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DIFFERENTIAL RESPONSES OF TWO CULTIVARS OF FLAX TO DIFFERENT LEVELS OF SALINITY .I. CHANGES IN CERTAIN GROWTH CRITERIA AND ENDOGENOUS CROWTH HORMONES

BY

M. Abd El-Hamid and Laila M. Zaky

Biology Dept, Faculty of Education,

Ain Shams University

ABSTRACT

Application of different levels of salinity in irrigation water (0, 2000, 4000 & 6000 ppm) to Giza 5 & Reina cultivars of flax plant, resulted in a differential responses in two different directions particularly at the highest level of salinity (6000 ppm).

The plants of Reina cultivar responded positively and exhibited stimulation in the growth criteria and yield, whereas the plants of Giza 5 cultivar followed a reverse situation. On the other hand, the plants of the two cultivars responded similarly to the low and moderate levels of salinity (2000 & 4000 ppm) but differed in the magnitude of the response.

It is suggested that, the plants of Reina cultivar are more tolerant to

salinity than those of Giza 5 cultivar. The difference in the magnitude of response between the plants of the two cultivars was discussed on the basis of the differential changes in the contents and activity levels of the endogenous growth hormones.

INTRODUCTION

Soil salinity is one of the most important factors affecting growth and yield of plants. It represents one of the main problems facing those who are interested in agriculture and plant physiology (Mass and Nieman, 1978).

Through the last few years, the problem of salinity has recieved much attention in Egypt due to the lack of good quality of water obtained from the River Nile owing to the reduction of its water level. On the other hand, the newely reclaimed areas which are far from the main course of the Nile or one of its branches, depends mainly on water of low quality pumped either from wells or collective drains. All of these water sources contain high levels of salinity.

The effect of salinity on the growth and yield of many plants have been reported by many investigators. In certain plant species, the response may be shown as a marked stimulation of the growth and yield. In this connection, we can

refer to the work of: Bakr Ahmed et.al.(1970); Ahmed et. al. (1977, 1978); Khalil et. al. (1978); Singh et.al. (1982), Ahmed et. al.(1983). Al-Rawi and Lazim (1983) ; Shalaby et. al. (1983) and Wassif et.al. (1983). On the other hand, the response may be reflected in the form of a severe reduction of the growth and yield of plants as reported by some authors. Balba (1960); Strogonov (1962); Hutton (1971); Lashin & Atansiu (1972). Shalhavet & Yaron (1973). Abaza et.al. (1974); Ghazi (1976); Heikal(1976); Heikal et.al. (1980 a, b); and Aly (1987). Generally, whatever the response of plants to the salinization treatments, the magnitude of such response varied according to the level of salinity and the species of plant.

Regarding the changes in the endogenous hormones (auxins, gibberellins & cytokinins) as influenced by salinization treatment and the reflection of such change on the growth and development of plants, limited work was carried out in this field (Itai and Vaadia, 1965. Itai et.al.1968, Browning, 1973; Zabadal, 1974 and Ghazi, 1976).

The present paper presents the differential responses of two cultivars of flax to salinization treatments for evaluating their tolerance to soil salinity and to bring into focus the change in growth and yield of plants in relation to the concomitant changes in the endogenous growth hormones in response to the salinization treatments.

MATERIALS AND METHODS

Two cultivars of flax plant (Linum usitatissimum. L) were used in the present investigation. They were :

1. Giza 5 : local variety, started to be released from 1978. It was originated from the cross between Giza 4 and Precederia in Field Crops Research Institute, Agricultural Research Center.

2. Reina : a fiber type variety imported from Holland.
A pure lot of the seeds of both cultivars was kindely obtained from Agricultural Research Center, Giza, A.R. Egypt.

Time Course Experiment :

Pot experiment was conducted in an open-air wirehouse at the Faculty of Education during the growing season. Seeds of both cultivars were sown on November 20th 1987 in 320 large unglazed pots(40 cm Ø) containing equal amounts of homogenous soil collected from the upper 30 cm layer from the Botanical Garden of the Faculty of Education, Ain Shams University. The pots were irrigated with equal volumes of tap water. Two weeks later, thinning was done so that ten uniform seedlings were left in each pot for experimentation. The plants were exposed to normal day length and natural illumination.

