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CERTAIN MORPHOLOGICAL, PHYSIOLOGICAL AND ANATOMICAL RESPONSES OF SOYBEAN (*Glycine max* (L.) MERR. PLANT TO WATERLOGGING AND SOME GROWTH SUBSTANCES

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ABSTRACT

This study aimed to investigate the effect of waterlogging for 5 days during the vegetative growth stage, Gibberellic acid (GA3); Paclobutrazol (PBz) and kinetin on certain morphological, physiological and anatomical responses of soybean plant. The ability of the above mention of growth substances on recovery the adverse effects of waterlogging were also examined.

Waterlogging for 5 days during the vegetative growth stage decreased significantly plant height, number of branches and leaves plant and leaf area (cm^2/plant) In addition, photosynthetic pigments content, total soluble carbohydrate content in both root and shoot systems, pods number, pods weight (g) and seed weight (g)/plant as well as seeds protein and oil content were also decreased. Application of both GA3 and kinetin at two concentrations used increased significantly plant height. GA3 at 100 ppm was most effective in this respect. On the other hand, PBz decreased significantly plant height during the two growing seasons.

It is interesting to mention that treatment with the above mentioned growth substances not only increased significantly the previous parameters but also overcome the adverse effects of waterlogging.

Anatomically, waerlogging treatment decreased leaflet thickness, mesophyll tissue thickness, palisade and spongy tissues thickness and midrib V.B. dimensions stem diameter, cortex thickness, number of cortical cell layers, large vascular bundle dimensions, phloem, xylem tissues thickness and pith tissue thickness as well as metaxylem vessel diameter were also decreased. GA3, PBz and kinetin at two concentrations used increased all the above mentioned anatomical parameters compared with both control and waterlogged plants.

Treatment with both kinetin and PBz at two concentrations used are recommended for recovery the adverse effects of waterlogging. Moreover, GA3 at high concentration (100 ppm) partially alleviated the adverse effects of waterlogging

INTRODUCTION

Soybean seeds are one of the main sources for protein and oil in fabaceous plants. In Egypt, there is wide gap between the production of vegetable oil and its consumption.

Due to surface irrigation and lack of efficient drainage system in Egypt, the possibility of waterlogging condition may be exist during some periods of growth and development for various species.

Excess soil water or waterlogging, is a serious environmental stress affecting plant growth and yield.

Low oxygen concentration in the rhizosphere resulting from soil waterlogging and flooding are often accompanied with morphological, physiological and anatomical responses (Bacanamwo and Purcell, 1999).

Several of the above responses can reduce plant growth in various plant species (Fouda, 1998) by their affecting several physiological processes such as water absorption, photosynthesis, uptake and transport of all essential nutrient elements (Pezeshki, 1994 and Huang and Johanson, 1995).In addition, it alters both carbohydrates status and plant hormones of both roots and shoots. Carbohydrates play an important role in plant productivity which is dependent upon its production, translocation, storage and utilization (Barta, 1988).

Efforts have been given not only to improve plant growth, oil yield and its quality by application of plant growth substances (Fouda and Salama, 1998), but also to overcome the adverse effects of waterlogging (Fouda, 1998).

Therefore, the present investigation aimed to study the effects of waterlogging and some growth substances on soybean growth as well as its yield and its components. Certain physiological aspects and the anatomical structure of the stem and leaves were also studied. The ability of GA_3, kinetin and paclobutrazol (PBz) on recovery the adverse effects of waterlogging was examined.

MATERIALS AND METHODS

Two pot experiments were carried out during the two successive seasons of 1998/1999 and 1999/2000 in the Experimental Station and Laboratories of Agricultural Botany Department, Faculty of Agriculture, Mansoura Univ., Mansoura, Egypt.

Soybean seeds (Glycin max, (L.) Merr. var. Giza 35 were obtained from the Agricultural Research Center Dokki, Giza, Egypt.

Plastic pots (30 cm diameter) were filed with 12 kg clean-air-dried clay loamy soil and arranged in complete randomized design system. The mechanical and chemical analysis (Piper, 1950) of the used soil during the two growing seasons are illustrated in Table (1).

Table 1: Mechanical and chemical analysis of the used soil during the two growing seasons of 1998/1999 and 1999/2000.

Seasons	Coarse sand %	Fine sand %	Silt %	Clay %	S.P %	F.C. %	(P^H) Soil reaction	E.C at 25°C
1998/1999	8.7	23.5	24.1	43.7	63.0	37.75	7.75	0.55
1999/2000	7.8	20.5	22.5	49.2	63.8	38.28	7.25	0.60

Uniform seeds were sown on the 1st of May in both seasons.The other agricultural practices were done according to the advices of the Ministry of Agriculture. The experiments were designed in a complete randomized design with three replicates, After 20 days from sowing, the plants were thinned for 3 uniform young plants per pot, each replicate contains 42 pots.

The pots were divided into four groups as follows:

1- The first group, was not subjected to waterlogging and sprayed with distilled water (control plants).

2- The second group of plants was irrigated with tap water over saturation percentage (waterlogging plants).

3- The third group of plants was sprayed with each of the growth substances used.

4- The fourth group of waterlogged plants was sprayed with each of the growth substances used as follows.

The plants were exposed to waterlogging for 5 days during the vegetative growth stage (32 days after sowing). The samples were taken after 15 days from the end of waterlogging treatment.

The following morphological characters were measured during the two growing seasons: plant height, number of branches and leaves/plant as well as leaf area (cm^2) per plant (Watson, 1958).

Photosynthetic pigments concentration (mg/g) fresh weight (Macking, 1941) and total soluble carbohydrates (mg/g) dry weight in both shoot and root system were determined (Sadasivam and Manickam, 1996).

At harvest stage, after 105 days from sowing, number of pods/plant, seed weight per plant were determined. Moreover, the percentage of both protein and oil in the seeds (A.OA.C., 1970) were estimated.

The anatomical studies were taken only in the second season at the vegetative growth stage (40 days after sowing) from the terminal leaflet of the 3^{rd} compound leaf and its internode. The samples were fixed in FAA, dehydrated in alcohol series, cleared by xylene and embedded in paraffin wax (52-54°C.mp). Cross sections 15-20 m thick were prepared by a rotary microtome, stained in saffranin-light green combination and mounted in Canada balsam (Gertach, 1977). The sections were examined microscopically and photographed.

