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MORPHOLOGICAL AND ANATOMICAL STUDIES ON GUAR PLANTS (*Cyamopsis tetragonoloba* L.) GROWN UNDER DIFFERENT LEVELS OF SALINITY

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ABSTRACT

A pot experiment was conducted in a wirehouse for studying the effect of different levels of salinity on morphology, anatomy and yield of guar plant at the different stages of growth. Results indicated that averages of all studied characters at the different stages of growth were decreased by all used levels of salinity. Effect of salinity was increased progressively with raising salinity level and reached its maximum at 6000 ppm.

At seedling stage, the highest decrease percentages were, 49.35% in seedling height, 42.72% in epicotyl length, 62.5% in first internode length and 57.58% in number of internodes/main stem less than the control. As to the vegetative growth stage, the highest decrease percentages were 71.12% in plant height, 85.40% in 5th internode length and 40.43% in number of internodes/main stem below the control. Concerning the flowering stage, the highest decrease percentages were, 65.93% in plant height, 26.70% in number of internodes/main stem, 84.31% in number of branches/plant, 85.53% in whole plant fresh weight and 85.21% in whole plant dry weight lower than the control. Similarly in maturity stage the highest decrease percentages were, 39.85% in plant height and 30.82% in number of internodes/main stem below the control. Moreover, the highest decrease percentages in yield and yield components were 78.68% in number of pods/plant, 23.19% in number of seeds/pod, 86.77% in number of seeds/plant, 91.64% in yield of seeds/ plant and 55.43% in seed index, less than the control.

Anatomical studies of transverse sections in the first internode and main root, revealed that 6000 ppm salinity reduced the whole diameter of cross section by 29.9% in stem and 30.8% in root, less than the control, due to the decrease in thickness of all included tissues. Longitudinal sections in stem of treated plants, showed a reduction in both length and width of the medullary cells. By contracts, treatment of salinity increased the whole diameter of hypocotyl by 10.8% and the thickness of cotyledon blade by 23.4% higher than the control. Moreover, as indicated before, all results of salinity showed a prominent decrease in the amount of xylem due to reducing in the size and number of vessels.

INTRODUCTION

Guar, (*Cyamopsis tetragonoloba* L.) is a leguminous plant of semiarid regions (Omar *et al.*, 1993), being moderately tolerant to salinity and drought. It gives high yield under favorable conditions and needs low nitrogen fertilization. The plant is slightly troubled by pests and diseases (Stutzel, 1989). Therefore, it is recommended to grow a belt of guar plants surrounding cotton fields to protect the fields from pests.

Guar is originally grown in India and Pakistan as a vegetable and green manure crop. It is used as a summer forage crop rich in protein (16%),

instead of corn (9% protein). Guar gives two cuttings, the first is after two months (10 tons/fed.) while the second is after another month (6 tons/fed.). A yield of seeds (500 kg/fed.) could be obtained after taking one cutting only. Moreover, a gum is extracted from the seeds, and is used in many food industries and medical purposes. Seeds are used also as a laxative (Stafford and Hymowitz, 1980).

Salt tolerance of many crops varies at different growth stages, and the seedling stage is the most sensitive stage. Lahiri *et al.,* (1987) reported that guar plant is moderately salt tolerant, and therefore, it is recommended to be grown in newly reclaimed lands in Egypt.

Several researches indicate that application of salt to guar plants reduced the vegetative growth and yield (Goverdhan and Singh, 1980; Maliwal and Paliwal, 1982; Kumar *et al.*, 1988; Khan *et al.*, 1989; Francois *et al.*, 1990; Garg *et al.*, 1997 and Afria, 1998).

The present research aimed to study the effect of different levels of salinity on morphological and anatomical characters of guar plant at different growth stages.

MATERIALS AND METHODS

A pot experiment was conducted in a wirehouse at the Agricultural Experiments and Researches Station, Faculty of Agriculture, Cairo University, Giza, Egypt.

Seeds of guar, cv. Local Land Race were secured from Forage Crop Research Department, Agricultural Research Center, Giza. The experiment was conducted in a complete randomized block design of 4 treatments with 12 replicates each.

Salinity and planting: four salinity levels (0, 2000, 4000 and 6000 ppm) were prepared by mixing sodium chloride, calcium chloride and magnesium sulphate at the rate of 2:2:1 by weight, respectively. The following amounts of salt mixture were added for each kg. Soil:
2 grams/kg. soil [0.8g Na cl + 0.8g Ca cl2 + 0.4g Mg so4], 4 grams/kg. soil [1.6g Na cl + 1.6g Ca cl2 + 0.8g Mg so4], and 6 grams/kg. soil [2.4g Na cl + 2.4g Ca cl2 + 1.2g Mg so4] to achieve 2000, 4000 and 6000 ppm salinity, respectively.

Guar seeds were sown on 25th May 2002, in black plastic pots 30cm. in diameter, each was filled with 9 kg. mixture of loam soil and sand (2:1 by weight). Ten seeds per pot were sown, irrigated with one liter of tap water/pot weekly. Plants were thinned to 4 plants per pot at age of 35 days and to 2 plants/pot at 60 days.

Morphological characters:

Data for the following parameters were recorded on 10 plants (one plant from each pot)

I. **Seedling stage, at the age of 35 days:**
   1. Seedling height (cm.).
   2. Length of epicotyl (cm.).

3. Length of first internode (cm.) from the stem base.
4. Number of internodes per main stem.

II. Vegetative stage, at the age of 60 days:

1. Plant height (cm.).
2. Length of 5th internode (cm.) from the stem base..
3. Number of internodes per main stem.

III. Flowering stage, at the age of 100 days:

1. Plant height (cm.).
2. Number of internodes per main stem.
3. Number of branches per plant.
4. Fresh and dry weight (g.) of the various plant organs, shoots, leaves and roots.

