is related mainly to (a) the role of K^+ in stomatal regulation, which is a major mechanism controlling the water regime of higher plants, and (b) the role of K^+ as the predominant osmotic solute in the vacuole, maintaining a high tissue water level even under drought condition.

These results are in partial agreement with the findings of **Swietlik *et al*.,(1982a), Ahmed (1990)and Osman (2004).**

REFERANCES

Ahmed, B. R. (1990): Physiological studies on draught resistance of fig transplants. Ph.D. Thesis, Fac. Agric., Ain Shams Univ., Cairo, Egypt.

Ahmed, S.(2001): Effect of boron and Zink application on dry matter yield and nutrient uptake of wheat. Proc. Of the international workshop boron 2001: Univ. Bonn, Bonn Germany, 23-28. June.

Al-Khateeb, A.F.M., (1996): The influence of some growth regulators and mineral nutrients on growth and drought resistance of some fig varieties. Ph.D. Thesis, Fac. of Agric. Moshtohor, Zagazig University. Benha.

Black, C. A. (1968): "Soil-Plant Relationship". Second Edition. Copyright 1957 & 1968 by John Wiley and sons. Inc. U.S.A.

Canny, M. K. (1973): "Phloem Translocation". London and New York: Cambridge University Press.

Deriaux, M.; Kerrest, R. and Montalon, Y.(1973): Etude de la sulface foliare et de 1, activite photosynthetique chez qulques hybrids de mais. Ann. Amelior plantes, 23: 95-107.

Draz, M. Y. (1986): Response of bitter almond seedling to different water regime. Ph. D. Thesis Fac. Agric., Cairo Univ. Egypt.

El-Desouky, S.A.; Kheder, Z.M.; Wanas, A.L. and Ahmed, H.S. (2001): Response of the Egyptian cotton plant to foliar spray with some macro- nutrients (NPK)and the growth regulator paclubutrazol(PP_{333}). 1- Effects on vegetative growth, leaf anatomy and chemical components. Ann. Agric. Sc., Moshtohor, 39(4): 2087-2107.

El-Hadeedy, M. A. (1984): Physiological studies on guava. Ph. D. Thesis, Fac. Agric. Zagazig Univ. Egypt.

El-Taweel, F.M.A.(1999): Response of some sugar beet varieties to potassium and magnesium fertilizers. Ph. D. thesis, Fac. Agric., Moshtohor, Zagazig University (Benha branch).

Hale, M.C. and Crcutt D.M. (1979): "The physiology of plant under stress". John Wiely & Sons, Inc, New York.

Hassan, M. S. Sawsan, M.; Taha, E.M.; El-Beltagy, A.S.; Gomaa, Hosniya and Moksoud, M.A. (1984): Effect of different water regimes on tomato 2- Water saturation deficit pigments and leaf anatomy. Ann. Agric. Sci. Fac. Agric. Ain Shams Univ. Cairo, Egypt, 29(2):957-70.

Horton, R.; F Bease and P. J. Wierenga, (1982): Physiological response of Chile pepper to trickle irrigation. Agronomy J., 74 (3): 551-555.

Johanson, D.V. (1940): "Plant Microtechnique". New York and London McGraw- hill Book Co. Inc. pp.27 - 154.

Kramer, P. J. (1969): "Plant and Soil Water Relationship". McGraw-Hill Inc., New York.

Layne, R. E. C. and Tan, C. S. (1984): Long term influence of irrigation and tree density on growth, survival and production of peach. J. Amer. Soc. Hort. Sci. 109 (6): 795-799.

Laz,, I. S. (1999). Anatomical studies on leaves of two olive seedling cultivars as affected by different levels of water irrigation. Zagazig J. Agric. Res. 26 (6): 1731-1749.

Manning, C.E.; Miller, D.G. and Teare, T.D. (1977): Effect of moisture stress on leaf anatomy and water use efficiency of peas. J. Amer. Soc. Hort. Sci., 102, (6) : 756-260.

Marschner, H. (1995): Mineral nutrition and yield response. In mineral nutrition of higher plants. 2^{nd} ed., New York Academic press. pp.148-397.