Data were subjected to statistical analysis of variance according to Snedecor and Cochran, 1967)

RESULTS AND DISCUSSION

1- Observation during growth:

The general effects of waterlogging were dwarfing and stunting of the plants. The plants were grown slowly and were inferior in size and unhealthy in general appearance. Stem was thin and the rate of leaf production and leaf size was much reduced. Plants showed obvious changes in colour, chlorosis in general, when compared with control plants. Senescence, abscission of the leaves and flower buds were also observed.

2- Morphological characters:

Data in Table (2) show the effects of waterlogging, GA3, kinetin, pBz and their interactions on plant height, number of branches and leaves per plant as well as leaf area per plant of soybean plant during the two growing seasons.

Data in the same table mentioned that waterlogging decreased significantly all the above growth parameters, during the two growing seasons. Growth substances used not only increased significantly number of branches and leaves per plant and leaf area / plant, but also recovered the adverse effect of waterlogging depending on their type and concentrations used.

Regarding the effect of growth substances on plant height. GA_3 and kinetin of two concentrations used not only nullified the depressing effects of waterlogging but also increased significantly plant height. GA_3 at 100 ppm was more effective. While. pBz counteracted the depressing effects of waterlogging on plant height. Moreover, it decreased plant height compared with control.

The depressing effect of waterlogging on plant height may be attributed to the accumulation of fermentation products to toxic levels in the plant media and in the plant organs (Morard and Silvestre, 1996). Ethylene is a natural occurring plant hormone, which responsible for shortening the stem by impeding cell division and elongation (Burg *et al.*, 1971). They added that, waterlogging responses are associated with changes in the production and translocation of hormones, *i.e.*, GA_3 and kinetin. In addition, the adverse effect or waterlogging on plant height may be attributed to a reduction in availability and uptake of essential nutrients and water as well as accumulation of organic and inorganic substances especially Mn^{++} to toxic levels under waterlogging conditions (Sandhu *et al.*, 1986). Mn^{++} toxicity is an important growth-limiting factor for plant growth (Weil *et al.*, 1997).

The decrease in leaf number/plant under waterlogging conditions may be attributed to its effect on increasing ethylene production, which promote senescence and leaf abscission (Jakson and Drew, 1984) through its effect on promoting the synthesis and movement of hydrolytic enzymes such as cellulase (Abeles and Leather, 1971).

The reduction in leaf area per plant may be attributed to the reduction in leaf expansion and increase in stomatal resistance which associated with a decrease in total water use per unit leaf area (Orchard *et al.*, 1986).

The promotive effects of GA3 on plant height may be due to its effects on increasing cell division in sub-apical meristem. In addition, the rapid growth that occurs may be a result of both large number of cells formed and elongation of the individual cells (Sacks, 1961). Moreover, Runkova (1977) reported that GA3 increased plant height by increase in the leaf content of active indolic compounds which accelerated the synthesis of IAA.

The increasing effect of kinetin on plant height may be attributed to its effects on increasing cell division and cell enlargement (Arteca, 1996).

2- Physiological characters:

2-1- Photosynthetic pigments:

Data in Table(3) show that waterlogging treatment decreased chlorophyll a, b and their total as well as carotenoids concentrations. Treatments with kinetin and pB2 at all concentrations used to waterlogged and/or non waterlogged plants increased significantly all photosynthetic pigments in comparison with the control. The most effective treatment was kinetin at 20 ppm. On the other hand, GA3 at 50 ppm had no significant effect on photosynthetic pigments whereas, the high level 100 ppm partially alleviated the adverse effect of waterlogging on these pigments.Similar results were previously reported by Fletcher and Arnold (1986) on cucumber and Fouda (1998) on soybean.

The reduction in photosynthetic pigment concentrations due to waterlogging may be attributed to an increase of ethylene production due to stimulating the synthesis of the ethylene precursor ACC and its conversion to ethylene by ACC-oxidase (Else *et al.*, 1993). Moreover, waterlogging caused damage to root system leading to reduction in cytokinin synthesis and its translocation from root to shoot, thus promoting leaf senescence and abscission (Reid and Bradford, 1984). Jackson (1994) added that waterlogging caused an accumulation of ABA in the leaves. ABA decreased photosynthetic pigment concentrations due to its effects on the promoting chlorophyll breakdown (Hall and Mc Wha 1981) and/or inhibiting chlorophyll synthesis (Bengtson *et al.*, 1977).

The enhancing effect of GA3 on photosynthetic activity may be attributed to an increase in hydrolysis enzymes, and translocation of carbohydrate from the shoot to root (Paul *et al.*, 1992) as well as an increase in number of chloroplasts in young leaves (Brzenkova and Makronozov, 1976).

The increase in photosynthetic pigments due to pBz application may be attributed to an increase in the synthesis of chlorophyll and its content in chloroplast (Fletcher and Arnold, 1986). They added that pBz increased cytokinin content, reducing chlorophyll degradation. Wang and Dunlap (1994) reported that the increase in pigments and delaying senescence due to PBZ treated leaves may be attributed to a great number of chloroplast in mesophyll cell per unit area.

The enhancing effect of kinetin on photosynthetic may be due to the increase in photosynthetic activity of the chloroplast (Nilovskaya *et al.*, 1985). Cytokinins are known to delay senescence (Bardford-Kent, 1983), and lead to increase number of chloroplasts in the leaf (Brzenkova and Makronozov, 1976).

Overcoming the adverse effects of waterlogging by application of GA3 and pB2 may be due to its effect on increasing cytokinin content in the leaves which, stimulate chlorophyll synthesis (Cowie *et al.*, 1996) as well as delay cholorophyll destruction and senescence (Dalziel and Lawrence, 1984). Moreover, pBz caused an inhibition of ethylene production (Grossmann, 1990).

3-2- Total soluble carbohydrates:

Data in Table (4) indicate that total soluble carbohydrates in both shoot and root systems of soybean plants were reduced significantly with waterlogging stress.