IV. Maturity stage, at the age of 150days:

1. Vegetative characters:
   - Plant height (cm.).
   - Number of internodes per main stem.
2. Yield and yield components:
   - Number of pods/plant.
   - Number of seeds/pod.
   - Number of seeds/plant.
   - Yield of seeds/plant (g.).
   - Seed index (g.), (weight of 100 seeds).

Anatomical studies:

Certain vegetative samples from the most effective treatment that showed the highest morphological variations (6000ppm salinity), were taken at the age of 35 days, to study the effect of salinity on the anatomical structure of different plant organs.

Specimens were taken from the middle of the main root, epicotyl, cotyledon and first basal internode of the main stem. Specimens were killed and fixed in F.A.A. (10 ml. formalin, 5ml. glacial acetic acid and 85 ml. ethyl alcohol 70%). Fixed materials were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series, and embedded in paraffin wax (m.p. 56°C). Sections 20µ thick were cut, stained by crystal violet and erythrosin combination (Jackson, 1926), cleared in xylene and mounted in Canada balsam (Willey, 1971).

RESULTS

I. Morophological studies:

Seedling stage:

Table (1) indicates average measurements (cm.) of seedling height, epicotyl length, first internode length and number of internodes per main stem, under different salinity levels.

Results showed that seedling height was significantly less than the control in the three salinity levels (Fig.1), and the decrease was corresponding with the increase of salinity level, being 24.89, 35.92 and 49.35% for 2000, 4000 and 6000 ppm salinity, respectively. The same trend

was present in epicotly length as measurements were significantly lower than the control in the three salinity levels, and the decrease was corresponding with the increase of salinity level, giving 21.96, 34.37 and 42.72% for 2000, 4000 and 6000 ppm salinity respectively.

Similarly, the lengths of 1st internode of the three levels were significantly less than the control, and the decrease was corresponding with the increase of salinity, being 29.58, 47.50 and 62.50% for 2000, 4000 and 6000 ppm salinity respectively. As to the internode numbers/main stem, it was decreased gradually with increasing the level of salinity with significant differences at the two higher levels (4000 and 6000 ppm) only, compared with the control. The highest decrease was achieved at 6000 ppm salinity, being 57.58% less than the control.

Table (1): Average of some vegetative characters of guar plant, at the seedling stage (35 days after sowing), as affected by different levels of salinity (average of 10 plants).

Character / Treatment	Seedling height (cm)	Epicotyl length (cm)	First internode length (cm)	Number of internodes per main stem
Control	11.61 a	4.19 a	2.40 a	3.30 a
2000 ppm	8.72 b	3.27 b	1.69 b	2.90 a
4000 ppm	7.44 c	2.75 b c	1.26 bc	1.90 b
6000 ppm	5.88 d	2.40 c	0.90 c	1.40 b
L.S.D. 0.05	0.89	0.71	0.51	0.65

Means having the same letter are not significantly different at 0.05 level.

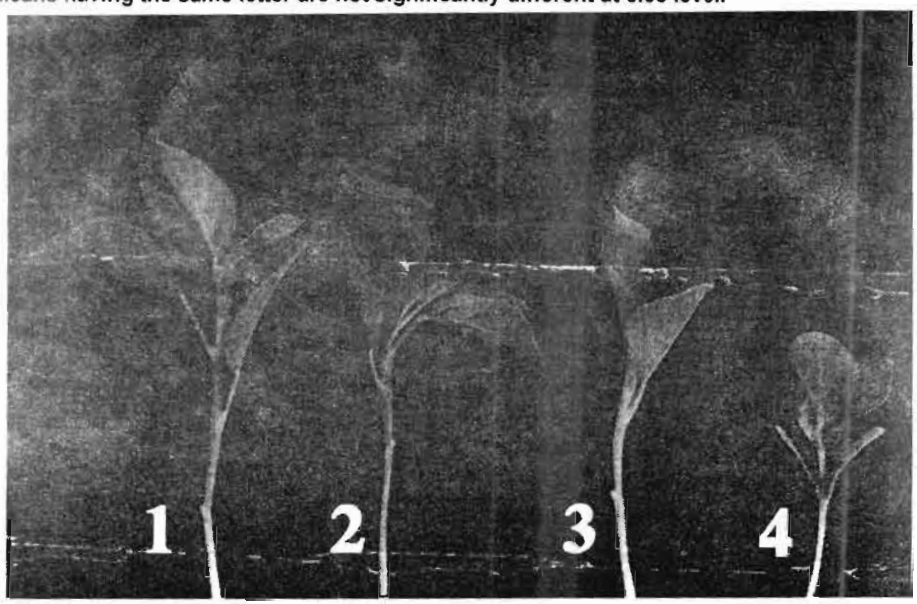

Fig. (1): seedlings of guar plant, as affected by different levels of salinity, at the age of 35 days.

1: control 2: 2000 ppm 3: 4000 ppm 4: 6000 ppm

Vegetative stage:

Table (2) indicates average measurements of plant height (cm.), length of 5th internode (cm.) and average number of internodes/main stem at the vegetative growth stage (at the age of 60 days). It is evident that the three levels of salinity significantly decreased plant height, the average length of internode and the average number of internodes per main stem than their controls and the decrease was corresponding with the increase of salinity levels. In the three studied characters the highest decrease was achieved by 6000-ppm salinity, being 71.12, 85.40 and 40.43% for plant height, 5th internode length and number of internodes per main stem, respectively.

