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GROWTH AND DEVELOPMENT OF BEAN PLANTS (PHASEOLUS VULGARIS L.) GROWN UNDER WATER-STRESS

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Abstract: Two pot experiments were carried out during the two successive seasons of the years 1994/1995 to investigate the influence of water-stress on growth, flowering and fruiting of two snap bean cultivars (Giza3 and Bronco). The seedlings were transplanted in sandy plastic pots at the fourth leaf stage and transferred to controlled growth chamber. The seedlings were treated with different levels of water-stress (50%, 75%, 100% and 125% of field capacity by weight). Plant growth parameters were recorded and pods' quality was estimated at different developmental stages of the snap bean plants. The results obtained showed that plant height, number of leaves, chlorophyll content, number of flowers, and fruit set percentage of both cultivars were significantly affected by water-stress levels. Pods' volume, weight, number, length and diameter were pronounced under 100% of field capacity of Giza3 cultivar, while Bronco cultivar was pronounced under 75% of field capacity with the fewest possible deformed pods' percentages and total fiber content as well as the increment in total protein content. From the results obtained it can be concluded that 10011/o and 75% of field capacity treatments were the most preferable levels for Giza3 and Bronco, respectively, in most cases under the experimental conditions.

INTRODUCTION

Common bean (Phaseolus vulgaris L.) is one of the most important vegetable crops grown in Egypt that occupies a great figure in local consumption and export. Common bean is known as a sensitive plant to water-stress condition.

El-Saeid, 1981 mentioned that bean plants grown at 90% of field capacity produced higher number of pods relative to those maintained at 54% of field capacity. Further more, El-Bettagy and Soliman, 1985 studied the effect of water logging for 4 or 8 days on tomato plant and found a decrease in plant height, leaf number and chlorophyll content. An increase in flower abscission was also observed. Also, Kahn et. al., 1985 found that growth suppression increased with longer duration of stress, and yield losses of surviving plants were primarily associated with smaller plant size and fewer pods per plant. One of the most important changes under stress is the decrease of the total chlorophyll content (Levitt, 1980; Becker et. al., 1986). Both of drought and water-logging can have a damaging effect on the snap bean crop (Hall, 1987). Concerning the sensitivity of plant to stress, Soja and Soja, 1989 found that faba beans' cultivars differed significantly in their sensitivity to drought stress. On the other hand, Husain et. al.,1990 found that faba beans' yields are equally sensitive to drought stress during all developmental phases. Also, they round that the crop responded to stress by decreasing its leaf area expansion rate slightly and producing leaves of smaller specific area.

This work aimed to study the effect of some water stress treatments (50, 75, 100 and 125% of field capacity) on growth and development of two cultivar of snap bean (Giza 3 and Bronco) under egyptian conditions.

MATERIALS AND METHODS

Pot experiments were carried out during two successive seasons, 1994 and 1995 in a growth chamber to investigate the effect of different levels of water-stress as a percentage of field capacity (by weight) on growth and development of bean (*Phaseolus vulgaris* L.) variety Giza3 and Bronco.

Seeds of bean (*Phaseolus vulgaris* L. var. Giza3 and Bronco) were sown in peatmoss trays under unheated greenhouse conditions. At the fourth leaf stage, the seedlings were transplanted in pots, 20 cm in diameter. Each pot was filled with 4 Kg of air-dry sandy soil with field capacity of which was 13.5% (based on weight of soil). Each pot contained two plants. The pots were transplanted to a growth chamber adjusted to 30/24 C, 85/60 % R.H day/night and light intensity approximately 3500 lux for a period 12 h a day. The application of water-stress treatments started when the plants were established (after one week from transplanting and transferring to the growth chamber).

Plants of both varieties were subjected to different levels of water stress (125%, 100%, 75%, 50% of field capacity by weight). The first treatment (125% of field capacity) was applied once at the beginning of the experiment then the water was added as mean of the amount of water added to the 100% treatment, with preventing drainage of those pots to represent excessive water treatment. The pots were weighed during two days intervals to compensate the water loss by evapotranspiration. The soil moisture in the other treatments was maintained every two days at 100%, 75%, 50% of field capacity. Normal agricultural practices were applied for all treatments.

The experiment was designed as a completely randomized with four replicates (8 pots / replicate). All data were subjected to statistical analysis according to the method of analysis of variance and value of least significant difference (L.S.D.) at 5% was calculated to compare every two means (Sendicor and cochran, 1980).