Kinetin and pBz at both concentrations used increased significantly this parameter in both shoot and root systems. Kinetin of 20 ppm was most effective in this respect.

Similar results were reported by Sayed (1999). She found that kinetin treated plants accumulated more soluble sugars due to its effects on increasing chlorophyll content and photosynthetic activity. However, GA3 had no significant effect on increasing total sugars in both organs.

The reduction effect of waterlogging on total soluble carbohydrate may be attributed to a reduction in leaf area and photosynthetic pigment concentrations as shown in Tables (2 and 3) and consequently a reduction in photosynthetic capacity and assimilation rate (Davis and Flore, 1986). These effects may probably due to chlorophyll breakdown and acceleration of senescence under stress conditions (Huang *et al.*, 1997).

Moreover, the accumulation of total soluble carbohydrate in the shoots of waterlogged plants may be attributed to a prevention of utilization of sugars by the roots (Barta, 1988).

Table (2): Effects of waterlogging, GA_3; kinetin,BPZ and their interactions on plant height, no. of branches and leaves/plants and leaf area (cm^2)/plant of soybean plant throughout the vegetative growth stage during the two growing seasons of 1998/1999 and 1999/2000.

Treatment			Cont	GA3 50	GA3 100	Kin 10	Kin 20	PBZ 100	PBZ 200	X-	LSD		
												5%	1%
Plant height	1998/1999	Cont	55.0	85.3	97.3	75.0	78.0	47.0	43.3	68.7	W	0.64	0.86
		W	42.7	81.0	85.0	63.0	65.0	34.3	30.3	57.3	G	1.19	1.62
		X	48.9	83.2	91.2	69.7	71.5	40.7	36.8		WG	1.68	2.28
	1999/2000	Cont	62.0	96.0	102	76.7	82.7	49.7	45.0	73.4	W	0.79	1.07
		W	47.0	85.0	91.7	67.0	71.0	41.0	36.3	62.7	G	1.47	2.00
		X	54.5	90.5	96.9	71.9	76.9	45.4	40.7		WG	2.08	2.83
No. of Branches/ Plant	1998/1999	Cont	2.67	2.67	2.33	3.33	4.33	4.33	4.67	3.48	W	0.27	0.36
		W	2.00	2.33	2.00	3.00	3.33	3.00	3.33	2.71	G	0.50	0.68
		X	2.34	2.50	2.17	3.17	3.83	3.67	4.00		WG	0.71	0.96
	1999/2000	Cont	4.00	2.67	3.33	4.33	4.67	4.00	4.33	3.90	W	0.34	0.47
		W	3.33	2.33	2.00	3.33	3.67	3.33	3.33	3.05	G	0.64	0.87
		X	3.67	2.50	2.67	3.83	4.17	3.67	3.83		WG	0.91	1.23
No. of leaves/plant	1998/1999	Cont	4.67	5.33	5.67	7.33	8.00	6.67	7.00	6.38	W	0.33	0.45
		W	3.67	4.33	4.67	6.67	7.67	5.33	6.67	5.57	G	0.62	0.84
		X	4.17	4.83	5.17	7.00	7.84	6.00	6.84		WG	0.88	1.19
	1999/2000	Cont	5.00	5.00	5.33	8.00	9.33	7.67	8.67	7.00	W	0.43	0.58
		W	4.33	4.00	4.33	7.33	8.00	6.33	7.33	5.95	G	0.81	1.09
		X	4.67	4.50	4.83	7.67	8.67	7.00	8.00		WG	NS	NS
Leaf area (cm^2)/plant	1998/1999	Cont	558.8	639.0	683.3	622.4	686.5	616.9	605.1	630.3	W	15.21	30.63
		W	367.3	542.7	582.0	506.4	568.0	577.7	581.0	532.2	G	28.45	38.58
		X	463.1	590.8	632.7	564.4	627.3	597.3	593.1		WG	40.23	54.56
	1999/2000	Cont	516.8	641.8	678.8	676.9	684.6	649.6	662.7	644.5	W	32.69	44.33
		W	346.9	552.2	578.3	583.9	611.9	574.9	598.4	548.2	G	61.16	82.93
		X	431.9	597.0	628.6	630.4	648.3	612.2	626.1		WG	86.49	117.2

Table (3): Effects of waterlogging, GA_3; kinetin,BPZ and their interactions on photosynthetic pigments concentrations (mg/g fresh weight) in terminal leaflet of the 3rd keaf from plant tip of soybean plant throughout the vegetative growth stage during the two growing seasons of 1998/1999 and 1999/2000.

Treatment			Cont	GA3 50	GA3 100	Kin 10	Kin 20	PBZ 100	PBZ 200	X-	LSD		
												5%	1%
CHL A	1998/1999	Cont	1.94	2.00	2.03	2.45	2.63	2.41	2.59	2.29	W	0.18	0.24
		W	1.52	1.79	1.80	2.30	2.93	2.18	2.44	2.14	G	0.33	0.45
		X	1.73	1.90	1.92	2.38	2.78	2.30	2.52		WG	NS	NS
	1999/2000	Cont	2.41	2.13	2.15	3.40	3.47	3.27	3.54	2.91	W	0.17	0.23
		W	1.80	2.32	2.35	2.55	2.61	2.09	2.31	2.29	G	0.32	0.44
		X	2.11	2.23	2.25	2.98	3.04	2.68	2.93		WG	NS	NS
CHL B	1998/1999	Cont	2.02	1.95	2.02	2.15	2.17	2.07	2.09	2.07	W	0.09	0.12
		W	1.63	2.01	2.05	2.07	2.16	2.06	2.08	2.01	G	0.16	0.22
		X	1.83	1.98	2.04	2.11	2.17	2.07	2.09		WG	NS	NS
	1999/2000	Cont	2.10	2.09	2.13	2.91	2.99	2.71	2.85	2.54	W	0.15	0.20
		W	1.75	2.03	2.05	2.47	2.56	2.36	2.53	2.25	G	0.28	0.38
		X	1.93	2.06	2.09	2.69	2.78	2.54	2.69		WG	0.40	0.54
TOTAL CHL	1998/1999	Cont	3.96	3.95	4.05	4.60	4.80	4.47	4.68	4.36	W	0.14	0.18
		W	3.15	3.80	3.85	4.37	5.09	4.24	4.52	4.15	G	0.26	0.35
		X	3.56	3.88	3.95	4.49	4.95	4.36	4.60		WG	0.36	0.49
	1999/2000	Cont	4.51	4.22	4.28	6.31	6.46	5.98	6.39	5.45	W	0.27	0.37
		W	3.55	4.35	4.40	5.02	5.17	4.45	4.84	4.54	G	0.51	0.69
		X	4.03	4.29	4.34	5.67	5.82	5.22	5.62		WG	0.71	0.97
CAROT.	1998/1999	Cont	0.94	1.03	1.03	1.09	1.18	1.07	1.20	1.08	W	0.05	0.06
		W	0.82	0.43	0.83	0.89	1.00	0.84	0.86	0.81	G	0.09	0.12
		X	0.88	0.73	0.93	0.99	1.09	0.96	1.03		WG	0.12	0.16
	1999/2000	Cont	0.96	1.39	1.41	1.50	1.53	1.46	1.58	1.40	W	0.11	0.15
		W	0.85	0.69	0.90	0.83	1.17	0.92	0.99	0.91	G	0.20	0.27
		X	0.91	1.04	1.16	1.17	1.35	1.19	1.29		WG	NS	NS