Table (2): Average of some vegetative characters of guar plant, at the age of 60 days after sowing, as affected by different levels of salinity (average of 10 plants).

Character / Treatment	plant height (cm)	5th internode length (cm)	Number of internodes per main stem (cm)
Control	39.78 a	5.89 a	9.40 a
2000 ppm	15.74 b	1.04 b	6.60 b
4000 ppm	14.13 b c	0.96 b	2.75 b
6000 ppm	11.49 c	0.86 b	2.40 b
L.S.D. 0.05	3.74	0.8	1.2

Means having the same letter are not significantly different at 0.05 level.

Flowering stage:

Results of some vegetative characters of guar plant under three salinity levels at the flowering stage are presented in Table (3). The three salinity levels significantly decreased plant height, the number of internodes of the main stem and the number of branches/plant, less than their controls. The decrease was corresponding with the increase of salinity level.

In the three studied characters the treatment with 6000-ppm salinity gave the highest decrease percentages, being 65.93, 26.70 and 84.31% for plant height, number of internodes of main stem and number of branches per plant, respectively.

Averages of fresh and dry weights of shoots, leaves, roots and whole plant are presented in Tables (4 and 5), respectively. It is clear that fresh and dry weights of all organs of guar plant were significantly decreased with the three salinity levels, and the decrease was corresponding with the increase in salinity. The maximum decrease percentages in fresh and dry weights of all plant organs were achieved by the treatment with 6000ppm salinity, being 87.43, 84.57, 76.94 and 85.53% in fresh weights, and 89.48, 79.33, 86.69 and 85.21% in dry weights for shoots, leaves, roots and whole plant, respectively.

Table (3): Average of some vegetative characters of guar plant, at the age of 100 days after sowing, as affected by different levels of salinity (average of 10 plants).

Character / Treatment	plant height (cm)	Number of internodes per main stem (cm)	Number of branches per plant
Control	130.10 a	35.20 a	5.10 a
2000 ppm	82.58 b	29.30 b	2.60 b
4000 ppm	63.16 c	26.80 c	1.10 c
6000 ppm	44.33 d	25.80 d	0.80 c
L.S.D. 0.05	11.34	0.97	1.29

Means having the same letter are not significantly different at 0.05 level.

Table (4): Average of fresh weight of different guar plant organs, at the age of 100 days after sowing, as affected by various levels of salinity (average of 10 plants).

Character / Treatment	Shoots fresh weight (g)	Leaves fresh weight (g)	Roots fresh weight (g)	whole plant fresh weight (g)
Control	62.70 a	57.10 a	7.46 a	127.26 a
2000 ppm	22.83 b	25.02 b	4.95 b	52.80 b
4000 ppm	9.26 c	9.75 c	1.82 c	20.83 c
6000 ppm	7.88 d	8.81 d	1.72 c	18.42 d
L.S.D. 0.05	0.06	0.13	0.54	0.31

Means having the same letter are not significantly different at 0.05 level.

Table (5): Average of dry weight of different guar plant organs, at the age of 100 days after sowing, as affected by different levels of salinity (average of 10 plants).

Character / Treatment	Shoots dry weight (g)	Leaves dry weight (g)	Roots dry weight (g)	whole plant dry weight (g)
Control	13.31 a	10.69 a	3.38 a	27.38 a
2000 ppm	4.30 b	6.11 b	2.04 b	12.45 b
4000 ppm	1.57 c	2.63 c	0.56 c	4.76 c
6000 ppm	1.40 d	2.21 d	0.45 d	4.05 d
L.S.D. 0.05	0.02	0.24	0.004	0.04

Maturity stage:

Averages of plant height and number of internodes of the main stem under three salinity levels at maturity stage are given in Table (6). It is obvious that the three salinity levels significantly decreased plant height and internodes number of main stem, compared with the control plants. Also the decrease was corresponding with the increase of salinity level. Salinity level of 6000 ppm gave the lowest results and the decrease percentages were 39.85% in plant height and 30.82% in internodes number of main stem.

Results of yield and yield components under the three salinity levels are indicated in Table (7). The three salinity levels significantly decreased all studied characters than the control plant except in number of seeds per pod, in which the difference was significant only between the control and 6000 ppm salinity. In all levels of salinity the decrease was corresponding with the increase of salinity. The maximum decrease was observed at 6000 ppm, being 78.68, 86.77, 91.64, 55.43 and 23.19% for number of pods/plant, number of seeds/plant, yield of seeds/plant, seed index and number of seeds/pod, respectively.

Table (6): Average of some vegetative characters of guar plant, at the age of 150 days after sowing, as affected by different levels of salinity (average of 10 plants).

Character / Treatment	Plant height (cm.)	Number of internodes/main stem
Control	182.2 a	43.8 a
2000 ppm	148.4 b	34.5 b
4000 ppm	120.3 c	31.9 b c
6000 ppm	109.6 c	30.3 c
L.S.D. 0.05	13.70	2.95

Means having the same letter are not significantly different at 0.05 level.

Table (7): Average of some reproductive characters of guar plant, at the age of 150 days after sowing, as affected by different levels of salinity (average of 10 plants).