The pots of each cultivar (160 pots in each) were divided into 4 groups, 40 pots each. The plants of the 1st group were irrigated with tap water to serve as control, whereas

those of the 2nd, 3rd & 4th groups were irrigated with 2000, 4000 & 6000 ppm of salinity levels respectively. The saline solution was composed of a mixture of Nacl + $Cacl_2$ (2:1 by weight). The plants of all treatments were irrigated occasionally with certain volume of tap water to keep the salinity level constant.

When the capsules of the differently treated and untreated plants attained full maturity, the following parameters were analysed in the shoot system :

1. Total length of stem (cm).
2. Technical length of stem (cm).
3. Straw yield / feddan (in tons).
4. Fiber yield / feddan (in tons).
5. Fiber percentage.

The data of the different treatments were statistically analysed using the least significant difference (L.S.D) at 1% and 5% levels of probability.

Extraction, separation and bioassay of growth hormones

Extraction : The method of extraction of the growth substances was essentially similar to that described by Zaky (1985).

Separation : Strip loading of the plant extract, each representing 0.5 g dry weight of plant tissue, was carr-

ied out on Whatman No. 1 paper chromatography and developed using isopropanol : ammonia : water (10: 1:1 V/V) in a descending manner. The dried chromatograms were cut into 10 equal strips which were eluted overnight at 5°C with distilled water.

Bioassay : The method used to assay the activity of auxins and growth inhibitors was the straight growth test of Hordeum coleoptile as adopted by Foda and Radwan (1962). The method used for the bioassay of gibberellins and gibberellin-like substances was similar to that adopted by Bently - Mowat (1966). The method used for the bioassay of cytokinins was essentially that of Esashi & Leopold (1969).

The results of the bioassays were analysed statistically using the method of the least significant difference (L.S.D) at 5% level of probability. The significant activities of auxins and growth inhibitors, gibberellins and gibberellin - like substances, and cytokinins are represented by shaded areas.

RESULTS

I. Changes in growth and yield components :

A- Total length of shoots :

It is obvious from Table 1 that, the shoot length of Giza 5 cultivar of flax plant was found to be either

significantly increased in the plants irrigated with the lowest concentration used of salinity (2000 ppm), or highly significantly increased in the plants irrigated with the medium concentration used of salinity (4000 ppm) over that of the control. On the other hand, the shoot length of the plants irrigated with the highest concentration used (6000 ppm) was found to be significantly decreased below that of the control.

Regarding the response of Reina cultivar to the same levels of salinity, it is evident that the shoot length of the treated plants followed a different trend as compared with that of Giza 5 cultivar. At all levels of salinity used (2000. 4000 & 6000 ppm), the shoot length was highly significantly increased.

B- Technical length of shoots :

The technical length of Giza 5 cultivar shoots was found to be highly significantly increased in plants treated with 2000 & 4000 ppm of salinity levels as compared with that of the control. On the other hand, in response to treatment with the highest level of salinity (6000 ppm), the technical length of the shoot appeared to be non significantly affected.

As concerning the change in the technical length of

Reina cultivar plants, it was found that at all salinity levels used, the technical length was remarkably increased over that of the corresponding control. This increase was found to be either highly significantly increased at 2000 & 4000 ppm of salinity level or significantly increased at the highest concentration used (6000 ppm).

C- Straw yield / feddan :

The changes in the straw yield / feddan of both Giza 5 and Reina cultivars in response to treatment with various levels of salinity were found to follow the same pattern of change as the technical length of the shoots (Table 1).

D- Fiber yield / feddan :

As regards Giza 5 cultivar, the fiber yield/feddan was found to be highly significantly increased at the relatively low levels of salinity (2000 & 4000 ppm), whereas the same character was highly significantly decreased in plants irrigated with the highest level of salinity (6000 ppm).

In Reina cultivar plants, the pattern of change in fiber yield/feddan was quite different. It was highly significantly increased at all levels of salinity.

E- Fiber percentage :

The fiber percentage of both Giza 5 and Reina cultivars showed highly significant increases in response to the irrigation of plants with the relatively low levels of salinity (2000 & 4000 ppm). On the other hand, the same character was found to be highly significantly decreased in Giza 5 cultivar and non significantly affected in Reina cultivar due to treatment with the highest level of salinity (6000 ppm).

II. Changes in the endogenous growth hormones :

A: Changes in auxins and growth inhibitors contents :

The pattern of changes in auxins and growth inhibitors in the control plants and those irrigated with the different levels of salinity are illustrated in fig.(1).

