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EFFECT OF WATER SUPPLY AND GROWTH REGULATORS ON GROWTH AND YIELD OF PISUM SATIVUM (L.)

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SUMMARY

The aim of the present investigation is to find out how far the application of growth regulators namely CCC and GA_3 increases the productivity of one of the most important vegetables (Pisum sativum) under shortage of irrigation water.

Plants treated with GA_3 exhibited the longest stem and greatest total leaf area of mature plants under all conditions of water supply. Although the total leaf area of mature plants was greatest in plants treated with GA_3 yet the total fresh weight of leaves was less than that of CCC treated plants.

Application of growth regulators increased seed production under high and low water supply. In case of plenty water supply, application of growth regulators increased the yield of fresh and dry seeds.

Also the nutritive value of the seeds was improved by the application of the growth regulators. The carbohydrate and protein contents of seeds increased signifiecanty with the application of growth regulators, particularly in case of GA_3. The deficiency in water supply was accompanied by decreased in carbohydrate and protein contents.

INTRODUCTION

Drought is one of the most common environmental factors which limit plant growth and agricultural development. In Egypt, there is a tendency for cultivation of more newly reclaimed desert areas in the front of population increment problem. Research on the response of plants to drought is therefore necessary for improving plant growth and crop production in these regions.

In the present investigation the rate of growth and yield production of one of the important vegetables namely Pisum sativum L. variety Victory freezer was studied under favourable and deficiency of water supply. To improve the growth and yield of the plant under the different conditions of water supply, two growth regulators were applied namely chlorocholine chloride (CCC) which is exogenous growth regulator and the other growth regulator namely gibberellic acid (GA_3).

MATERIAL AND METHODS

The soil was obtained from a newly reclaimed desert region in Quisna, Menoufiya province, Egypt. The pea seeds (Pisum sativum L. var. Victory Freezer) were obtained from the Agriculture Research Centre, Giza, Cairo.

Pea seeds were planted in plastic pots (25 cm diameter) each containing 20 kg soil. The pots were divided into three groups, each group consisted of three sets, and each set consisted of 10 pots. Each of the first three sets was sibjected to water supply of 100, 150 and 200 mm rainfall. Each of the second three sets was subjected to the same water regime system and sprayed with 400 ppm cycocel (CCC), while each of the third three sets was subjected to the same water regime system and sprayed with 20 ppm gibberellic acid (GA_3).

The range of rainfall involved (200, 150 and 100 mm) was determined experimentaly as the lowest level of rainfall which is sufficient for growth of plants and production of seeds and also the highest level of rainfall affects the yield. Irrigation was applied at week intervals throughout the whole growth period.

The concenteration of the applied GA_3 (30 ppm) was chosen according to Midan et al. (1982) on Pisum sativum. The results showed that concenteration 20 ppm was the best one used. 20 ppm GA_3 enhanced protein accumulation significantly in peas kernels and increased the green seeds as a precentage from the green pods (Midan et al, 1982).

The concenteration of the applied CCC (400 ppm) was chosen according to Rafigue - Uddin (1984) who reported that application of 400ppm cycocel (chlormequat) in 2 or 4 foliar sprays to two Phaseolus vulgaris cv. increased significantly the seed yield by 15%. The yield increase in large - seeded cv. was due to the increase in the number of seeds / pod and in small - seeded cv. in the number of pods / plant. The growth regulators were sprayed three times at 20 - day intervals. The first spray was started on two - week old plants. The treated plants were sprayed by an atomizer until dripping. Teepol was used as a wetting agent in order to minimize the surface tension between leaves and the growth regulating substance. The spraying process was always performed early in the morning.

After full germination (two weeks after sowing), plants were thinned to three healthy seedings per pot. The samples were collected at two stages of the plant growth, after 50 and 80 days from sowing.

Vegitative Growth :

The vegetative growth parameters e.g. shoot height, number of leaflets and leaf area were recorded on five plants chosen at random.

Yield Production :

Yield production was assessed as pod number per plant, seed number per pod, fresh weight of 100 seeds and dry weight of 100 seeds.

RESULTS AND DISCUSSION

I) Effect of Moisture Stress and Growth Regulators on Vegetative Growth :

1- Height of Plant :

The height of plants (50 days old) exhibits progressive decrease with the deficiency in water supply from the highest level (200 mm water supply) to the lowest level (100 mm water supply) as shown in Table 1 & Figs. 1 & 2.

The plant height was 22 cm at the highest level of water supply and 14.7 cm at the lowest level of water supply.

Application of cycocel has resulted in a decrease in plant height from 22.4 cm at the highest level to 14 cm at the lowest level of water supply.

Spraying plants with GA_3 was accompanied by a great rise in plant height to 79.5 cm at the highest level of water supply. The fall in the water supply to the lowest level was associated with a decrease in plant height to 41.6 cm.

It is evident from these results that water shortage leads to a considerable reduction in plant height in sprayed and unsprayed plants.

Application of GA_3 has resulted in a great increase in plant height in comparison with the unsprayed plants. With high water supply the height of plants sprayed with GA_3 was more than twice that of unsprayed plants. At the lowest water supply the height of plants sprayed with GA_3 was more than three times that of unsprayed plants.

The effect of CCC on plant hight was negligible as compared with unsprayed plants in both conditions of water supply.

In the mature stage (80 day - old) the effect of GA_3 was more pronounced. The height of sprayed plants with GA_3 was about four times that of unsprayed plants at the highest level of water supply and about three times at the lowest level of water supply. Treatment of plants with CCC has resulted in a slight increase in plant height in comparison with unsprayed plants.

2- Number of Leaflets Per Plant :

The number of leaves is an important factor affecting the assimilating area of the plant and consequently the vegetative growth. Data present in Table 1 and Figs. 1 & 2 show that treatment with each growth regulator has resulted in an appreciable increase in the number of leaflets per plant. The influence of GA_3 was more prominent than the effect of CCC under all levels of water supply. The greatest number of leaves per plant was observed at the highest level of water supply in plants treated with GA_3.

With the progress in time from 50 to 80 days, the number of leaves per plant increased significantly at all levels of water supply in treated and untreated plants.

3- Mean Leaflet Area :

The variations in leaf area under the different conditions of water supply and application of growth regulators are demonstrated in Table 1 and expressed in Figs. 1 & 2.

The effect of water supply and growth regulators on leaf area was more pronounced in the later stage (80 days). At this stage, the leaf area decreased with the deficiency in water supply and increased slightly with the application of growth regulators. (Table 1 and Fig.1)

4- Total Leaf Area :

It is the most important index of the vegetative growth, since it represents the photosynthetic surface. The data are expressed in Table 1 and illustrated in Fig. 3.

It is evident that there is a remarkable decrease in the total leaf area with water deficiency and an increase with the application of growth regulators, particularly at the late vegetative stage (80 days). In this stage, there is a remarkable decrease with increase moisture stress in the treated and untreated plants and a considerable increase with the application of GA_3. At the highest and lowest levels of water supply, the total leaf area of plants sprayed with GA_3 was nearly twice as much that of untreated plants.

5- Total Fresh Weight of Leaves Per Plants :

The total fresh weight of leaves per plant did not follow the same trend of total leaf area. This phenomenon may be referred to variations in thickness of the leaf under the different conditions. The data presented, in Table 1 and illustrated in Fig. 4 reveal that total fresh weight of leaves diminished considerably in the two stages of growth with deficiency in water supply, in unsprayed and sprayed plants with growth regulators.