Table (4): Effect of waterlogging, GA3, kinetin, PBz and their interactions on carbohydrates concentrations mg glucose/g dry weight) in the shoot and root systems of soybean plants during the two growing seasons of 1998/1999 and 1999/2000.

Treatment	Total soluble carbohydrates (mg glucose/g dry weight)											
	shoot						Root					
	1998/1999			1999/2000			1998/1999			1999/2000		
	Cont.	W	X̄	Cont.	W	X̄	Cont.	W	X̄	Cont.	W	X̄
cont	12.1	9.2	10.7	12.0	9.4	10.7	2.40	1.75	2.08	2.21	1.60	1.91
$GA_{3\ 50}$	12.1	10.1	11.1	11.9	9.9	10.9	2.41	2.02	2.22	2.16	1.82	1.99
$GA_{3\ 50}$	12.2	10.9	11.6	12.1	10.5	11.3	2.51	2.12	2.32	2.20	1.98	2.09
$Kin._{10}$	15.2	12.0	13.6	14.9	12.0	13.5	3.59	3.02	3.31	3.27	2.80	3.04
$Kin._{20}$	15.5	12.9	14.2	15.1	13.6	14.4	4.91	3.69	4.30	4.64	3.38	4.01
PBZ_{100}	13.8	11.5	12.7	13.0	11.3	12.2	3.16	2.91	3.04	3.93	2.69	3.31
PBZ_{200}	15.2	11.9	13.6	15.9	12.6	14.3	4.78	3.02	3.90	4.53	2.81	3.67
X̄	13.7	11.2		13.6	11.3		3.39	2.65		3.28	2.44	
LSD	W.	G.	WG	W.	G.	WG	W.	G.	WG	W.	G.	WG
5%	0.41	0.77	1.09	0.41	0.76	1.03	0.17	0.32	0.46	0.17	0.32	0.41
1%	0.56	1.05	1.48	0.55	1.04	1.42	0.24	0.44	0.62	0.23	0.43	0.60

The stimulating effects of GA3 application on carbohydrate concentrations may be attributed to its effect on enhancing the translocation of sucrose.

3- Yield and its components

Waterlogging treatments decreased significantly yield and its components represented by pods weight and number per plant, as well as seed weight per plant in the two growing seasons (Table 5).

Plants grown under waterlogging and non-waterlogging conditions and treated with all growth substances at two used concentrations had high yield parameters. The growth substances used decreased the adverse effects of waterlogging on seed yield and the effects depend on their types and concentrations. Kinetin at 20 ppm was most effective in this respect. Similar results were obtained by Fouda (1998) on soybean and Leul and Zhou Weijun (1999) on rape.

The reduction in yield and its components due to waterlogging may be due to a decrease in branches number carrying pods (Table 2) and photosynthetic pigments (Table 3). Moreover, the reduction in seed yield due to waterlogging may be back to the death of some stem apices, many recently opened flower and some young pods as well as inhibition of the floral development (Cowie *et al.*, 1996). Evan's (1982) noted that the reduction in seed yield due to waterlogging may be attributed to the reduction in assimilates translocation to reproductive organs and reduced nitrogen fixation during flowering.

GA3 increased number of pods/plant due to an increase in the flowering period (Castro and Vello,. 1983b), thus producing more flowers resulting in more pods (Castro *et al.*, 1987).

The effects of growth substances on overcoming the adverse effects of waterlogging on yield may be attributed to an increase in branches and leaf numbers; leaf area, photosynthetic pigments formation and consequently photosynthetic activity.

4- Seed quality:

Data presented in Table (6) indicate that soybean seed oil and protein percentages decreased significantly with waterlogging stress. On the other hand, application of growth substances at the two concentrations used increased these parameters. The best treatment was found with kinetin (20 ppm), which alleviated the harmful impact of waterlogging on both seed oil and protein percentages and consequently increased the two plant components.

The decreasing effect of waterlogging on seed oil and protein percentages may be due to its effects on triacylglycerol (TAG) enzymes synthesis, especially diacylglycerol acyltranferase (DAGT) (Tzen *et al.*, 1993 and Ross and Murphy, 1993). In addition, waterlogging stress inhibits nitrogen fixation (Hwang *et al.*, 1995) and reduces nitrogen content in soil solution (Gambrell and Patrick, 1978).

The increase in oil percentage due to kinetin and pBz as noticed in the present investigation may be attributed to their functions in preventing the hydrolytic breakdown of oil naturally occurring in the plants, as a result of the balance between the endogenous plant hormones (Schive and Sisler, 1976 and Young *et al.*, 1994).

Table (5) Yield and its component of soybean plants treated with waterlogging at the vegetative growth stage, GA_3; kinetin,BPZ and their interactions during the two growing seasons of 1998/1999 and 1999/2000.