It is apparent that the extract of the control plants of Giza 5 cultivar contained at least 4 growth promoting zones having significant auxin activity, the R_f of which are at : 0.0 - 0.2, 0.2 - 0.4, 0.4 - 0.6 and 0.8 - 1.0. The last two zones appeared likely to be indole acetic acid (IAA) and indole acetonitrile (IAN) since they produced the same positive colour reactions with the reagents testing for indole substances as the authentic compounds. In addition the same extract appeared to contain one significant growth inhibiting zone (R_f: 0.6 - 0.8)

which appeared to be unsaturated lactone since it gave a positive colour reaction with diazotized p - nitroaniline reagent.

The extracts of plants irrigated with the lowest level of salinity (2000 ppm), showed a marked increase in the activity levels of the growth promoting zones which appeared to be unchanged in its number but their R_f values were different as compared with those of the corresponding control. Their R_f values ranged between : 0.0 - 0.2, 0.3 - 0.5, 0.5 - 0.7 and 0.7 - 0.9.

The extract of plants treated with the moderate level of salinity (4000 ppm) contained the highest number of significant growth promoting zones which reached their maximum activity levels as compared with that of the untreated plants and that of the treated ones.

On the other hand, the highest level of salinity (6000 ppm) caused a sharp decrease in the content and the activity levels of the growth promoting zones. The zones of IAA sharply decreased and IAN disappeared completely and two significant growth inhibiting zones (R_f:0.1 - 0.2 & 0.7 - 0.9) appeared in the extract of plants treated with that highest level of salinity.

Concerning auxins and growth inhibitors of Reina cultivar, it is clearly shown from the histogram illus-

trated in fig.(1) that, the extract of the untreated plants contained 4 growth promoting zones having significant auxin activity, all of which appeared to contain indole compounds. The R_f values of which ranged between: 0.1 - 0.3, 0.3 - 0.5, 0.6 - 0.8 and 0.8 - 0.9. On the other hand, only one growth inhibiting zone was found in the same extract (R_f: 0.5 - 0.6).

The content and the activity levels of growth promoting zones which have the significant auxin activity were progressively and markedly increased as the level of salinity was increased. However, this increase in the auxin activity was accompanied by complete disappearance of the growth inhibitors at 2000 and 4000 ppm salinity level. On the other hand, the highest level of salinity used (6000 ppm) increased slightly the auxin activity as compared with that of the control.

It is of interest to mention that in all treatments of salinity, both IAA and IAN did not disappear from the extracts of the treated Reina plants.

B: Changes in gibberellin contents :

The results of changes in gibberellins and gibberellin-like substances of differently salinized - treated and untreated plants of both Giza 5 and Reina cultivars are

illustrated in fig. (2).

It is clearly shown that the extract of the untreated plants of Giza 5 cultivar contained at least 4 growth promoting zones having significant gibberellin activities, the R_f values of which ranged between : 0.0 - 0.1, 0.1 - 0.3, 0.4 - 0.6 and 0.7 - 0.9 respectively. All of the previously detected zones appeared likely to contain gibberellin compounds since they produced a positive colour reaction with the reagent testing for gibberellins. Treating plants with the relatively low levels of salinity (2000 & 4000 ppm) caused marked and progressive increase in the content and activity levels of the zones having significant gibberellin activities without any change in their number. On the other hand, the highest level of salinity (6000 ppm) did not cause any obvious change in the biological activity of the extract since the content and the activity levels of the detected zones having gibberellin activities appeared to be more or less comparable to those appeared in the extract of the control plants.

It is of worthy mentioning that all zones detected in extracts of the differently treated plants of Giza 5 cultivar appeared to contain gibberellin-like substances, since they produced negative colour reactions with the reagent testing for gibberellins with the exception of the zone detected at R_f ranged between : 0.6 - 0.8 in the extract of plants treated with the lowest level of salinity (2000

ppm) which exhibited gibberellin nature since it gave positive colour reaction with the previous reagent.

With regard to Reina cultivar plants, it is clear that treatment with various levels of salinity resulted in marked and progressive increases in the content and the activity levels of the promoting zones having significant gibberellin activities which reached their maximum in the extracts of plants treated with the moderate level of salinity (4000 ppm). In the extract of the plants treated with the highest level of salinity (6000 ppm), the biological activities and the contents of the significant gibberellins were found to be lowered slightly as being compared with those detected in the extracts of plants treated with the relatively lower levels of salinity (2000 & 4000 ppm), but still higher than those detected in the corresponding control.