In the later stage of growth (80 days), the highest record of total fresh weight of leaves per plant was obtained by CCC - sprayed plants supplied with high water level, followed by GA_3 - sprayed plants as compared with untreated plants. Under deficiency of water supply, the total fresh weight of leavews followed the same sequence as in case of plants supplied with high water level.

6- Total Dry Weight of Leaves Per Plant :

The total dry weight of leaves per plant (Table 1 & Fig. 5) followed the same trend as the total fresh weight of leaves per plant in response to variations in water supply and treatment with each of CCC and GA_3.

The above mentioned resutls concerning the effect of moisture stress on plant growth of Pisum sativum are in agreement with the findings of the following investigators.

Some studies had been done on castor plants and Datura metal showed a significant reduction in plant growth parameters with increasing the irrigation intervals from 10 up to 40 days. Kamel et al. (1979) demonstrated that limited soil moisture critically influnced the performance of soybean plants by reducing the height, weight and size of assimilating leaf area and dry matter accumulation. This agree also with Momen et al (1979) who noticed that limited soil moisture resulted in reduced plant height and assimilating leaf area. Also in maize, the plant height and leaf area were reduced significantly as drought increased (Hussein et al, 1980). Bananno and Mack (1983) showed that the total leaf area, average area/leaf and number of leaves / plant were reduced by water deficits in Phaseolus vulgaris.

Nagwan (1988) noticed that the increase in water stress had resutled in a reduction in plant height, total leaf area and fresh and dry weight of soybean plants.

With regard to the application of growth regulators, some workers obtained a remarkable increase in growth with GA_3 treatment. Mohamed (1979) found that GA_3 application to Trifolium alexandrinum caused a significant increase in fresh and dry weight / plant, El-Shihy (1979) also observed a significant increase in dry matter accumulation of the leaves, stems and grains of corn plants as a result of GA_3 treatment, El-Sherbeny (1982) recorded that GA_3 application to Hibiscus sabdariffa caused an increase in shoot growth, number of leaves / plant and fresh and dry weight of shoot. Gibberellic acid treatment increased plant height, leaf area, leaf number and shoot dry weight in broad bean (Abdul and Said, 1984).

The effect of cycocel (CCC) on plant growth was studied by some investigators. Abou-Khadrah and El-Moursi (1978) recorded a reduction in the height of sunflower plants as a result of cycocel treatment. In addition, the dry weight of leaves increased, with a slight increase in plant growth although, the application of CCC caused a remarkable reduction in plant height and a significant increase in the number of tillers per plant, leaf area and leaf length in other crop.

In sprayed maize plants grown at different irrigation regimes with cycocel, it was found that the height growth tended to decrease at constant normal or low water levels by CCC than in unsprayed plants, whereas the dry weights of stem and leaves tended to increase by CCC treatment.

Nagwan (1988) reported that cycocel application to soybean, particularly at higher concentrations had resulted in shorter stem and tremendous increase in the number of branches and leaves, total leaf area and fresh and dry weights of the plant shoot.

II) Effect of Moisture Stress and Growth Regulators on Yield:

For determination of the yield under different conditions of water stress and application of growth regulators, the following measurements should be were taken into consideration.

1- Number of Pods / Plant :

The number of pods per plant varied widely under the different conditions. The deficiency in water supply from the highest to the lowest level was accompanied by a great reduction in the number of pods / plant to about 37% in the untreated plants with growth regulators. Application of growth regulators has resulted in a considerable increase in the number of pods / plant.

2- Number of Seeds / Pod :

Also the number of seeds was considerably affected by soil moisture stress and treatment with growth regulators. The changes in number of seeds per pod were more or less similar to those of the number of pods per plant under the different conditions.

3- Number of Seeds / Plant :

The number of seeds per plant showed the same tendency as the previously mentioned measurements but more exaggerated. The deficiency in water supply from the highest to the lowest level has resulted in a great reduction reaching 25%. Application of CCC has resulted in a remarkable increase in the number of seeds per plant at all level of water supply.

4- Fresh Weight of 100 Seeds :

The fresh weight of 100 seeds is considered a good indicator of the quality of seeds of plant used as a vegetable. There was great reduction in the quality of seeds of treated and untreated plants when subjected to severe stress due to the deficiency in water supply from the highest to the lowest level. Application of growth regulators has improved the quality of seeds to a certain extent.

5- Dry Weight of 100 Seeds :

The changes of dry weight of 100 seeds due to the decrease in water supply or application of growth regulators run parallel to those of fresh weight of 100 seeds.

6- Yield of Fresh Seeds of 100 Plants :

The yield of fresh seeds of 100 plants exhibited great variations under the different conditions. The fall in water supply from the highest to the lowest level caused a sharp fall in the yield of 100 untreated plants from 730 to 30 g. Application of growth regulators, praticularly GA_3 improved the yield to a certain extent.

7- Yield of Dry Seeds of 100 Plants :

The changes in yield of dry seeds with deficiency in water supply and treatment with growth regulators were identical with those of fresh seeds.

III) The Nutritive Value of Seeds :

The nutritive value of the seeds is mainly represented by the carbohydrates and protein contents.

a) Carbohydrate Contents :

The increase in soil moisture stress due to the decrease in water supply from 200 to 100 mm has exerted a considerable reduction in carbohydrates from 33.2% to 25.5%. Application of growth regulators exerted a remarkable increase in carbohydrate content at the different levels of water supply (Tables 4 & 5 and Figs. 9 & 10).

b) Protein Content :

Generally, the protein content in seeds was less than that of carbohydrates but exhibited nearly the same response to deficiency in water supply and treatment with growth regulators (Tables 4&5 and

Figs. 9&10). Under severe water stress, the protein content dropped to about 72% compared to untreated plants. Application of growth regulators has resulted in a slight increase in protein content.

With respect to the effect of water stress on yield, Kreeb (1957) reported that grain yield of barley decreased about 60 kg. / ha. and the yield of straw about 1000 kg. / ha. per bar decrease in mean osmotic potential. The same author (1963) observed that the decrease of the yield of barley at lower hydrature conditions depends on the diminution of the number of grains more than the size of the caryopsis, Abd El-Rahman (1973) indicated that deficiency of soil water content led to a significant reduction in the yield of wheat. Biuk (1983) reported that while Phaseolus vulgaris plants were able to adjust osmotically to maintain turgor under severe water stress, pod number / plant was reduced by 50% and yields were reduced from 33.58 (unstressed) to 8.28 pods / ha. (severely stressed). Nagwan (1988) observed that rise in water stress by elongation of irrigation interval from 10 to 18 days was accompanied by a sharp drop in yield of 100 soybean plants from 3493 to 648 g. Mahmoud (1990) noticed also that soybean cultivars exhibited progressive reduction in yield with increase in moisture stress due to elongation of irrigation interval.

It was found also that application of CCC to wheat increased the number of grains per ear, weight of 100 grains and the final yield per plant. Abou-Khadrah and El-Moursi (1978) recorded that CCC treatment of sunflower plants had increased the number of seeds per head, weight of 1000 seeds and the yield of seeds per plant. Nagwan (1988) found that application of CCC had a great effect on the yield of soybean at all levels of water supply. At the level of 14 days irrigation interval, the increase in yield reached about more than double that of the control plants.

Jaiswal et al. (1989) showed that CCC application significantly enhanced the total yield of mng bean.