Character / Treatment	Number of pods per plant	Number of seeds per pod	Number of seeds per plant	Yield of seeds per plant (g.)	Seed index (weight of 100 seeds g.)
Control	57.70 a	6.9 a	46.7 a	18.27 a	4.38 a
2000 ppm	21.80 b	6.5 a	124.9 b	5.51 b	2.95 b
4000 ppm	13.60 b	6.2 a	65.3 b	1.87 c	2.15 c
6000 ppm	12.30 b	5.3 b	59.1 b	1.53 c	1.95 c
L.S.D. 0.05	10.52	0.81	66.00	2.39	0.35

Means having the same letter are not significantly different at 0.05 level.

II. Anatomical studies:

This part of study aimed to prove the effect of salinity on the internal structure of guar plant. Transverse sections in the first basal internode, hypocotyl, cotyledon and root of guar plant at the age of 35 days, as treated with 6000 ppm salinity and its controls were examined.

The stem structure

Fig. (2) and Table (8) revealed that salinity decreased the diameter of cross section of the first internode, being 29.9% less than the control. This reduction was accompanied by a decrease in all included tissues, as the decrease percentages were, 40, 9.4, 30.8, 14.3 and 20% for epidermis thickness, cortex thickness, pith diameter and number of both large and small vascular bundles, respectively.

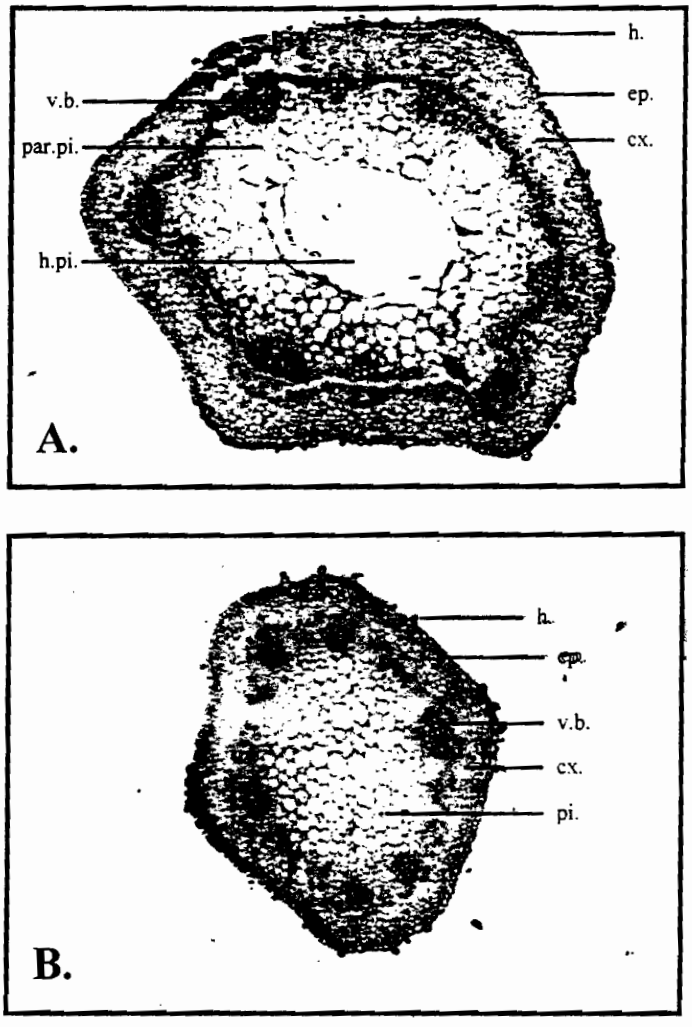

Fig. (2): Transverse sections through the first internode of the main stem in guar seedling. as affected by 6000 ppm salinity, at the age of 35 days. (X40)

A: Untreated seedling.
B: Seedling treated with 6000 ppm.

h.. hair; ep.. epidermis: cx.. cortex; v.b.. vascular bundle: par.pi.. parenchyma pith: h.pi., hollow pith.

As to the number of vessels per bundle, it was also reduced by salinity compared with the control, giving decrease percentages of 31.8 and 55.6% for the large and small bundles, respectively. Longitudinal sections through the first internode indicated that salinity at 6000 ppm decreased the medullary cells by 30.5 and 20.2% in length and width lower than control, respectively (Fig. 3).

Table (8): Averages of different anatomical parameters (in μ) of the first internode of guar plant at the age of 35 days, as affected by 6000 ppm salinity (means of three specimens).

Anatomical characters	Control	6000 ppm
1. Transverse section		
Diameter of cross section	1588	1113.6
Thickness of:		
Epidermis	28.8	17.3
Cortex	153.6	139.2
Number of vascular bumdles:		
Large	7	6
Small	10	8
Diameter of pith	968.6	670.8
Number of vessels/bundle:		
Large	22.3	15.2
Small	9	4
2. Longitudinal section:		
Length of medullary cell	147.8	102.7
Width of medullary cell	66.2	52.8

The hypocotyl structure:

Fig. (4) and Table (9) showed that salinity at 6000 ppm increased the diameter of the hypocotyl by 10.8% higher than the control. The increment of hypocotyl diameter was due mainly to the increase in epidermis thickness by 33.3%, cortex thickness by 39.1% and pith diameter by 4%, compared with the control. On the other hand the thickness of xylem was decreased by 13.8%, lower than the control.