The following plant growth parameters were measured: Plant height, Number of leaves, flowers and pods per plant and Total chlorophyll content (in SPAD unit) using digital chlorophyll meter (model minolta chlorophyll meter SPAD-501). The leaf area was recorded by using a digital leaf meter (LI-3000 Portable Area Meter Produced by LI-COR Lincoln, Nebraska, USA) and Percentage of dry matter content per m^2 of leaves' area, Number of flowers, Fruit set, Pods' number, weight, Pods' fiber content percentage (According to Chapman and Pratt (1961) and Pods' total protein content (g/100 gm of dry matter) was determined according to Chapman and Pratt (1961) at the end of the experiment..

RESULTS AND DISCUSSION

Vegetative growth and flowering

a- Plant height

The height of plants was significantly affected by changes in soil moisture (fig.1). The interaction among treatments was significant during the two successive seasons. It was clear that Giza3 cultivar was significantly increased in plant height compared with Bronco cultivar under the water-stress treatments. By the end of stress period, the differences between 125% and 50% treatments become vanish and they were equal in their injurious effects. These results agree with Soja and Soja (1989) who stated that cultivars of faba beans as well as peas differed significantly in their sensitivity to drought stress.

The depression of plant height could be resulted from a reduction in plant photosynthetic efficiency as reported by Vieira et. al., (1990); Abdul-Hamid et. al., (1990); Nunez-Barrios (1991) and Castonguay and Markhart (1992).

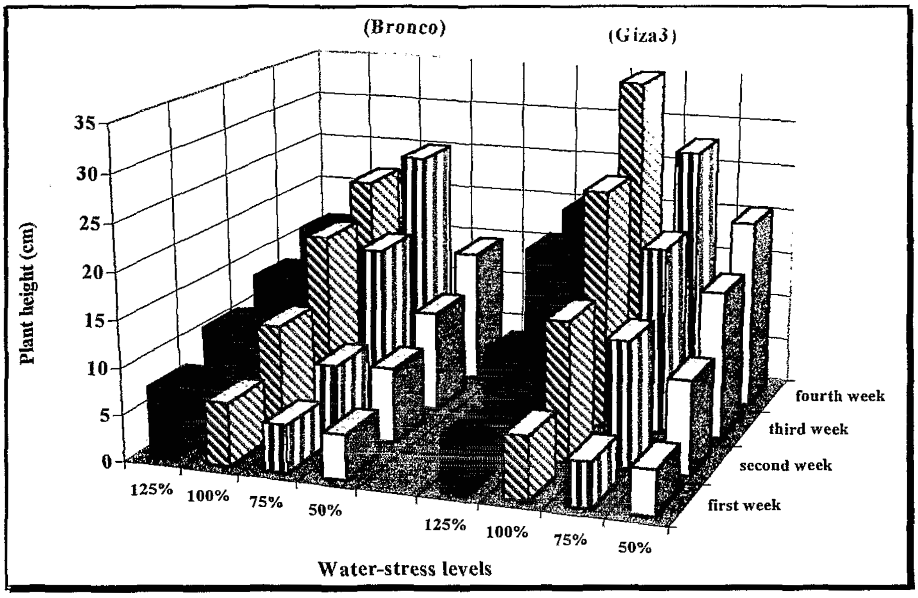

Figure 1. Effect of water-stress levels on plant height (cm)

b- Leaves numbers

As shown in fig. (2), a decrease in leaves' number was observed under various water-stress levels. The differences among water stress treatments were not significant while there was a significant difference between cultivars. An acceleration of leaves senescence was observed in the plants exposed to injurious levels of drought (50%) or excessive water treatment (125%), that resulted in a leaf abscission by the end of the stress period and that was one of the main mechanisms by which plants adapted to water-stress. These results agree with the indication of Nunez-Barrios (1991).