With regard to the effect of GA_3, Midan et al. (1982) showed that foliar application of 5 - 20 ppm increased freen pod and seed production of pea plants. Sebanek and Padesva (1984) reported that GA_3 application increased the seed weight of pea crop. El-Sweify (1989) found that the highest value of number of capsules/plant, number of seed / capsule as well as weight of 100 seeds were observed in flax plants treated with 100 and 500 ppm. GA_3 respectively. Also, GA_3 application (50 ppm) to mature tea (Assam type) increased crop yield considerably (Barman and Manivel, 1990).

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Table 1 : Effect of water supply and growth regulators on vegetative growth of pea plants.

Stage I. (50 days) :

Growth regulators	Water supply (mm)	Shoot height (cm)	No. of leaflets/ plant	Mean leaflet area (cm^2)	Total leaf area/ plant (cm^2)	Total fresh wt. of leaves / plant (mg.)	Total dry wt. of leaves / plant (mg.)
0	200	18.5	21.0	2.84	59.7	850.5	96.6
	150	15.5	17.4	2.23	38.8	568.5	75.3
	100	11.7	15.2	1.71	26.0	410.4	65.8
CCC	200	17.8	23.4	3.04	71.1	1029.6	147.4
	150	15.0	20.0	2.49	49.8	788.0	120.0
	100	11.3	18.2	1.85	33.7	589.7	91.0
GA_3	200	41.9	28.0	2.32	65.0	569.2	86.8
	150	38.4	24.0	1.92	46.1	432.0	69.6
	100	34.8	19.2	1.40	26.9	268.8	44.7
Stage II. (80 days) :							
0	200	22.0	30.0	3.04	91.2	1680.0	192.0
	150	18.3	23.4	2.58	60.4	1216.8	139.2
	100	14.7	20.4	1.95	39.8	775.2	93.8
CCC	200	22.4	31.4	3.45	108.3	1946.8	232.4
	150	18.3	26.2	2.76	72.3	1545.8	186.0
	100	14.0	24.2	2.19	53.0	1161.6	142.8
GA3	200	79.5	52.2	3.60	187.9	1800.9	208.8
	150	59.0	49.0	2.97	145.5	1666.0	196.0
	100	41.6	42.4	2.10	89.1	932.8	110.2
L.S.D.	5% :	2.31	2.31	0.48	13.76	92.97	13.76
	1% :	3.07	3.07	0.64	18.3	123.65	18.3

Table 2 : Effect of water supply and growth regulators on yield production.

Growth regulators	Water supply (mm)	No. of pods/ plant	No. of seeds/ pod	No. of seeds/ plant	Fresh Wt. of 100 seeds (g.)	Dry Wt. of 100 seeds (g.)	Yield of fresh seeds/100 plants (g.)	Yield of dry seeds/100 plants (g.)
0	200	6.4	4.8	30.72	23.79	4.85	730.83	148.99
	150	4.0	4.2	16.80	12.91	2.72	216.89	45.70
	100	2.4	3.2	7.68	4.00	1.20	30.72	9.22
CCC	200	7.2	5.2	37.44	25.66	5.03	960.71	188.32
	150	4.8	4.6	22.08	19.84	3.94	438.07	87.00
	100	4.0	3.6	14.40	6.15	1.74	88.56	25.06
GA_3	200	7.6	4.0	30.40	31.37	5.96	953.65	181.18
	150	5.2	3.6	18.72	23.25	4.16	435.24	77.88
	100	4.4	2.4	10.56	8.13	1.79	85.85	18.90
L. S. D.	5 % :	0.99	1.01	5.35	1.7	0.34	40.3	7.94
	1 % :	1.33	1.36	7.2	2.28	0.46	54.28	10.69

Table 3 : Effect of water supply and growth regulators on yield production (as percent of control plants).

Growth regulators	Water supply (mm)	No. of pods / plant (%)	No. of seeds / pod (%)	No. of seeds / plant (%)	Fresh Wt. of 100 seeds (%)	Dry wt. of 100 seeds (%)
0	200	100	100	100	100	100
	150	62.50	87.50	54.69	54.27	56.08
	100	37.50	66.67	25.00	16.81	24.78
CCC	200	112.50	108.33	121.87	107.86	103.75
	150	75.00	95.83	71.87	83.40	81.24
	100	62.50	75.00	46.88	25.85	35.84
GA_3	200	118.75	83.33	98.95	131.86	122.89
	150	81.25	75.00	60.94	97.73	85.85
	100	68.75	50.00	34.38	34.17	36.95
L.S.D.	5 % :	15.49	21.03	17.4	7.13	7.11
	1 % :	20.85	28.33	23.44	9.6	9.58

Table 4 : Effect of water supply and growth regulators on carbohydrate and protein contents of pea seeds.

Growth regulators	Water Supply (mm)	Carbohydrates (%)	Protein (%)
	200	33.2	23.5
0	150	31.9	22.5
	100	25.5	17.0
	200	37.5	24.4
CCC	150	35.5	23.3
	100	27.1	19.6
	200	38.7	25.1
GA_3	150	35.9	23.3
	100	30.9	20.1
L.S.D.	5 % :	1.6	1.23
	1 % :	2.16	1.66

Table 5 : Effect of water supply and growth regulators on carbohydrate and protein contents of pea seeds (as percent of control plants).

Growth regulators	Water Supply (mm)	Carbohydrates (%)	Protein (%)
	200	100	100
0	150	96.0	95.7
	100	76.8	72.3
	200	113.0	103.9
CCC	150	105.5	99.2
	100	81.6	83.4
	200	116.5	106.9
GA_3	150	107.6	99.3
	100	93.0	85.5
L.S.D.	5 % :	4.79	5.23
	1 % :	6.47	7.07