Treatment			Cont	GA3 50	GA3 100	Kin 10	Kin 20	PBZ 100	PBZ 200	X-	LSD		
												5%	1%
Whole pods weight (g)	1998/ 1999	Cont	42.8	47.8	50.2	46.7	48.7	47.5	52.1	48.0	W	1.32	1.79
		W	35.9	43.5	44.3	55.5	59.1	47.0	50.4	48.0	G	2.47	3.35
		X	39.4	45.7	47.3	51.1	53.9	47.3	51.3		WG	3.49	4.47
	1999/ 2000	Cont	39.2	47.8	50.6	60.4	67.9	66.2	60.1	56.0	W	0.24	0.33
		W	31.5	44.5	47.6	58.7	66.3	50.8	55.2	50.7	G	0.45	0.61
		X	35.4	46.2	49.1	59.6	67.1	58.5	57.7		WG	0.64	0.87
Pods no./ plant	1998/ 1999	Cont	68.3	81.0	84.7	88.7	92.3	78.0	83.0	82.3	W	0.31	1.78
		W	52.0	70.3	71.0	80.7	82.3	72.7	75.7	72.1	G	2.45	3.32
		X	60.2	75.7	77.9	84.7	87.3	75.4	79.4		WG	3.5	4.70
	1999/ 2000	Cont	63.7	84.0	93.7	109	111	99.7	107	95.4	W	2.12	2.88
		W	43.3	65.0	68.0	84.7	87.0	69.7	75.0	70.4	G	3.97	5.38
		X	53.5	74.5	80.9	96.9	99.0	84.7	91.0		WG	5.61	7.61
Seed weight/plant (g)	1998/ 1999	Cont	23.8	24.5	27.5	32.5	34.5	30.0	30.9	29.1	W	0.69	0.94
		W	20.4	23.9	25.5	30.8	32.5	27.1	28.2	26.9	G	1.29	1.75
		X	22.1	24.2	26.5	31.7	33.5	28.6	29.6		WG	1.83	2.48
	1999/ 2000	Cont	24.0	26.6	27.6	31.0	33.8	29.7	30.2	29.0	W	0.18	0.24
		W	20.7	24.3	25.8	29.5	32.1	27.6	28.1	26.9	G	0.33	0.45
		X	22.4	25.5	26.7	30.3	33.0	28.7	29.2		WG	0.47	0.64

Table (6): Effects of waterlogging at vegetative growth stage, GA_3; kinetin,BPZ and their interactions on oil and protein percentage in the seeds of soybean plant during the two growing seasons of 1998/1999 and 1999/2000.

Treatment			Cont	GA3 50	GA3 100	Kin 10	Kin 20	PBZ 100	PBZ 200	X-	LSD		
												5%	1%
Oil%	1998/1999	Cont	19.7	20.4	20.2	22.3	23.3	20.4	21.1	21.1	W	0.24	0.32
		W	17.9	19.8	19.8	20.8	21.9	20.5	21.7	20.3	G	0.44	0.60
		X	18.8	20.1	20.0	21.6	22.6	20.5	21.4		WG	0.06	0.09
	1999/2000	Cont	19.5	20.3	19.9	21.3	23.2	21.8	22.5	21.2	W	0.22	0.30
		W	17.2	19.9	19.8	20.6	21.5	19.7	20.5	19.9	G	0.41	0.57
		X	18.4	20.1	19.9	21.0	22.4	20.8	21.5		WG	0.05	0.08
Protein%	1998/1999	Cont	41.0	40.7	42.6	46.9	47.7	45.1	46.0	44.3	W	0.59	0.81
		W	36.0	30.1	30.0	36.4	37.0	34.5	35.2	34.2	G	1.11	1.51
		X	38.5	35.4	36.3	41.7	42.4	39.8	40.6		WG	1.57	2.13
	1999/2000	Cont	40.6	40.3	42.1	46.5	47.2	44.6	45.3	43.8	W	0.57	0.80
		W	35.5	29.5	29.4	35.8	36.3	34.1	34.6	33.6	G	1.09	1.48
		X	38.1	34.9	35.8	41.2	41.8	39.4	40.0		WG	1.55	2.11

The increase in protein percentage due to the application of pBz may be attributed to its effect on increasing cytokinin, which increased the activity of cytoplasm ribosomes leading to stimulation of RNA synthesis followed by an increase in protein synthesis (Sankhla *et al.*, 1992). They stated that the increase in protein level may be due to an increase in the amino acid content and activities of the enzyme systems related to soluble protein.

6- Anatomical structure:

6-1 Leaflet structure:

Data in Table (7) and Fig. (1.B) show that waterlogging decreased the thickness of leaflet blade as a result of decreasing thickness of palisade and spongy tissues. The size of the mid-vein vascular bundle was also decreased as indicated by its dimensions as well as xylem and phloem tissues thickness. In addition, metaxylem vessels diameter was also decreased.

Treatment with GA3, kinetin and pBz as well as their interactions with waterlogging at two concentrations used increased the previous parameters compared with those of the control (Figs. 1 and 2). Kinetin at high concentration (20 ppm) was the most effective in this respect.

6- 2 Stem structure:

Data in Table (8) and Fig. (3B) indicated that waterlogging treatment decreased stem diameter, cortex thickness, number of cortical cell layers, large vascular bundle dimension, phloem, xylem tissues thickness and pith tissue diameter. Metaxylem vessel diameter was also decreased.

Data in the same Table and illustrated in Figs.3 and 4 show that GA3, kinetin and pBz as well as interactions with waterlogging increased the previous anatomical parameters compared with those of the control. Kinetin at high concentration (20 ppm) was the most effective in this respect.

The increase in stem diameter due to application of GA3 and kinetin may be attributed to their effects on promotion of cell division and cell enlargement (Artica, 1996). In addition, an increase in cortex thickness, pith tissue and vascular bundles dimension in Table (8).

The increase in vascular bundle dimensions may be due to a stimulation in the cambial cell activity forming secondary vascular tissues (Fouda, 1998). The increase in stem diameter due to application of pBz may be attributed to its promotive effects on lateral cell division and enlargement (Barlow *et al.*, 1991). They added that the increase in stem diameter by uniconazole may be attributed to its effect on increasing number and size of cortical cells.