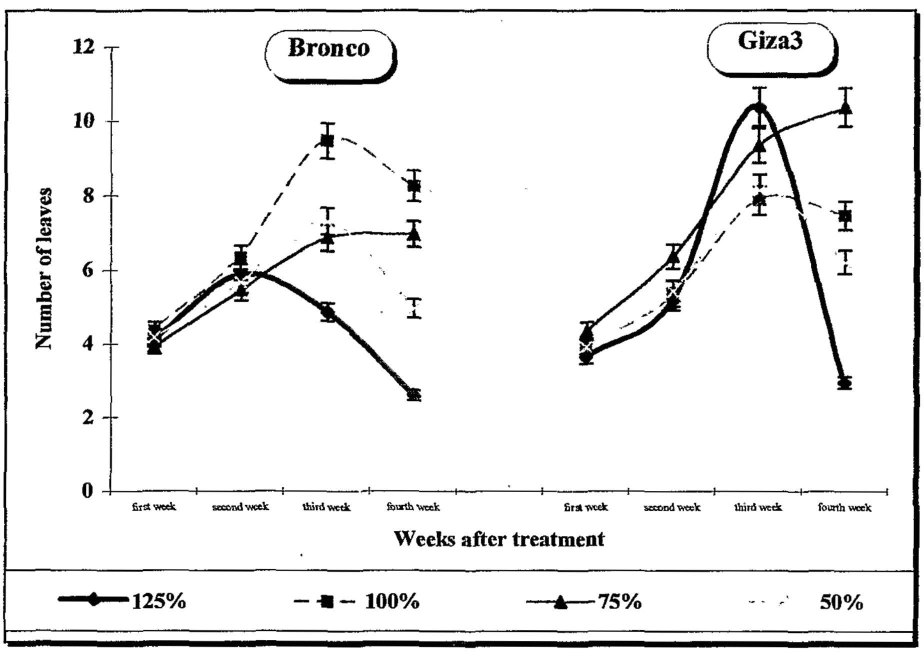

Figure 2. Effect of water-stress levels on the accumulated number of leaves per plant

c- Chlorophyll content

It is clear from the data shown in fig. (3) that total chlorophyll content increased as the amount of water increased concerning the 75% and 100% of field capacity treatments. On the contrary, subjecting to severe drought (50% of field capacity) caused a decrease in total chlorophyll contents. These could be a result of a reaction center or a photosystem II modification as Jaspers et. al., (1984); Cornic et. al., (1989); Levitt, (1980) and Becker et. al., (1986) pointed out.

Bronco cultivar was more affected by excessive water-stress treatment where the decrease of total chlorophyll content was rapidly high. That could be explained as a result of genetic differences between cultivars which mean that Giza3 was more tolerant to excessive water-stress than Bronco cultivar (Robinson et. al., (1983); El-Beltagy and Soliman (1983).

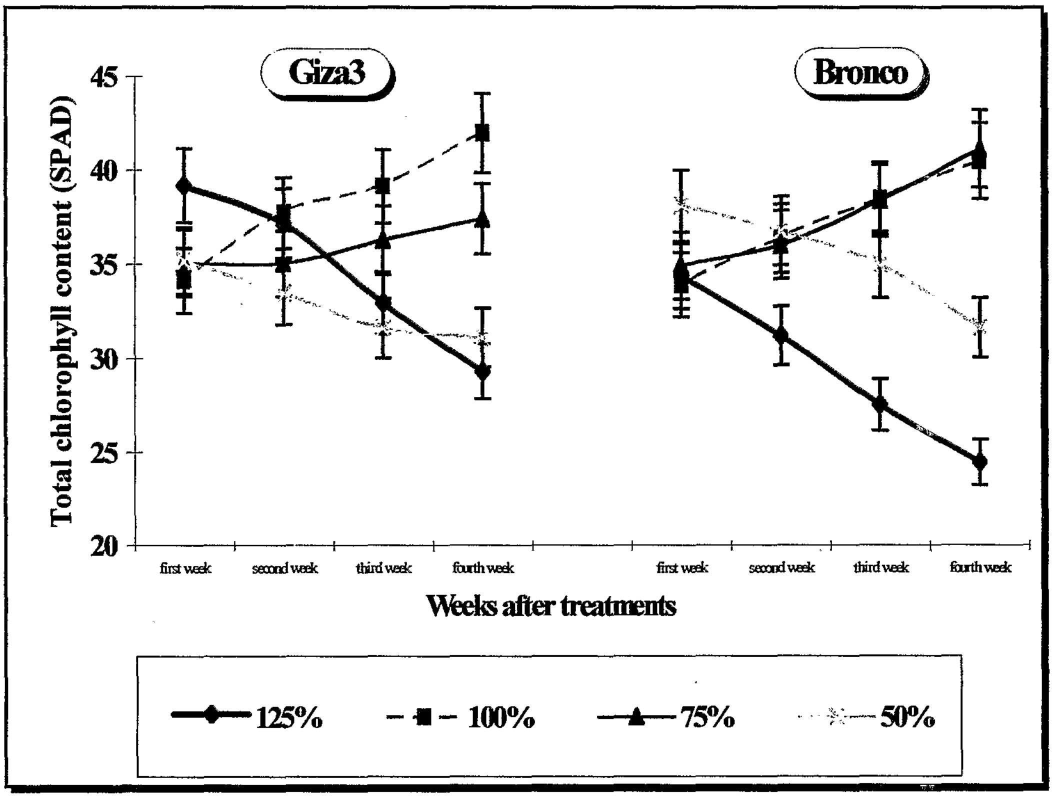

Figure 3. Effect of water-stress levels on the total chlorophyll content (SPAD).