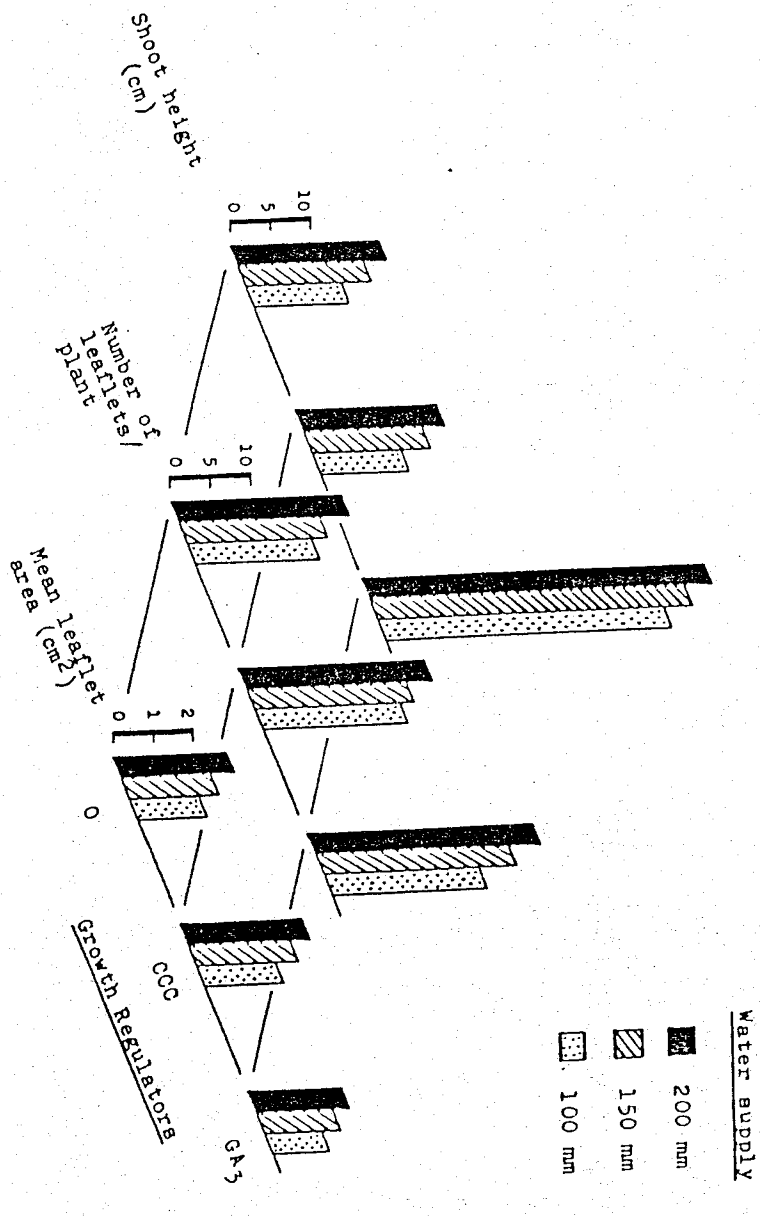

Fig. (1). Effect of water supply and growth regulators on vegetative growth of pea plants after 50 days.

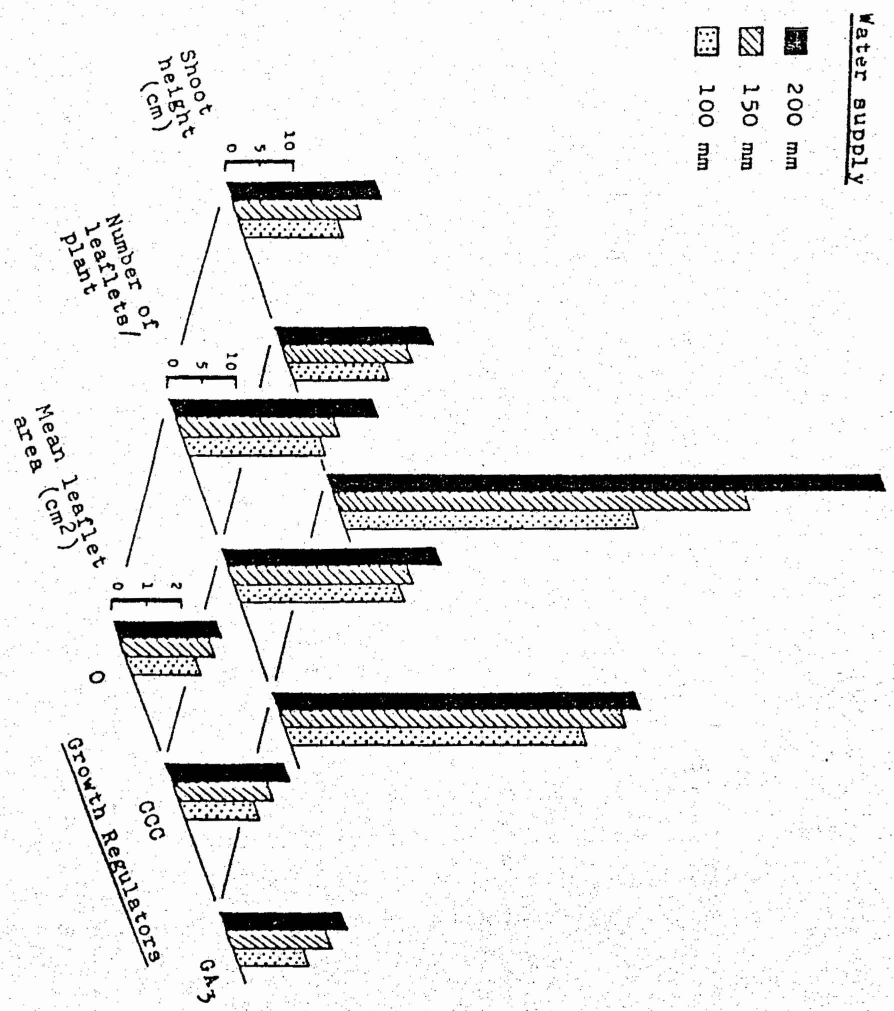

Fig. (2). Effect of water supply and growth regulators on vegetative growth of pea plants after 80 days.

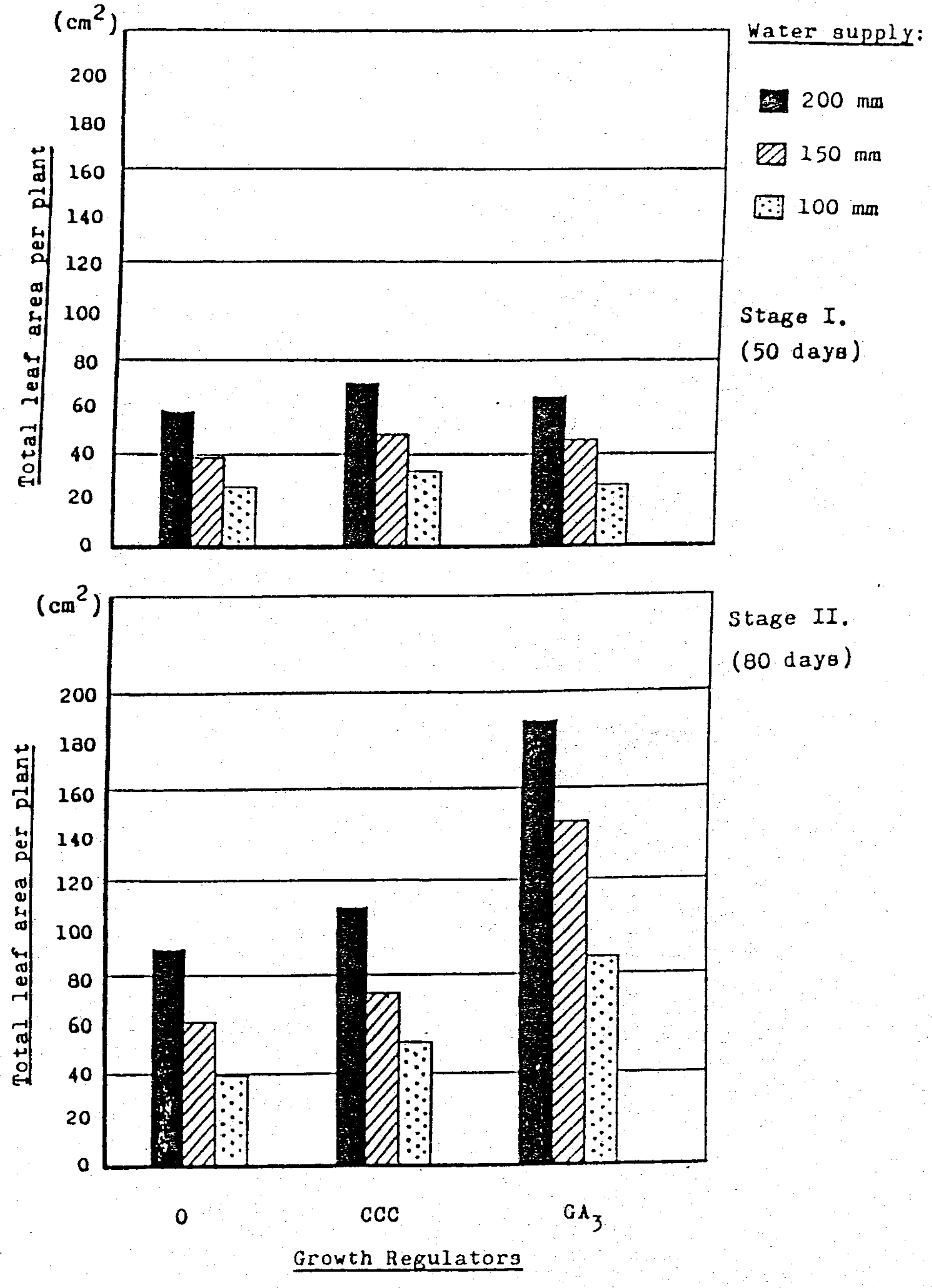

Fig. (3). Effect of water supply and growth regulators on total leaf area per plant of pea shoots.