It is of interest to mention that, the observed marked progressive increases in the gibberellin contents of the Reina cultivar plants in response to salinization treatments, were accompanied by the appearance of gibberellin compounds in the extracts of these plants on one hand, since all zones detected gave a positive colour reaction with the reagent testing for gibberellins, and the increase in the content and the activity level of the zone detected at R_f 0.6 - 0.8 which was corresponding to GA_3

on the other hand.

C: Changes in cytokinin contents :

The results of the changes in cytokinins due to salinization treatments of Giza 5 and Reina cultivars are illustrated in Fig. (3).

It is clearly shown that, the fractionated extract of the control plants of Giza 5 cultivar exhibited cytokinin activity represented by 4 significant zones. The R_f of which are nearly at : 0.1 - 0.2, 0.3 - 0.5, 0.5 - 0.7 and 0.7 - 0.9 respectively. The colour test of the previously mentioned zones indicates that these zones are occupied by cytokinin compounds of purine nature. On the other hand, the extracts of the corresponding control of Reina cultivar exhibited cytokinin activity represented by only 3 significant zones. Their R_f values are nearly at : 0.2 - 0.4, 0.4 - 0.5 and 0.6 - 0.8 respectively, all of which are of purine nature since they gave positive colour reactions with the reagent testing for purines. The activity levels of the significant zones which appeared in the fractionated extract of Reina cultivar were found to be lower than those of Giza 5 cultivar.

As regards the changes in cytokinin content of Giza 5 and Reina cultivar plants in response to salinization treatments, it was found that such changes followed more or

less similar pattern (Fig. 3). It is clearly shown that the responses of the test objects due to the different levels of salinity showed increases in the content and the activity levels of the cytokinin compounds at all concentrations applied as compared with those of the corresponding controls. At the same time, the moderate concentration of salinity (4000 ppm) induced the maximum level of cytokinin compounds in both Giza 5 and Reina cultivar plants without any change in the number of the significant zones having cytokinin activity.

DISCUSSION

The results of the present investigation reveal that the two cultivars of flax plant (Giza 5 & Reina) exhibited a differential response by applying the highest level of salinity. The growth characters, yield and the changes in the endogenous growth hormones (auxins, gibberellins & cytokinins) were found to be negatively affected in response to the salinization treatments of Giza 5 cultivar particularly when the highest level of salinity was used (6000 ppm). On the other hand, the same characters of Reina cultivar were found to be positively affected at all levels of salinity, where such characters exhibited either significant or highly significant increase over the values of the corresponding controls (Table 1).

Regarding the effect of the low and moderate levels of

salinity (2000 & 4000 ppm) on the growth characters and yield of Giza 5 & Reina cultivars, it was found that, the shoot length, technical length of shoot, straw yield, fiber yield and fiber % were found to be stimulated over those of corresponding controls. The magnitude of stimulation was higher in plants of Reina cultivar than that observed in plants of Giza 5 cultivar. In this connection, similar findings were reported by several investigators, among them we may refer to the work of Ahmed et. al. (1977, 1978) working on cotton and safflower plants; Khalil et. al. (1978) working on flax plant; Singh et. al.(1982) working on Capsicum; Al-Rawi and Lazim (1983) working on flax plant, Shalaby et. al. (1983) working on wheat plants and El-Gayar (1988) working on flax plant.

Based on the preceeding results, it appears that at the low and moderate levels of salinity , the plants of the two studied cultivars (Giza 5 & Reina), not only could tolerate the salinization treatments, but also exhibited a significant stimulation in the different criteria of growth and yield of plants. Such stimulation in growth criteria may be attributed to the stimulatory effect of the low and moderate levels of salinity on the endogenous growth hormones including auxins, gibberellins and cytokinins (Figs 1,2&3). In this regard, it could be concluded that the tolerance of plants of the two studied cultivars to the low and moderate levels of salinity and their significant stimulated growth and yield might be caused through the enhancement of such levels of salinity on the synthesis of the

endogenous growth hormones to considerable activity levels which enable plants to cope with water deficits and finally exhibit a growth rate surpassing that of the control plants. This conclusion is supported by the findings of Miller & Kramer (1965) and Fischer (1970).