(d) Leaf area:

Leaf area as shown in figure (4) was measured at the end of the stress period. Bronco cultivar had a significantly larger plant canopy than Giza3 resulted in higher leaf area except when treated with excessive water treatment. That could be due to its sensitivity to the excess of water (Anisa et. al., (1995); Koraki (1992) and Herz et. al., (1992)). It could be concluded that the most preferable treatments for both cultivars were 100% and 75%, respectively. Exposing the plants to a drought stress of 50% of field capacity resulted in reduction of leaf area and that agrees with the results obtained by Soja and Soja (1989); Husain et. al., (1990) and Nunez-Barrios (1991).

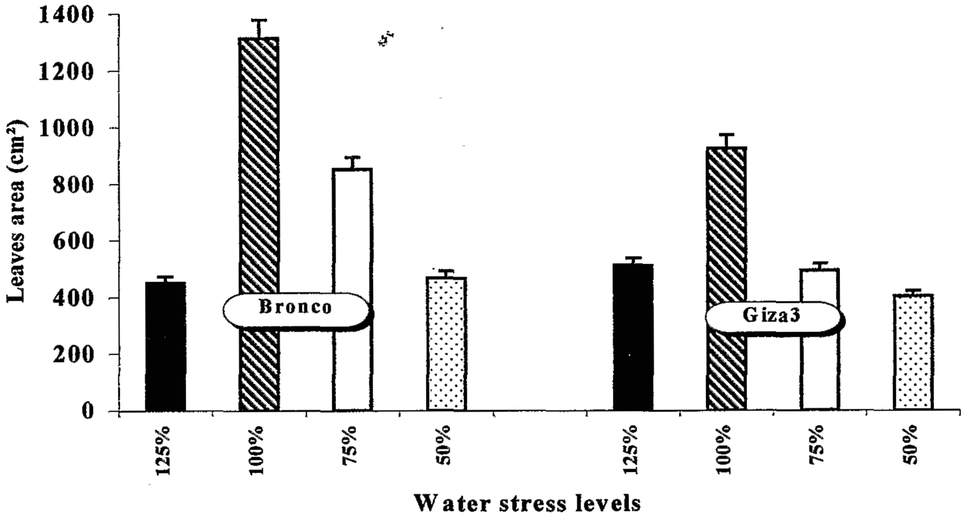

Figure 4. Effect of water-stress levels on total leaf area (cm²)

e- Percentage of leaves' dry matter content per m² of leaves area:

Leaves dry matter content as a percentage per m² of leaves' area) significantly increased by decreasing the soil moisture (Fig.5). Giza3 cultivar showed an ability to produce a significantly higher dry matter content than Bronco cultivar especially under the excessive water treatment. Whereas the 100% and the excessive water treatment did not differ from each other, but there was a significant difference between them and the 50% treatment. It is obvious that increasing water supply decreased the ability of producing the dry matter that could be explained as a result of reduction in the chlorophyll content and consequently the plant photosynthesis as Abdul-Hamid et. al., 1990 pointed out.