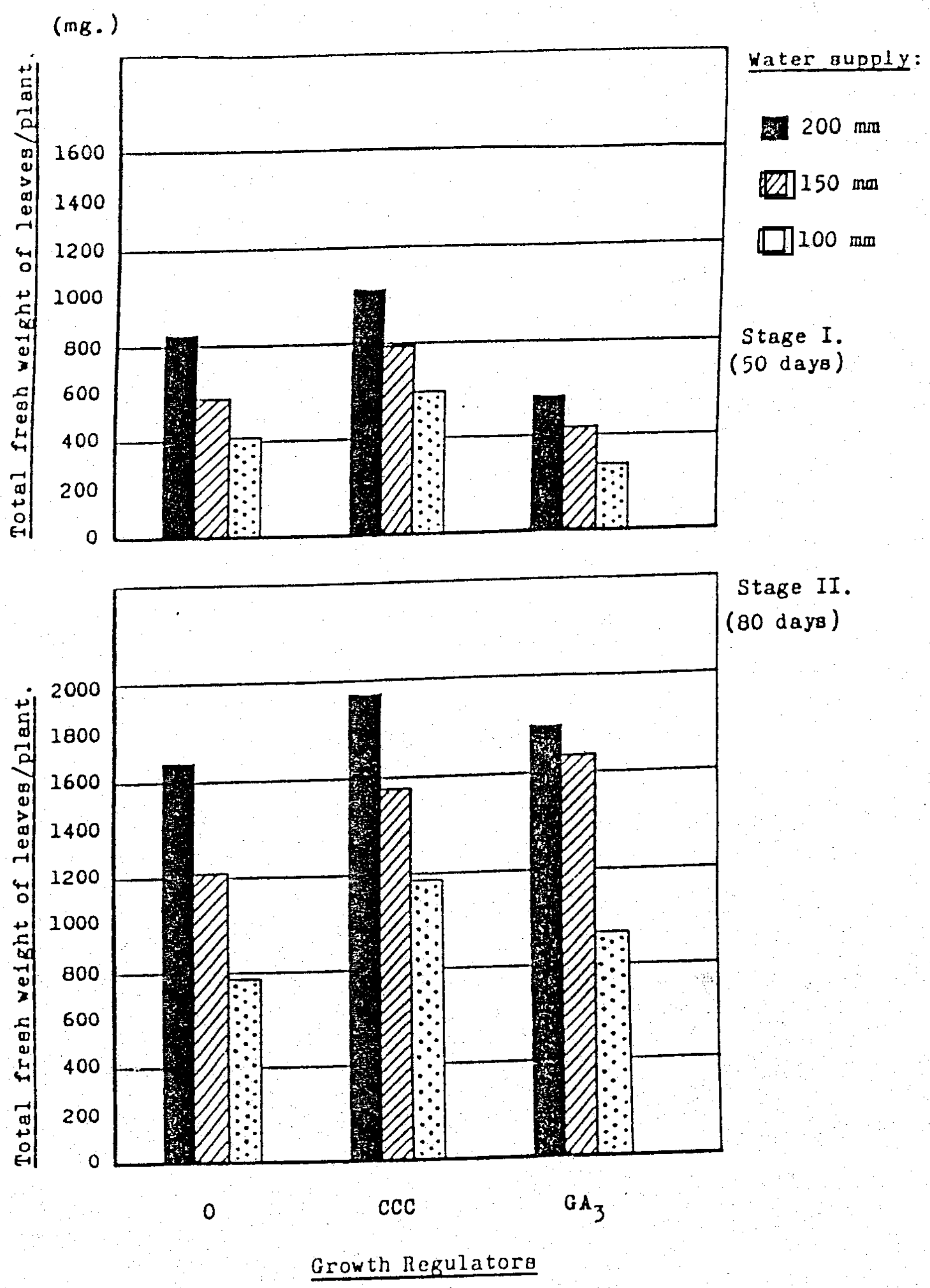

Fig. (4). Effect of water supply and growth regulators on total fresh weight of leaves per plant of pea shoots.