Osman, I. M. S. (2004): Physiological studies on growth and drought tolerance of some olive cultivars. Ph. D. Thesis, Fac. Agric., Moshtohor, Benha Univeristy.

Perepadya y. G. (1976): Characteristics of water relations in capsicum in the lower vilga region. Byulleten vsesoyuzo ordena Lenina Instituta Rastenievodstvo imevi N.I. Vavilova, 63: 36-40 (Hort. Abst. 48: 516).

Proebsting, E.L. ; S. R. Drakes and R. G. Evans (1984): Irrigation management, fruit quality and storage life of apple. J. Amer. Soc. Hort. Sci. 109 (2):229-232.

Sass, J. E. (1951): "Botanical Microtechnique".Iowa state college press, Ames, Iowa, pp.228.

Stoddard, E. M. (1965): Identifying plants by leaf epidermal characters. Conn. Agr. Expt. Sta Cir. 227 (C. F. J. Amer. Soc. Hort. Sci.; 102: 756-760).

Swietlik, D.; Faust, M. and Karcak, R.F. (1982a): Effect of mineral nutrient sprays on photosynthesis and stomatal opening of water stress and unstressed apple seedlings. 1. Complete nutrient sprays. J. Amer. Soc. Hort. Sci. 107 (4) 563-567.

Swietlik and Miller. S.S. (1983): The effect of pactobutrazol on growth and response of water stress of apple seedlings. J. Amer. Soc. Hort. Sci. 108 (6): 1076-1080.

Tan, C.S. and Buttery, B.R. (1982). Response of stomatal conductance, transpiration, photo-synthesis and leaf water potential in peach seedlings to different watering. Hort. Sci., 17(2): 222-223.

Waister, P. D. and Hudson, J. D. (1970): Effect of soil moisture regimes of leaf water deficit transpiration and yield of tomatoes. J. Hort. Sci. 45: 359-370.

تأثير البوتاسيوم والبورون على تحمل نباتات القطن للجفاف
١ - النمو الخضرى والدراسات التشريحية

حسنى محمد عبد الدايم وفاتن حسن محمود إسماعيل
قسم النبات الزراعي - كلية الزراعة بمشتهر- جامعة بنها

أجريت هذه التجربة خلال عامى٢٠٠٥ و٢٠٠٦ كتجربة أصص في قسم النبات - كلية الزراعة بمشتهر – جامعة بنها بغرض دراسة تأثير الرش بالبوتاسيوم تركيز ١٢٥و٢٥٠ و٥٠٠ جزء في المليون والبورون بتركيز ٥ و٢٥ و٥٠ جزء في المليون على نباتات القطن صنف جيزة ٦٧ النامي تحت مستويات مختلفة من الرطوبة الأرضية (٢٠، ٤٠ و٦٠ % من الماء الميسر).

تم الرش بالمعاملات تحت الدراسة ثلاث مرات:- بعد تمام الإنبات وفى طور النمو الخضري وقبل الإزهار. وتم دراسة الصفات المورفولوجية للنبات والوزن الجاف الكلى / نبات وأيضاً الصفات التشريحية لكل من الجذر والساق والأوراق كما تم دراسة خصائص الثغور وتوزيعها على السطح السفلى للورقة.

أدى انخفاض نسبة الرطوبة الأرضية إلي نقص واضح في معظم الصفات تحت الدراسة بينما أدت المعاملة بالبورون ٢٥ جزء في المليون يتبعه البوتاسيوم بتركيز ٥٠٠ جزء في المليون عند مستوى رطوبة ٦٠% أعلى نمو خضري مقارنة بالكنترول وأيضاً أعلى وزن جاف كلى/ نبات.

البوتاسيوم بتركيز ٥٠٠ جزء في المليون عند مستوى رطوبة ٦٠% أعلى القياسات التشريحية مقارنة بمستويات الرطوبة الأخرى التي هي أيضاً أكبر من الكنترول. كما أظهرت دراسة خصائص الثغور وتوزيعها فروق واضحة من حيث عددها وأبعادها (طولها وعرضها).