Cotyledon structure:

Transverse sections in the cotyledon of guar seedling, as affected by 6000 ppm salinity, showed that treatment caused considerable increase in thickness of blade (23.4%) and midrib (21.6%) higher than the control. The increment of blade thickness was due mainly to the increase in thickness of palisade layer as well as spongy tissue, being 25 and 27.3% higher than the control, respectively. On the contrary, midvein dimensions and number of vessels/bundle were decreased by salinity. The decrease in midvein size was attributed mainly to the reduction in the amount of xylem, due to the decrease in both number and size of vessels, (Table 10 and Fig. 5).

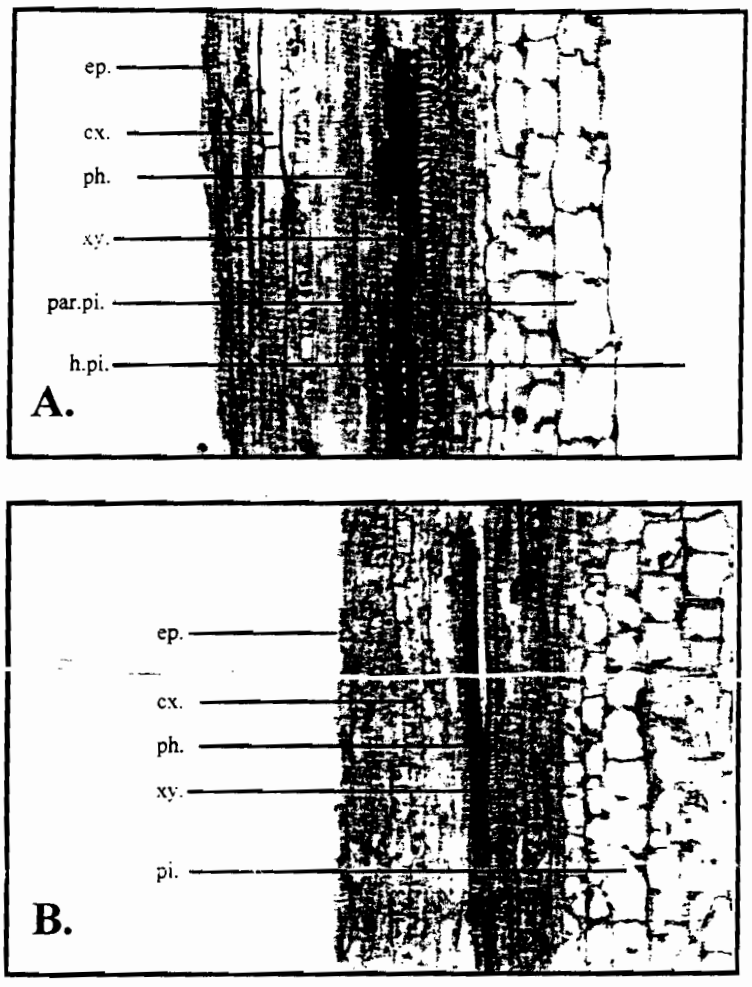

Fig. (3): Longitudinal sections through the first internode of the main stem in guar seedling, as affected by 6000 ppm salinity, at the age of 35 days. (X100)

A: Untreated seedling.
B: Seedling treated with 6000 ppm.

ep.. epidermis; cx.. cortex; ph., phloem; xy., xylem: par.pi.. parenchyma pith: pi.. pith: h.pi.. hollow pith.

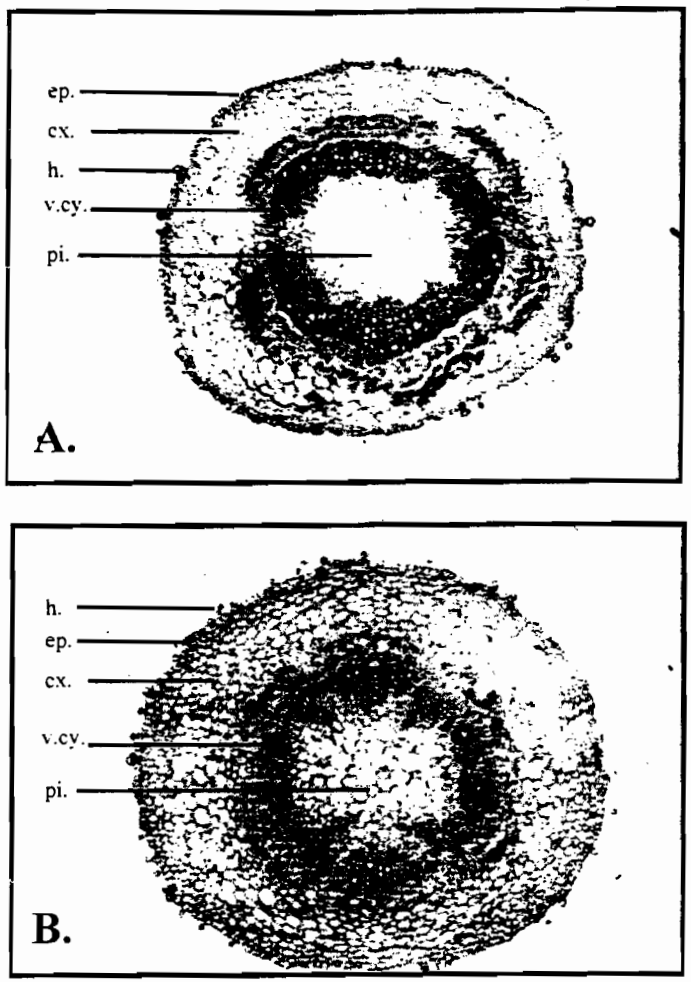

Fig. (4): Transverse sections in the hypocotyl of guar seedling as affected by 6000 ppm salinity, at the age of 35 days. (X40)

A: Untreated seedling.
B: Seedling treated with 6000 ppm.

h.. hair; ep.. epidermis; cx.. cortex; v.cy.. vascular cylinder; pi.. pith.