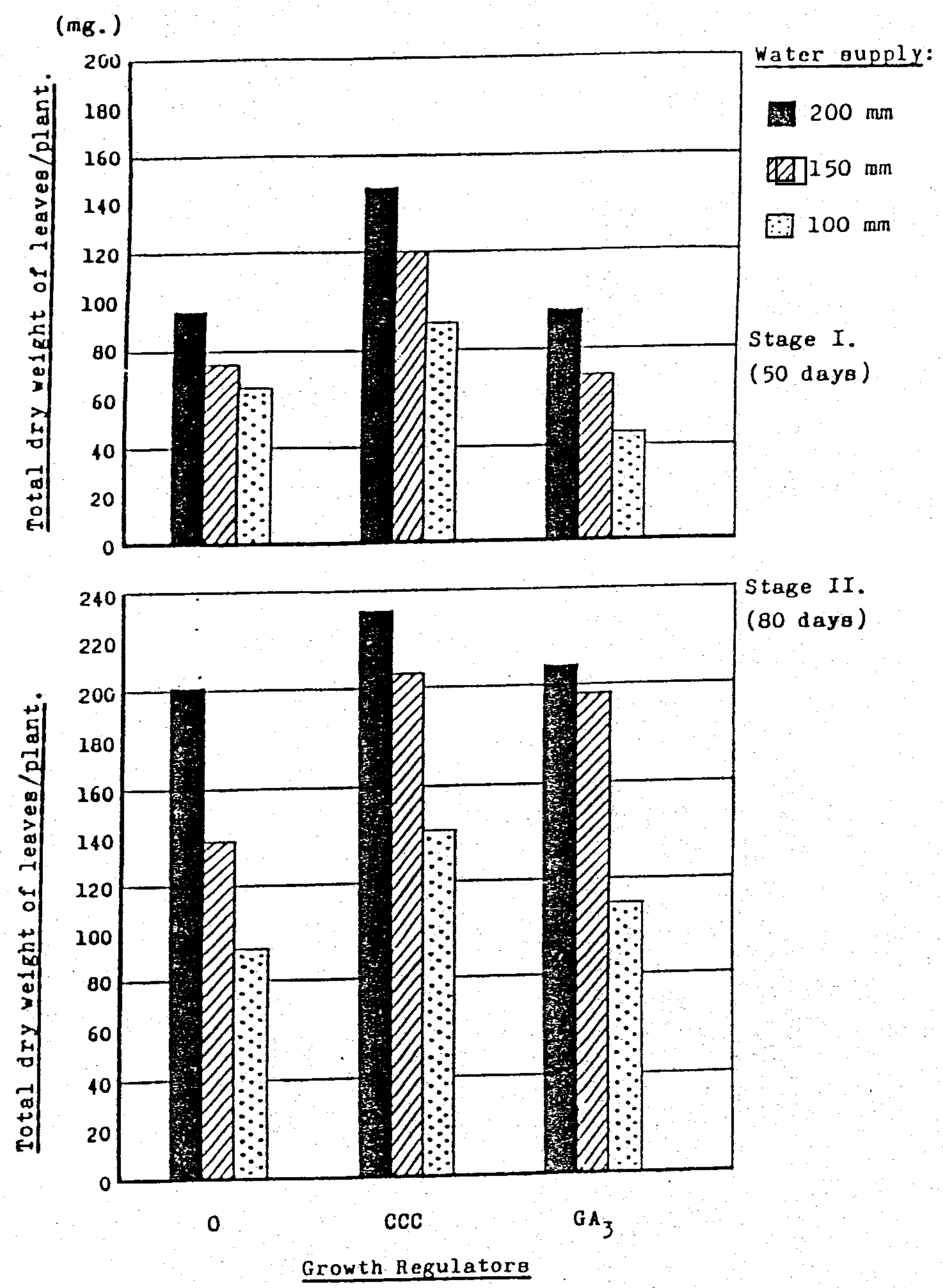

Fig. (5). Effect of water supply and growth regulators on total dry weight of leaves per plant of pea shoots.

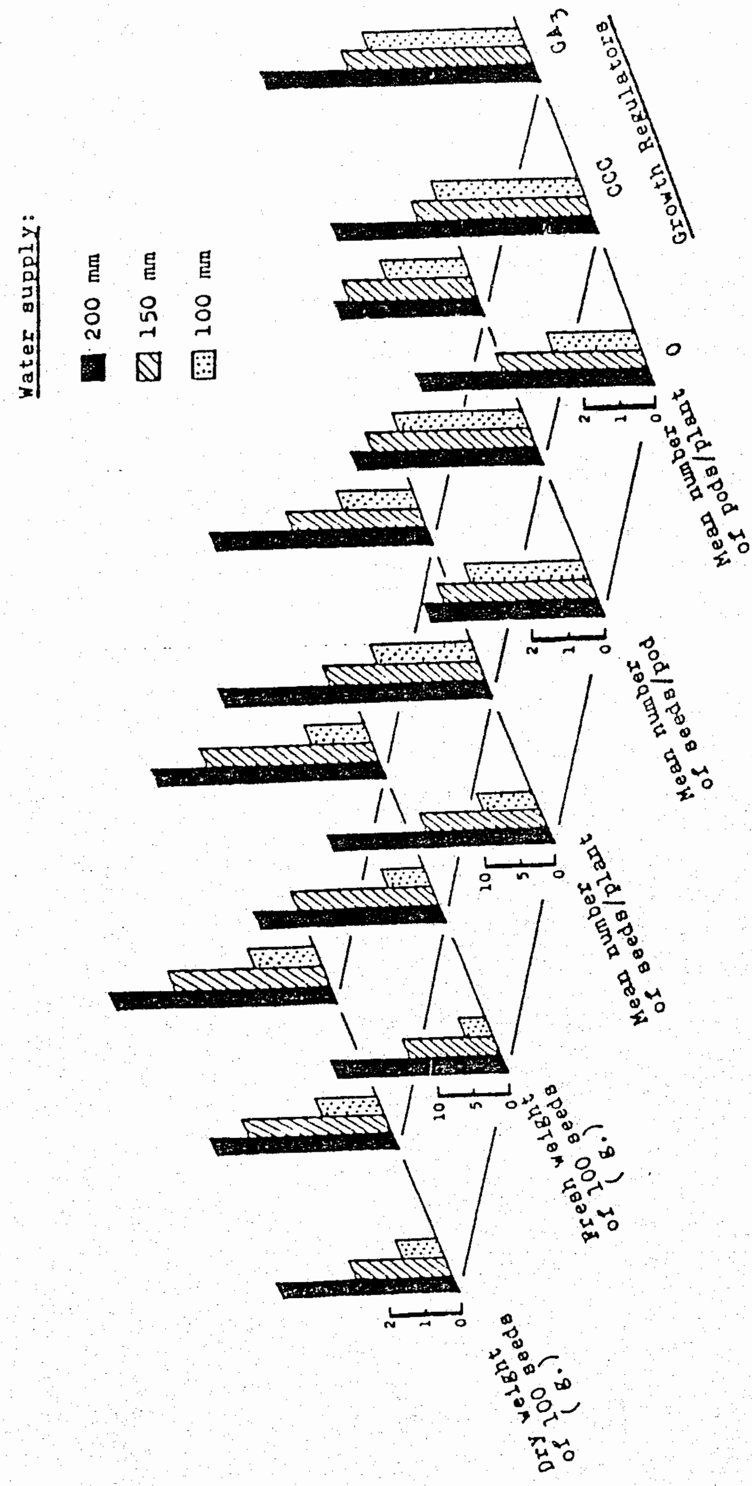

Fig. (6). Effect of water supply and growth regulators on the yield production of pea plants.