On the other hand, it was found that the highest level of salinity (6000 ppm) induced a different responses in plants of Giza 5 and Reina cultivars respectively. Whereas such high level of salinity caused either non significant or highly significant decline in the parameters of growth and yield of plants of Giza 5 cultivar, the same level of salinity (6000 ppm) induced either significant or highly significant increases in the parameters of the growth and yield of plants of Reina cultivar. Both negative and positive responses of plants of Giza 5 and Reina cultivars respectively as a result of treatment with the highest level of salinity, were found to be correlated to a great extent to the changes in the endogenous growth hormones. In this connection, it is suggested that the changes in the hormonal level evoked certain concurrent sequence of events leading to water unavailability for plants of Giza 5 cultivar and water availability for plants of Reina cultivar. This suggestion is supported by the findings reported by Ouda & Bandurski (1984) and Reid and Wample (1985).

Concerning the changes in auxins and growth inhibitors content of plants in response to salinization treatments with

the low and moderate levels (2000 & 4000 ppm), it was found that the plants of Giza 5 and Reina cultivars followed a more or less similar pattern. In their extracts,there was a marked increase in the content and activity levels of the significant growth promoting zones having indole nature which reached their maximum when the moderate level of salinity was used (4000ppm).It is of worthy mentioning that the magnitude of the content and activity level of growth promoters in the extract of plants of Reina cultivar were found to be relatively higher than those of plants of Giza 5 cultivar. On the other hand, the extract of plants of Giza 5 cultivar which were treated with the moderate level showed the presence of growth inhibiting substance, whereas the extract of plants of Reina cultivar treated with the same level of salinity was found to be completely devoid from the growth inhibitors (Fig. 1). When the highest level of salinity was used (6000 ppm), the extract of plants of Giza 5 cultivar showed a marked decline in the content and activity levels of the indolic auxins and an increased number of the significant growth inhibiting zones, whereas the extract of plants of Reina cultivar showed an increased content in the growth promoters over that present in the extract of the control plants. From such results, it appears that the plants of the two studied cultivars differs in their magnitude of response to high salinization treatment and that difference depends- to a great extent - on the potentiality of plants of each cultivar not only to synthesize adequate levels of the growth promoters, but also maintained such levels from enzymatic destruction by IAA -

oxidase, so the growth promoting substances can serve as modulators of plant response. Our results offer a great support for the previous suggestion.

It is worthy to refer to the complete disappearance of both IAN and sharp decrease of IAA in the extract of plants of Giza 5 cultivar which were treated with the highest level of salinity, while both substances IAA & IAN showed high activity levels in the extracts of plants of Reina cultivar treated with the same level of salinity.

The relative high levels of auxins especially IAA and IAN in the extract of Reina cultivar plants grown in the soil irrigated with the highest applied level of salinity (6000 ppm) may play an important role in increasing the active water uptake (non-osmotic absorption) against the osmotic gradient (Audus, 1972; Wareing & Phillips, 1981; Wilkins, 1984).

This may be one of the mechanisms by which the plants of Reina cultivar were shown to be relatively more tolerant to the high level of salinity than those of Giza 5 cultivar. In this regard, Livine and Vaadia (1972); Hsiao (1973); El-Beltagy & Hall (1974) and Reid & Wample (1985) reported that the endogenous hormonal levels are considered to be a link between water potential and growth responses. They also added that the adaptive

mechanisms of plants to water stress may involve regulation through changes in hormone balance including growth components which serve as modulators or turners for the alterations in water status .

As regards the changes in gibberellins and cytokinins in response to salinization treatments, it was found that the gibberellins of both Giza 5 and Reina cultivars followed a pattern of change more or less comparable to that of auxins (Fig. 2 & 3). On the other hand, the content and activity levels of cytokinins in plants of the two cultivars were found to be nearly comparable and increased over that of the control plants. These results appear to be in accordance with those obtained by Mizrahi et. al. (1971) and in contradiction with the findings of Itai and Vaadia (1965); Itai et al (1968); Blumenfeld (1970) and Itai & Ben - Zioni (1976).

In conclusion, the overall obtained results in the present investigation suggest that plants of Giza 5 and Reina cultivar responded differently to the salinization treatments. The plants of Reina cultivar were found to be more tolerant to high salinity than those of Giza 5 cultivar. The difference in the magnitude of response between the plants of the two cultivars may be attributed to the changes in the contents and activity levels of the endogenous growth hormones and / or the operation of certain adaptive control mechanism leading to the alterations in water status.