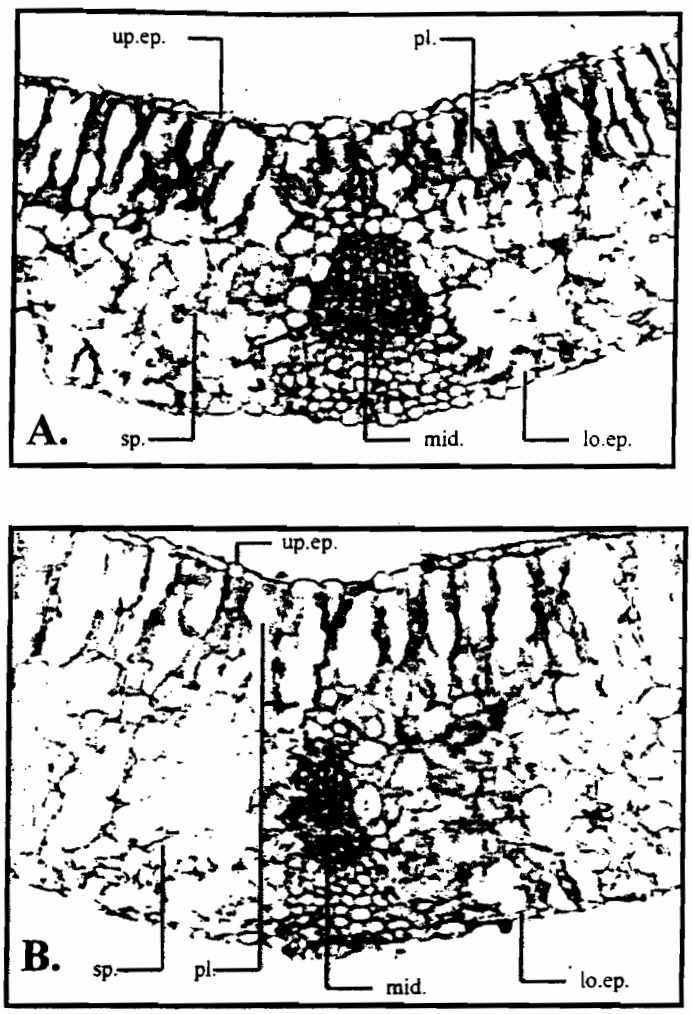

Fig. (5): Transverse sections in cotyledon of guar seedling, as affected by 6000 ppm salinity, at the age of 35 days. (X100)

A: Untreated seedling.
B: Seedling treated with 6000 ppm.

up.ep.. upper epidermis: lo.ep.. lower epidermis; pl.. palisade tissue: sp.. spongy tissue: mid.. midvein bundle.

Table (9): Averages of certain anatomical measurments (in µ) of the hypocotyl of guar plant at the age of 35 days, as affected by 6000 ppm salinity (means of three specimens).

Anatomical characters	Control	6000 ppm
Diameters of the hypocotyl	1489.9	1651.2
Thickness of:		
Epidermis	23.1	30.7
Cortex	201.6	280.3
Xylem	167.1	144.0
Pith diameter	480.6	499.7

Root structure:

From table (11) and Fig. (6) it is realized that salinity at the level of 6000 ppm reduced the root diameter of guar plant, at the age of 35 dayes, by 30.8% less than the control. This could be attributed mainly to the prominent decrease in the amount of xylem, due to the reduction in number and size of vessels, compared with the control Table (11).

Table (10): Averages of different anatomical measurments (in µ) of the cotyledon of guar plant at the age of 35 days, as affected by 6000 ppm salinity (means of three specimens).

Anatomical characters	Control	6000 ppm
Thickness of:		
Blade	451.2	586.8
Palisade tissue	192.0	240.0
Spongy tissue	211.2	268.8
Midrib	489.6	595.2
Dimensions of midvein bundle		
Length	211.2	192.0
Width	192.0	115.2
Number of vessels/bundle	26	16

Table (11): **Measurements (in µ) of some anatomical characters in transverse sections in the root of guar plant, at the age of 35 days, as affected by 6000 ppm salinity (means of three specimens).**

Anatomical characters	Control	6000 ppm
Diameter of the root	748.8	518.4
Diameter of xylem	365.8	240.0
Diameter of vessel	38.4	26.4