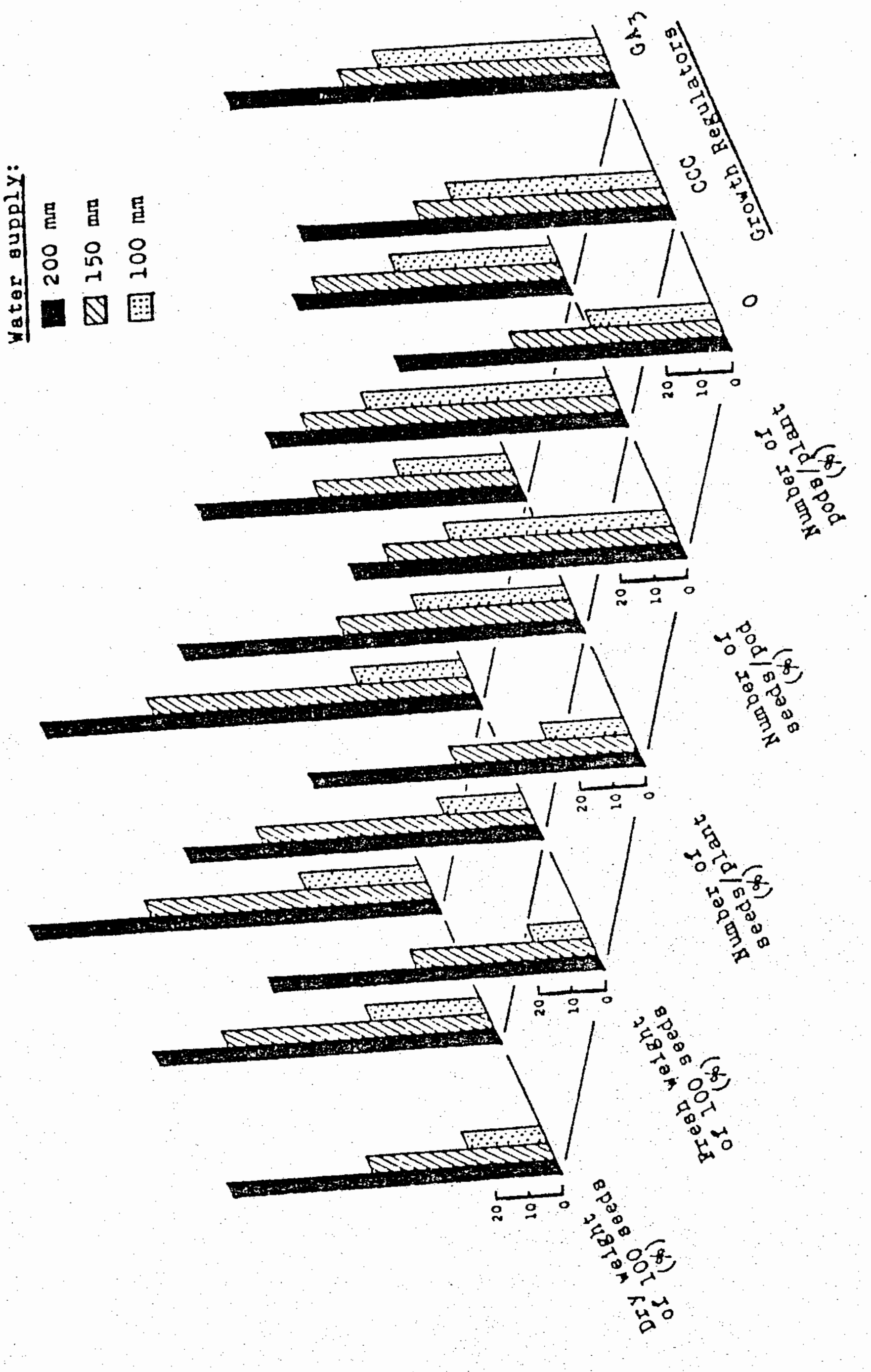

Fig. (7). Effect of water supply and growth regulators on the yield production of pea plants (as percentage of the control).

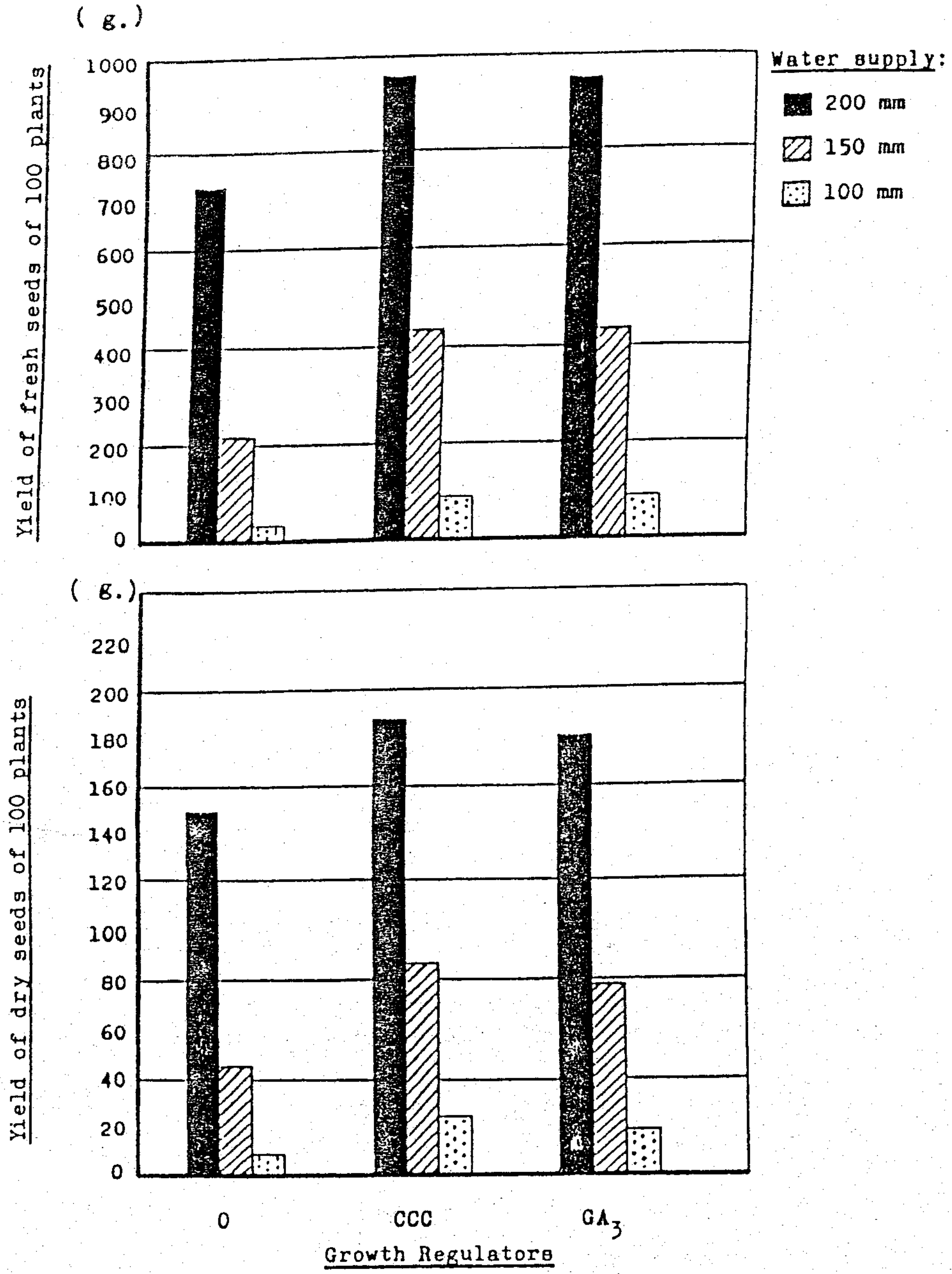

Fig. (8). Effect of water supply and growth regulators on the yeild of pea plants (total fresh and dry weight of seeds/100 plants).