From the previous results, it could be concluded that waterlogging treatment during the vegetative growth stage decreased plant growth, photosynthetic pigments content, total soluble carbohydrate in both shoot and root systems, yield and its components as well as seed quality represented by N, P, K, and oil percentages in the seeds of soybean plant. In addition, it modified the internal structure of both leaf and stem. Treatment with both kinetin at 10 and 20 ppm and PBz at 100 and 200 ppm used are recommended for recovery the adverse effects of waterlogging. Moreover, GA3 treatment at high concentration (100 ppm) partially alleviated the adverse effects of waterlogging.

Table (7): Some anatomical characters in the terminal leaflet of soybean plant taken from the 3[rd] leaf from the plant tip as affected by waterlogging, GA_3; kinetin,BPZ and their interaction throughout the vegetative growth stage during the two growing seasons of 1998/1999 and 1999/2000.

Treatment	Leaflet thickness (µm)	Mesophyll tissue thickness (µm)	Palisade tissue thickness (µm)	Spongy tissue thickness (µm)	Midrib VB dimensions		Xylem tissue thickness (µm)	Phloem tissue thickness (µm)	Metaxylem vessele diameter (µm)
					length	width			
Control	1280	233	115	118	336	550	200	156	65
Waterlogging (W)	980	166	64	52	246	449	160	123	54
GA_3 100	1190	290	162	128	408	650	239	185	75
GA_3 200	1130	298	173	141	411	654	235	188	84
Kin 10	1753	340	196	144	541	719	271	217	92
Kin 20	1773	372	199	173	593	767	291	225	126
PBZ 100	1712	339	186	153	486	716	260	209	105
PBZ 200	1734	335	192	143	492	666	264	215	122
W. GA_3 100	1130	201	113	88	340	551	210	153	60
W. GA_3 200	1100	208	108	100	342	555	206	157	64
W. kin 10	1356	258	145	113	425	621	243	185	90
W. kin 20	1379	287	159	128	452	668	263	193	91
W. PBZ 100	1316	255	137	118	400	619	232	176	82
W. PBZ 200	1335	251	141	110	431	567	237	182	86
LSD 5 %	333.8	32.9	0.94	110.9	76	30.9	59.7	10.2	20.7
LSD 1 %	414.9	44.9	1.29	151.5	103.9	42.3	81.6	13.9	64.8

Table (8): Some anatomical characters in soybean plant stems taken from the 3rd internodesfrom the plant tip as affected by waterlogging, GA_3; kinetin,BPZ and their interaction throughout the vegetative growth stage during the two growing seasons of 1998/1999 and 1999/2000.

Treatment		Stem diameter (µm)	Cortex thickness (µm)	No. of cortical layers	Pith tissue diameter (µm)	VB L Dimensions (µm)		Phloem tissue thickness (µm)	Xylem tissue thickness (µm)	Metaxylem vessele diameter (µm)
						Length	Width			
Control		3100	310	7.7	2086	590	620	246.7	346.7	86.7
Waterlogging (W)		1570	267	6.3	880	492	632.5	200	287.5	93
GA_3 100		2933	296	7	1850	696	969.7	210	486.7	85.3
GA_3 200		2920	335	7.5	1785	647	820	200	447.5	73
Kin 10		3970	395	8	2380	926	1052.5	342.5	577.5	106
Kin 20		4046	403	8.7	2533	846	1103.3	296.7	550	76
PBZ 100		4490	430	9	2937	800	985	365	460	55
PBZ 200		4670	423	8.5	3055	807	1130	287.5	520	88
W. GA_3 100		2900	323	7.3	1780	653	616.7	203.3	453.3	96
W. GA_3 200		2710	355	7.8	1645	567	730	290	362.5	84
W. kin 10		3606	430	8.3	2153	893	926.7	393.3	500	70.7
W. kin 20		3620	377	8.5	2298	745	947.5	265	530	82
W. PBZ 100		7020	370	8.7	2573	876	1100	296.7	580	80
W. PBZ 200		4100	370	9	2586	673	710	253.3	420	137.3
LSD	5 %	153.3	17.8	0.7	30	21.7	26.2	11.6	16.6	17.8
	1 %	209.4	24.3	0.8	41.1	29.6	35.8	15.8	22.7	24.3