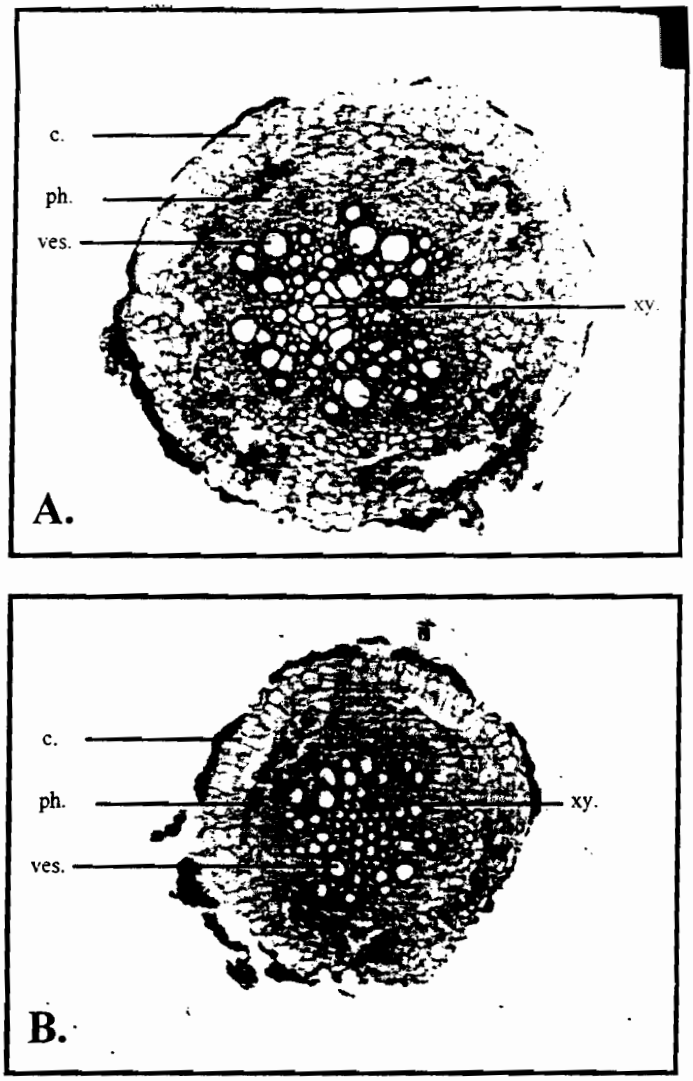

Fig. (6): Transverse sections in the root of guar seedling, as affected by 6000 ppm salinity. at the age of 35 days. (X100)

A: Untreated seedling.
B: Seedling treated with 6000 ppm.

c., cork; ph., phloem; xy., xylem; ves., vessel.

DISCUSSION

It is obvious from the previous results that, generally, all adopted levels of salinity reduced the averages of the vegetative characters at the different stages of growth and yield components with significant differences in most cases. The effect of salinity varied with the growth stage. The seedling stage was the least in sensitivity to salt, as the decreases were less than the following stages. This result is in contrast with that of Garg *et al.* (1987). While the vegetative stage was severely affected with salinity. Moreover, in all growth stages the treatment with 6000 ppm salinity gave the highest decreases in all studied characters.

I. Morphological studies:

Seedling stage:

The highest decrease percentages were 49.35% in seedling height, 42.72% in epicotyl length, 62.50% in first internode length and 57.58% in number of internodes per seedling main stem. These findings are generally in agreement with those of Goverdhan and singh (1980); Maliwal and Paliwal (1982); Datta and Dayal (1988); Kumar *et al.* (1988); Garg *et al.* (1997) on guar plant, and Promila and Kumar (2000) on mung bean.

Vegetative stage:

Similarly, the highest decrease percentages were 71.12, 40.43 and 85.40% less than the control for plant height, number of internodes/main stem and 5th internode length, respectively. The decrease in plant height was reported by Kumar *et al.* (1988) on guar plant and Elham (2002) on mung bean.

Flowering stage:

The results of flowering stage, showed that the decrease percentages were 65.93, 26.70 and 84.31% less than the control, for plant height, number of internodes/main stem and number of branches/plant, respectively. The decrease in the averages of fresh and dry weights of the various plant organs were 87.43, 84.57, 76.94 and 85.53% for the fresh weight and 89.48, 79.33, 86.69 and 85.21% for dry weight in shoots, leaves, roots and whole plant, respectively. This reduction was due to the decrease in the vegetative characters. The reduction in fresh and dry weights was recorded by Datta and Dayal (1988) on guar seedling, Egeh and Zamora (1992) reported that plant height and dry matter production of mung bean decreased with increasing salinity levels.

Maturity stage:

In this stage the decreases were 39.85 and 30.82% for plant height and number of internodes/main stem, respectively. As to the number of pods/plant, number of seeds/pod, number of seeds/plant, yield of seeds/plant and seed index, were 78.68, 23.19, 86.77, 91.64 and 55.43% respectively less than the control. The decrease in number of pods/plant was reflected on decreasing number of seeds/plant, and the latter, along with the seed index, were responsible for the reduction in the yield of seeds/plant. These results

for reduction in plant height and yield components were in accordance with those reported by Kumar *et al.* (1988); Khan *et al.* (1989); Francois *et al.* (1990) and Afria *et al.* (1998) on guar plant.

II. Anatomical studies:

Salinity caused a considerable reduction in the diameter of both main stem and root by 29.9 and 30.8% respectively compared with the control. This was due mainly to the decrease in all included tissues. The longitudinal sections of internode, showed that treatment reduced the dimensions of the medullary cells by 30.5% in length and 20.2% in width. This result indicates that the shortening of stem induced by salinity was due to retarding the elongation of cells. These findings are generally in agreement with those of Soliman (1984) on soybean; Nagdy *et al.* (1989) on soybean and Elham (2002) on mung bean.

On the other hand, salinity increased the diameter of hypocotyl by 10.8% and the cotyledon blade by 23.4% more than the control. The increase in thickness of cotyledon blade was, in general, in accordance with those found on the leaf by Longstreth and Nobel (1979) on guar plant, Gonzalez *et al.* (2000) on 9 forage legumes; Rhee *et al.* (2001) on tomato and Elham (2002) on mung bean.

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دراسات مورفولوجية وتشريحية علي نباتات الجوار النامية تحت تأثير تركيزات مختلفة من الملوحة.