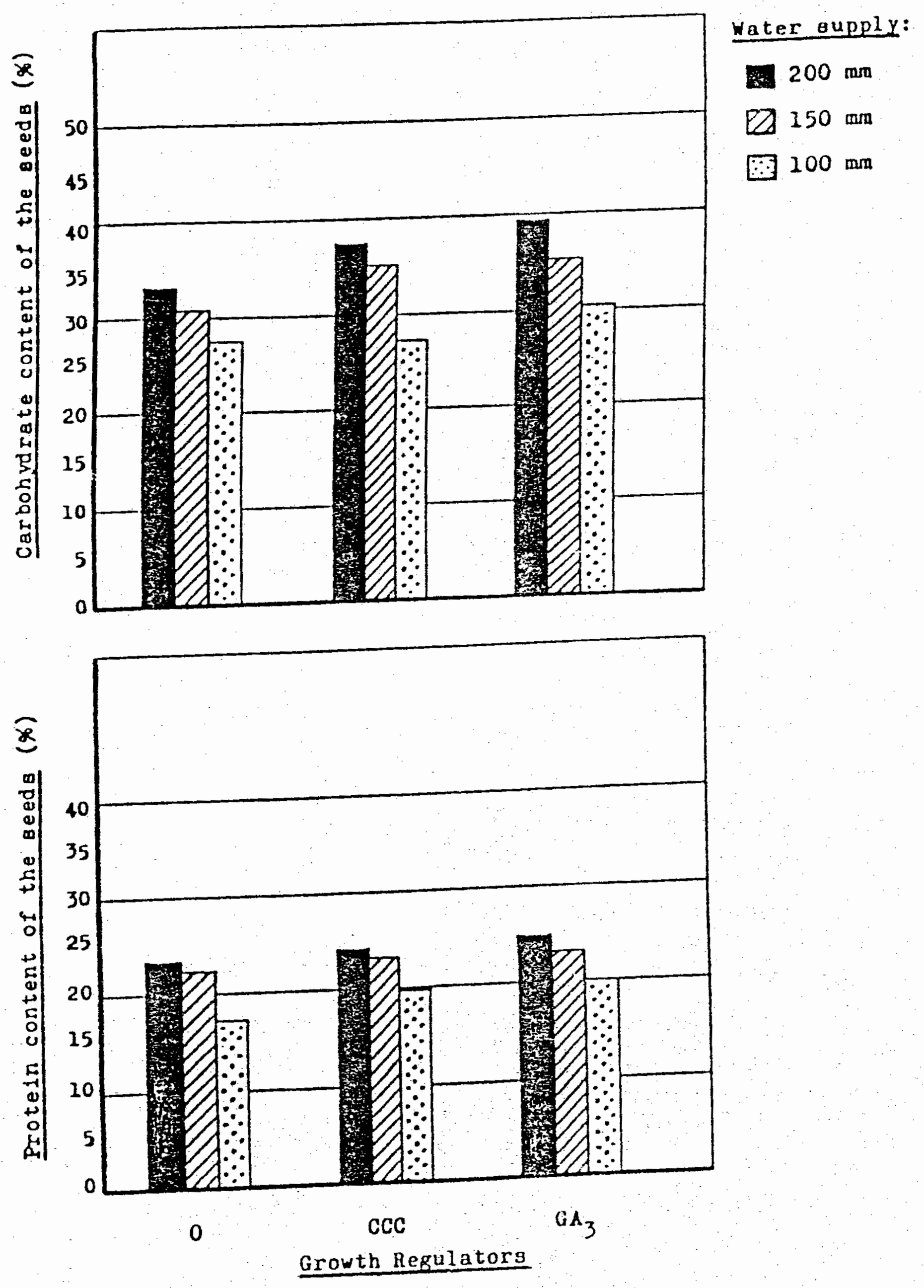

Fig. (9). Effect of water supply and growth regulators on carbohydrate and protein contents of the seeds (%).

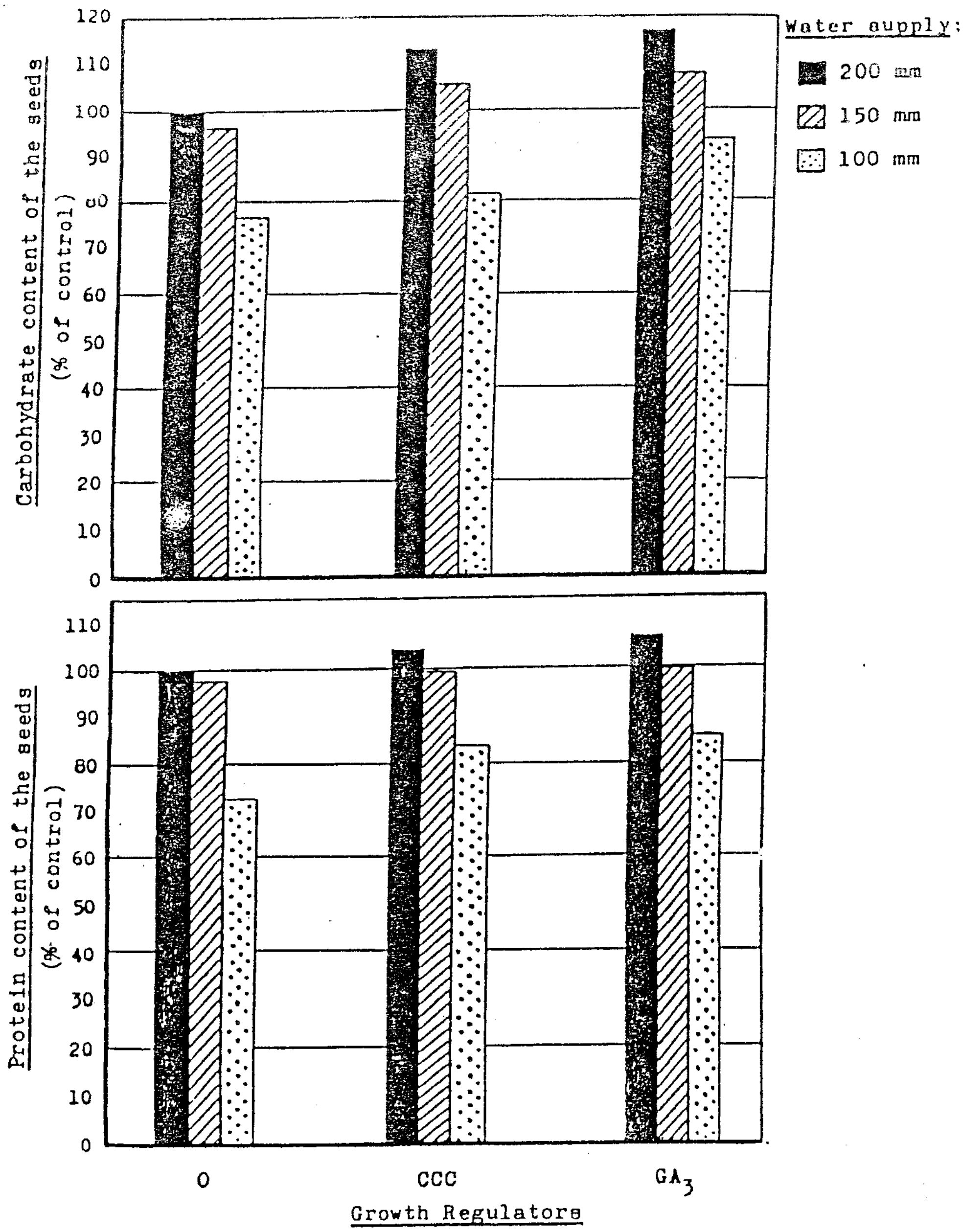

Fig. (10). Effect of water supply and growth regulators on carbohydrate and protein contents of pea seeds (% of control).

تأثير الإمداد المائى ومنظمات النمو على نمو وانتاجية نبات البسلة

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يهدف البحث معرفة مدى تأثير الجبريللين والسكوسيل على إنتاجية أحد المحاصيل الهامة وهو نبات البسلة تحت ظروف النقص فى الإمداد المائى.

الجبر يللين أدى إلى زيادة كبيرة فى طول الساق ومساحة الورقه فى كل حالات الإمداد المائى، إلا أن الوزن الغض كان أقل من النباتات المعاملة بالسيكوسيل.

المعاملة بمنظمات النمو زادت من إنتاج البذور تحت ظروف الإمداد المائى العالى والمنخفض.

وأيضا إستعمال منظمات النمو أدى إلى تحسين القيمة الغذائية للبذور فقد زادت نسبه الكربوهيدرات والبروتين فى البذور وخاصة بالمعاملة بالجبريللين، إلا أن نقص الامداد المائى أدى إلى نقص محتوى الكربوهيدرات والبروتين فى البذور.