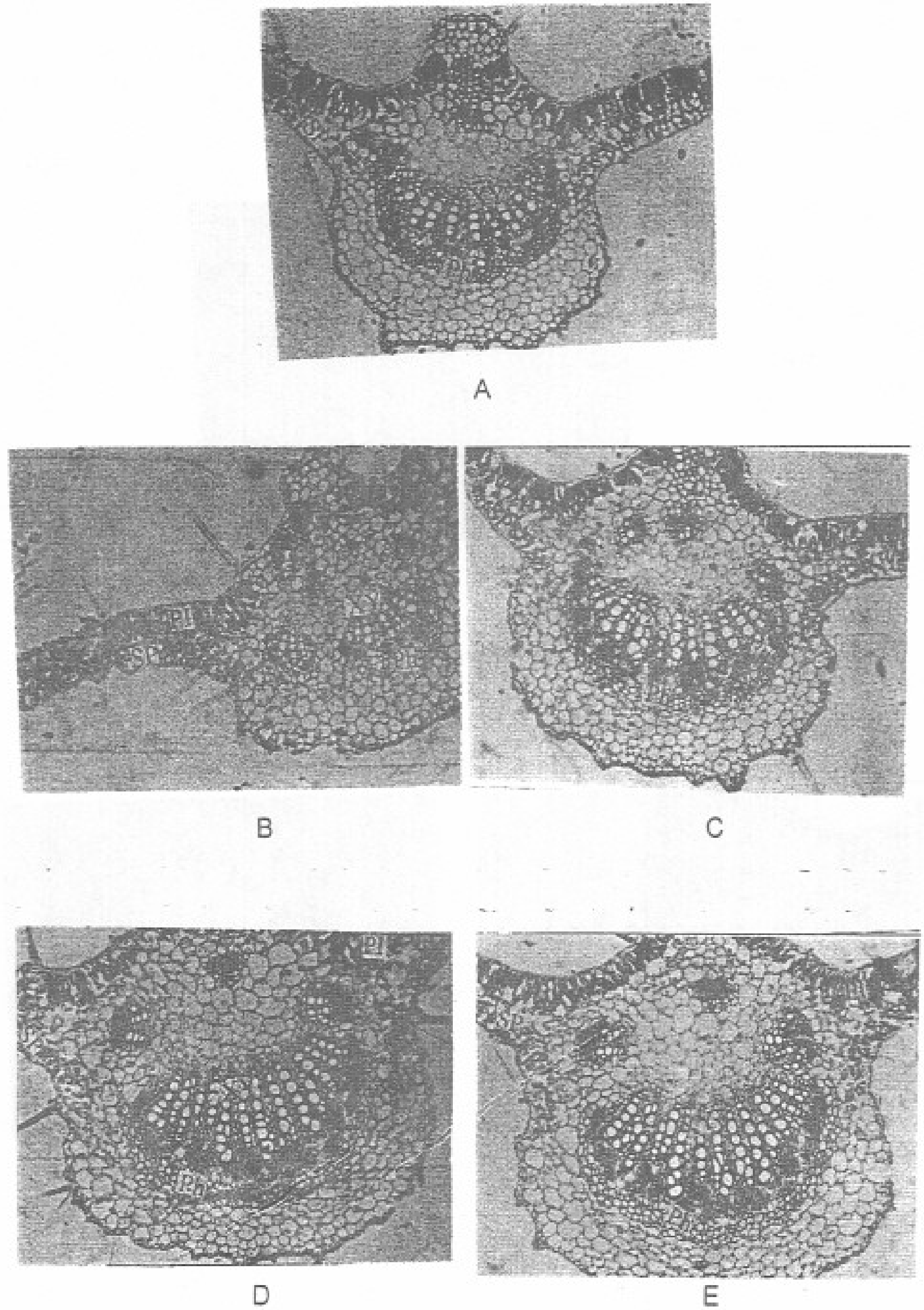

Fig (1): Cross section of the terminal leaflet of the 3rd leaf from the soybean plant tip affected by water logging and some growth substance (Objx10. Oc.x15) A: control B: water logging C: GA_3 100 ppm D: Kinetin 20 ppm E: PBz 200 ppm. pL: palisade tissue sp: spongy tissue X: xylem Ph: phloem.

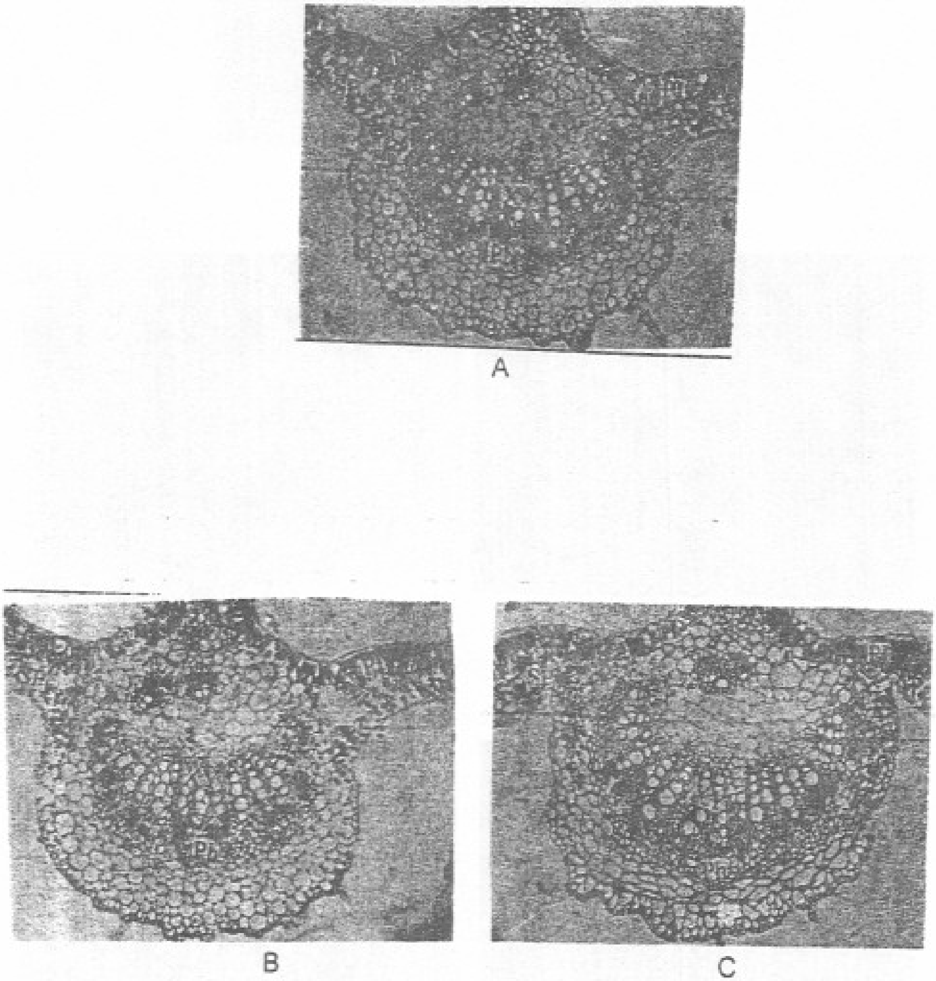

Fig (2): Cross section of the terminal leaflet of the 3rd leaf from the soybean plant tip as affected by water logging and some growth substance (Objx10. Oc.x15) A: W+GA_3 100ppm B: W+ Kinetin 20ppm C: W+ PBz 200 ppm