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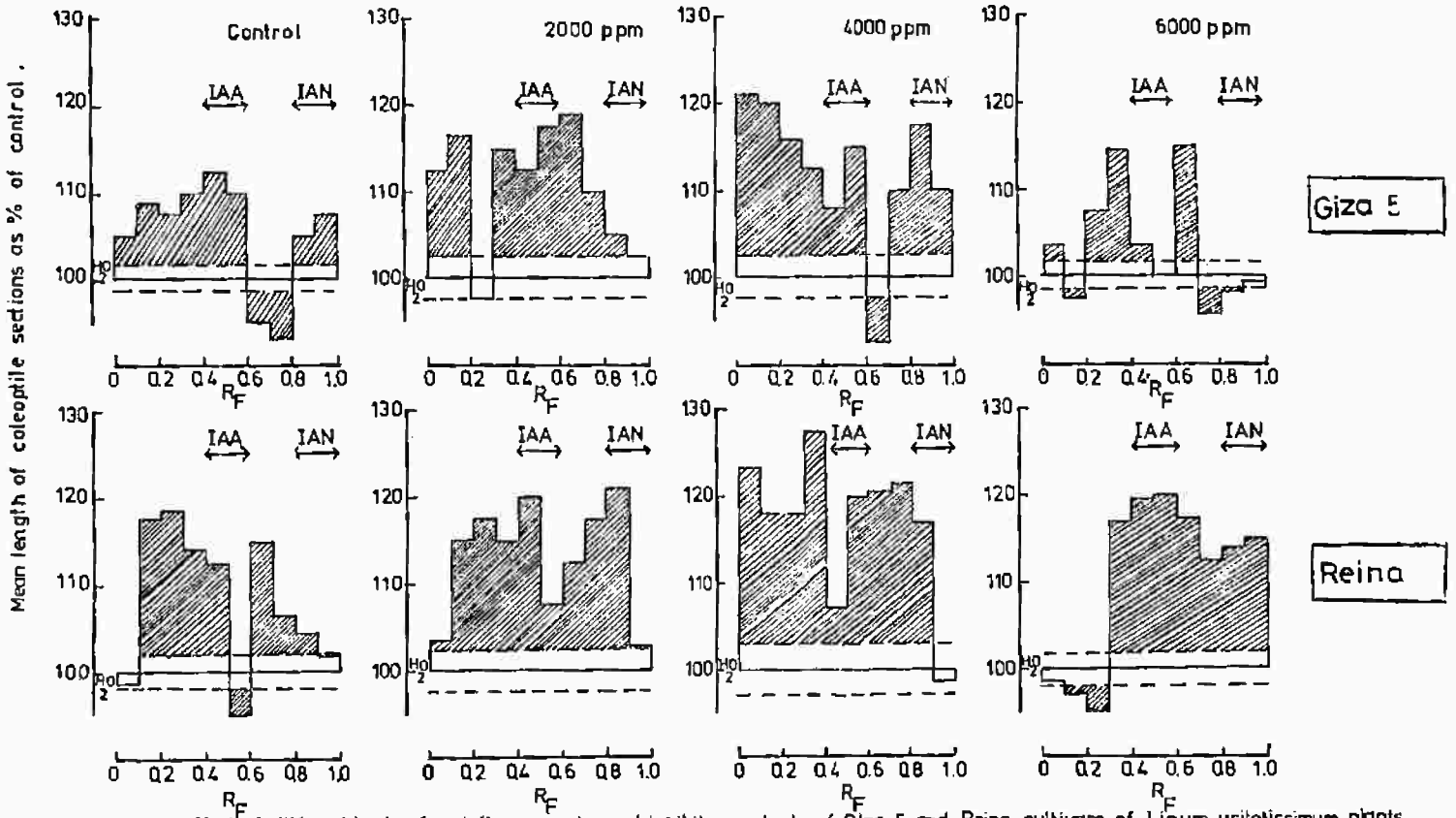

Fig(1) Effect of different levels of salinity on auxin and inhibitor contents of Giza 5 and Reina cultivars of Linum usitatissimum plants