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لجري هذا البحث في محطة التجارب بكلية الزراعة جامعة القاهرة بالجيزة لدراسة تأثير تركيزات مختلفة من الملوحة علي كل من الصفات الخضرية – المحصول ومكوناته والتركيب التشريحي لنبات الجوار. أجريت التجربة في أصص حيث استخدمت ثلاثة تركيزات من الملوحة هى ٢٠٠٠، ٤٠٠٠، ٦٠٠٠ جزء في المليون بالإضافة إلى معاملة الكنترول. أخذت القياسات خلال أربعة مراحل من النمو وهي مرحلة البادرة – النمو الخضري – التزهير وأخيرا مرحلة النضج (الحصاد).

أوضحت التجربة أن الملوحة بصفة عامة أثرت علي جميع الصفات تحت الدراسة في كل مراحل النمو بالنقص مقارنة بالكنترول. ووجد أن التأثير يزداد بزيادة تركيز الأملاح حيث كانت أكثر المعاملات تأثيرا هي اعلي تركيز (٦٠٠٠ جزء في المليون) ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

أولا الصفات المورفولوجية:

مرحلة البادرة (عمر ٣٥ يوم من الزراعة):

أثرت الملوحة بالنقص في كل من ارتفاع البادرة – طول السويقة الجنينية – طول السلامية الأولي (القاعدية) وعدد سلاميات الساق الرئيسية للبادرة حيث بلغ أقصي نقص ٤٩,٣٥، ٤٢,٧٢، ٦٢,٥٠، ٥٧,٥٨% أقل من الكنترول للصفات السابقة علي التوالي

مرحلة النمو الخضري (عمر ٦٠ يوم من الزراعة):

أخذت قياسات ارتفاع النبات – طول السلامية الخامسة وعدد سلاميات الساق الرئيسية وجميعها تأثرت بالنقص نتيجة المعاملة بالملوحة حيث سجل أقصي نقص وهو ٧١,١٢، ٨٥,٤٠، ٤٠,٤٣% اقل من الكنترول لكل من الصفات السابقة علي التوالي

مرحلة التزهير (عمر ١٠٠ يوم من الزراعة):

سجل النقص في ارتفاع النبات – عدد سلاميات الساق الرئيسية وعدد أفرع النبات حيث كان أقصي نقص هو ٦٥,٩٣، ٢٦,٧٠، ٨٤,٣١% أقل من الكنترول علي التوالي. كما قدر الوزن الرطب والجاف لأعضاء النبات المختلفة حيث سجلت جميعها نقص ملحوظ وكانت النسبة المئوية للنقص ٨٧,٤٣، ٨٤,٥٧، ٧٦,٩٤، ٨٥,٥٣% للوزن الرطب ، ٨٩,٤٨، ٧٩,٣٣، ٨٦,٦٩، ٨٥,٢١% للوزن الجاف لكل من السوق – الأوراق – الجذور والنبات الكلي علي التوالي.

مرحلة النضج (الحصاد عمر ١٥٠ يوم من الزراعة):

سجل أقصي نقص لبعض الصفات الخضرية حيث بلغ ٣٩,٨٥، ٣٠,٨٢% اقل من نباتات المقارنة لكل من ارتفاع النبات وعدد سلاميات الساق الرئيسية علي التوالي. ومن ناحية أخري بلغ أقصي نقص في المحصول ٧٨,٦٨، ٢٣,١٩، ٨٦,٧٧، ٩١,٦٤، ٥٥,٤٣% أقل من الكنترول لكل من عدد القرون علي النبات – عدد البذور في القرن – عدد البذور علي النبات – محصول النبات من البذور والوزن النوعي للبذور (وزن ١٠٠ بذرة) علي التوالي.

ثانيا الصفات التشريحية:

الساق: أظهرت القطاعات العرضية في السلامية الأولي القاعدية للبادرة أن زيادة الملوحة في التربة أدت إلى نقص ملحوظ في قطر السلامية وذلك نتيجة لنقص في سمك جميع الأنسجة البشرة – القشرة وقطر النخاع الذي لم يظهر به تجويف مقارنة بالكنترول. كذلك حدث نقص في سمك الاسطوانة الوعائية نتيجة لنقص في كمية الخشب بسبب نقص حجم وعدد الأوعية بالحزمة علاوة علي النقص في عدد الحزم الوعائية. كما أظهرت القطاعات الطولية لنفس السلامية نقص في طول وعرض الخلايا البرانشيمية المكونة للنسيج الأساسي نتيجة لزيادة الملوحة.

السويقة الجنينية: تسببت زيادة الملوحة في زيادة قطر السويقة الجنينية نتيجة لزيادة سمك كل من القشرة والنخاع بينما قل سمك الاسطوانة الوعائية لنقص كمية الخشب نتيجة لقلة حجم وعدد أوعية الخشب.

الورقة الفلقية: أظهرت القطاعات العرضية في الورقة الفلقية زيادة في سمك النصل نتيجة لزيادة سمك كل من البشرة العليا والسفلي وكل من النسيج العمادي والإسفنجي نتيجة لزيادة حجم الخلايا وعلي العكس من ذلك حدث نقص في حجم الحزمة الوعائية لنقص حجم وعدد أوعية الخشب نتيجة لزيادة الملوحة.

الجذر: أظهرت القطاعات العرضية في الجذر أن زيادة الملوحة أدت إلى نقص واضح في قطر الجذر وهذا النقص يرجع معظمه إلى نقص ملحوظ في حجم وعدد عناصر الخشب.