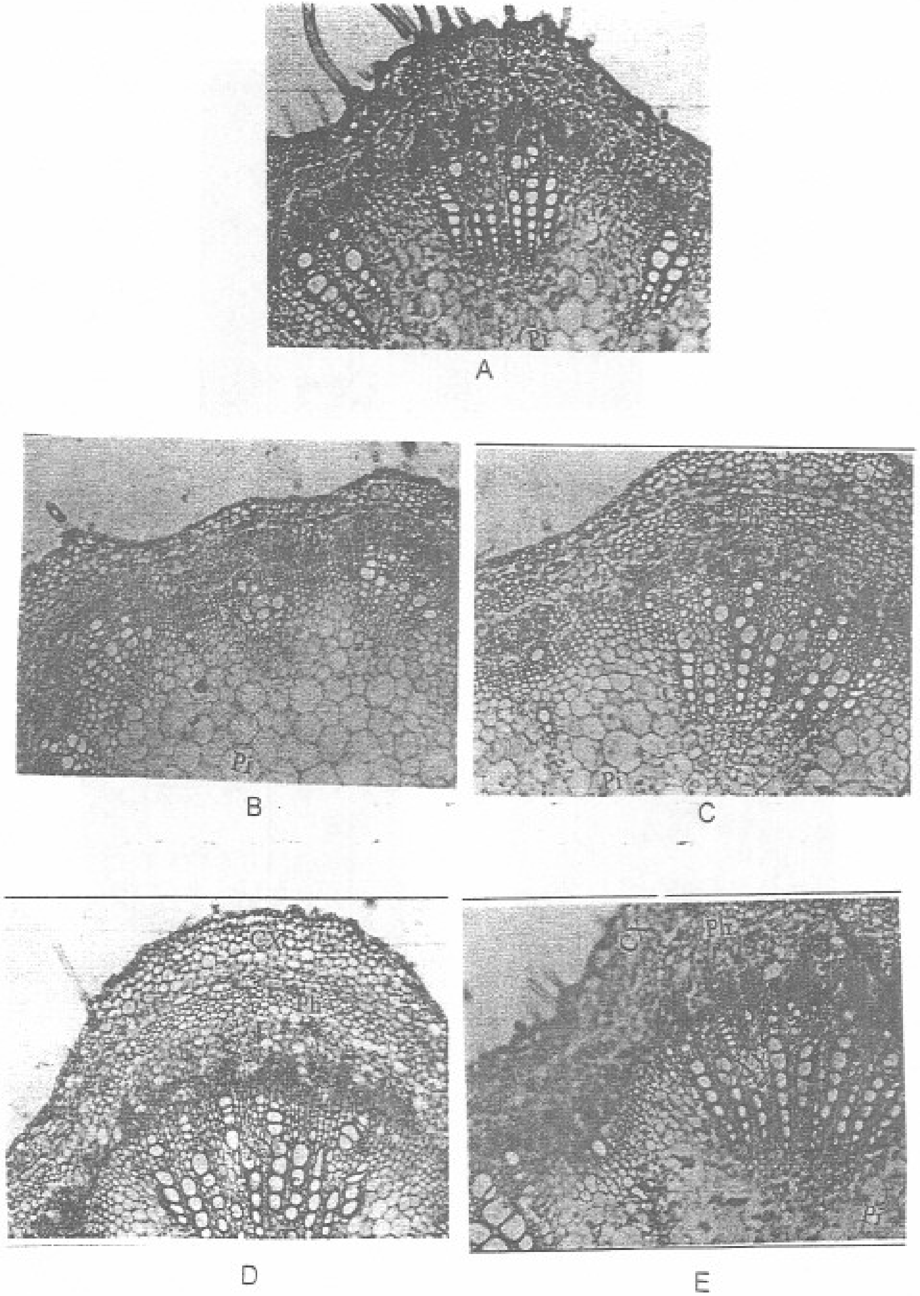

Fig (3): Cross section of the 3rd soybean internode from the plant tip as affected by water logging and some growth substances (Objx10. Oc.x15) A: control B: water logging C: GA_3 100 ppm D: Kinetin 20 ppm E: PBz 200 ppm.

Fig (4): Cross section of the 3rd soybean internode from the plant tip as affected by water logging and some growth substances (Objx10. Oc.x15) A: W+GA3 100ppm B: W+ Kinetin 20ppm C: W+ PBz 200 ppm.

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بعض لإستجابات المورفولوجية والفسيولوجية والتشريحية لنبات فول الصويا للغدق وبعض مواد النمو

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نظرا لتعرض بعض النباتات الإقتصادية الهامة لظروف العزق خلال مراحل النمو المختلفة نتيجة للرى الغزر وارتفاع مستوى الماء الأرضى فقد إستهدف هذا البحث دراسة بعض الاستجابات المورفولوجية والفسيولوجية والتشريحية لنبات فول الصويا للعزق لمدة ٥ أيام خلال فترة النمو الخضرى وكذلك حمض الجبريلليك بتركيز ٥٠، ١٠٠ جزء فى المليون، الكينتين بتركيز ١٠، ٢٠ جزء فى المليون والباكلوبترازول بتركيز ١٠٠، ٢٠٠ جزء فى المليون ودراسة دور هذه المواد فى تقليل الأثر الضار للعزق وكانت أهم النتائج كالتالى:

١- أدى العزق إلى نقص طول النبات وعدد الأفرع والأوراق ومساحة الورقة للنبات ومحتوى صبغات البناء الضوئى فى الأوراق وكذلك محتوى الكربوهيدرات فى كل من المجموع الخضرى والجذرى كما أدى إلى نقص عدد القرون ووزن القرون والبذور للنبات ومحتوى البذور من البروتين والزيت وكذلك نقص سمك الوريقة نتيجة لنقص سمك النسيج العمادى والإسفنجي وأبعاد الحزمة الوعائية الرئيسية كما أدى إلى نقص قطر الساق نتيجة لنقص سمك نسيج القشرة وعدد طبقات خلاياها وأبعاد الحزمة الوعائية على الجانب الآخر أدت المعاملة بمواد النمو بالتركيزات المستخدمة إلى زيادة جميع الصفات السابقة مقارنة بالنباتات الغير معاملة أو التى تعرضت للعزق فيما عدا طول النبات مع المعاملة بالباكلوبترازول كما أدت المعاملة بتلك المواد إلى تلافى التأثيرات الضارة للعزق وكانت المعاملة بكل من الباكلوبترازول والكينين بتركيز جزء فى المليون إلى تلافى التأثيرات الضارة للعزق جزئيا.