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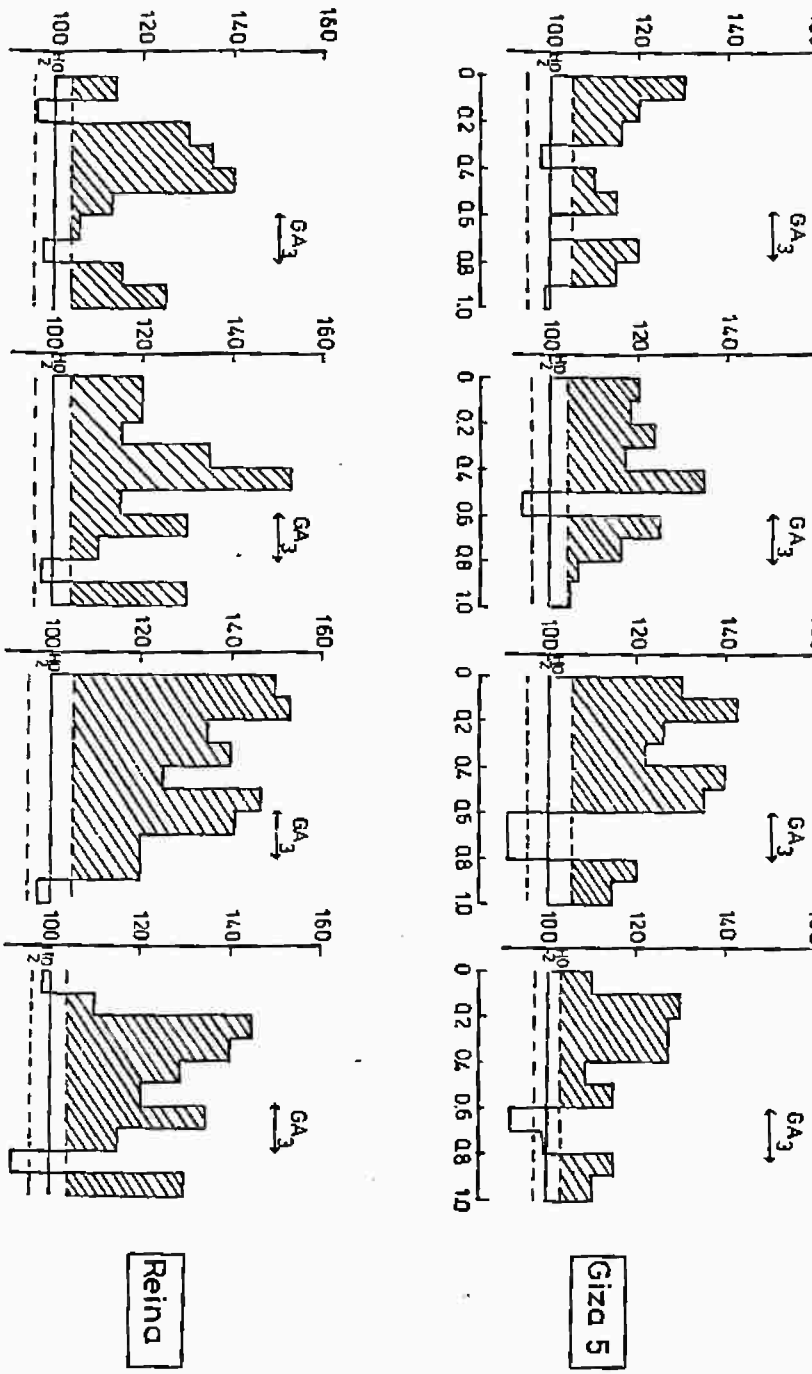

Fig.(2) Effect of different levels of salinity on gibberellin and gibberellin-like substance contents of Giza 5 and Reina cultivars of Linum usitatissimum plants.

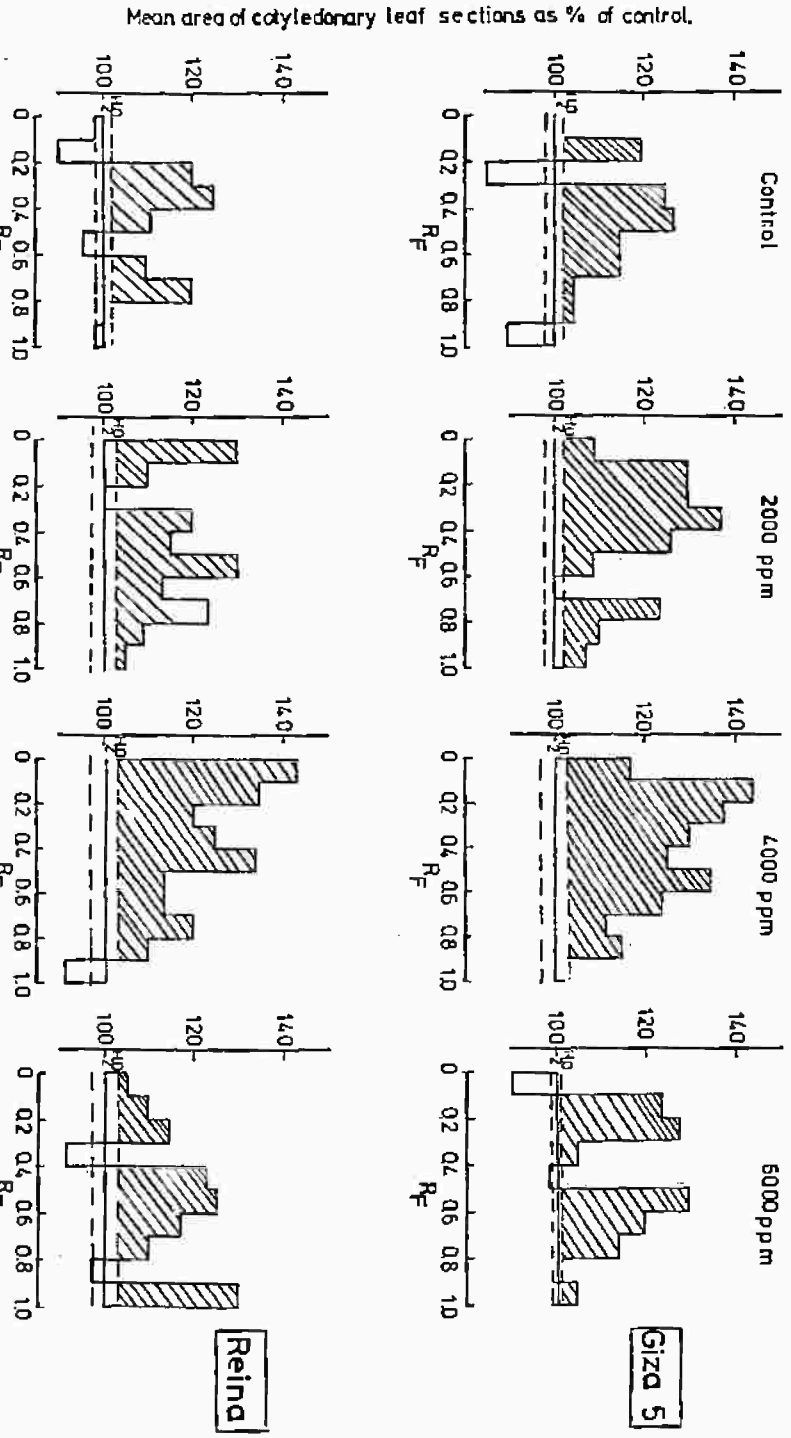

Fig. 3) Effect of different levels of salinity on cytokinin contents of Giza 5 and Reina cultivars of Linum usitatissimum plants.

Table(1): Effect of different levels of salinity on growth and yield components of Giza 5 and Reina cultivars of Linum usitatissimum plants.

Cultivar of flax	Salinity concentration ppm	Total length (cm)	Technical length (cm)	Straw yield in tons/feddan	Fiber yield in tons/feddan	Fiber%
Giza 5	0 (Control)	82.09	73.99	2.80	0.354	12.66
	2000	84.95 + S	78.85 + HS	3.08 + HS	0.412 + HS	13.38 + HS
	4000	90.28 + HS	83.18 + HS	3.26 + HS	0.454 + HS	13.92 + HS
	6000	79.03 - S	73.93 NS	2.70 NS	0.298 - HS	11.02 - HS
	L.S.D at 5% level L.S.D at 1% level	2.17 3.18	3.12 4.13	0.12 0.16	0.006 0.011	0.12 0.16
Reina	0 (Control)	97.44	90.02	1.97	0.330	16.77
	2000	101.91 + HS	96.08 + HS	2.17 + HS	0.386 + HS	17.78 + HS
	4000	106.58 + HS	100.16 + HS	2.34 + HS	0.417 + HS	17.82 + HS
	6000	102.36 + HS	94.01 + S	2.12 + S	0.356 + HS	16.79 Ns
	L.S.D at 5% level L.S.D.at 1% level	3.76 4.07	3.16 4.76	0.11 0.18	0.010 0.013	0.13 0.16