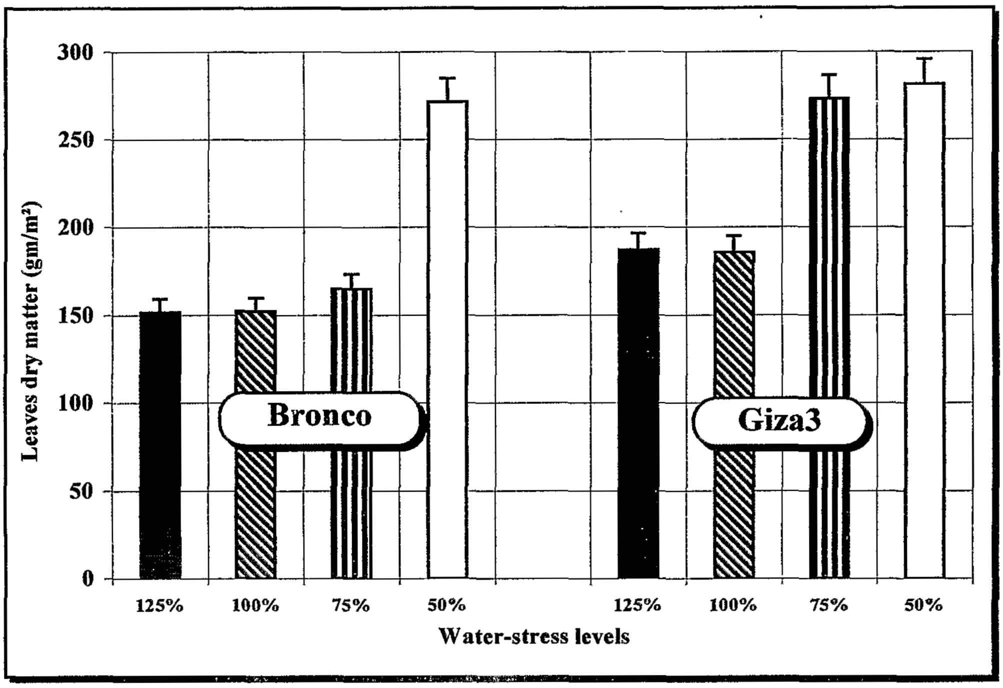

Figure 5. Effect of water-stress levels on leaves dry matter (gm) per m² of leaves area

f- Number of flowers and fruit set

The effect of water-stress levels on the accumulated number of flowers produced through out the stress period is shown in fig. (6). The number of flowers per plant was recorded every 3 days. 125% of field capacity treatment stimulated the production of flowers earlier than the other treatments, by 4-5 days and the 50% of field capacity was the latest treatment concerning the onset of flowering. These results are in agreement with those obtained by Nunez-Barrios (1991). Moreover, in both water-stress levels (125% and 50%), Giza3 obtained a higher percentage of fruit set as shown in fig. (7) but almost 85% of those pods failed to develop.

Under the excessive water treatment the flowers' production of Bronco cultivar decreased and by the end of the stress period all the flowers had been abscised and fruit set was suppressed, these results are similar to that reported by El-Beltagy and Soliman (1983).

Giza3 cultivar produced a few numbers of flowers when subjected to the excessive water treatment through out the first two weeks then stopped since the third week of treatment application until the end of the stress period.

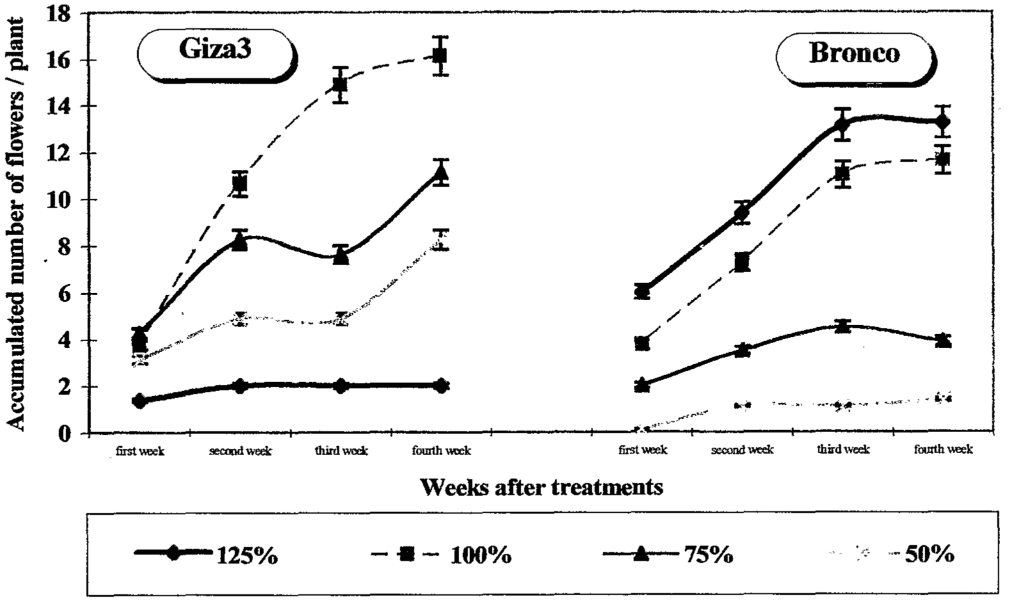

Figure 6. Effect of water-stress levels on the accumulated number of flowers per plant

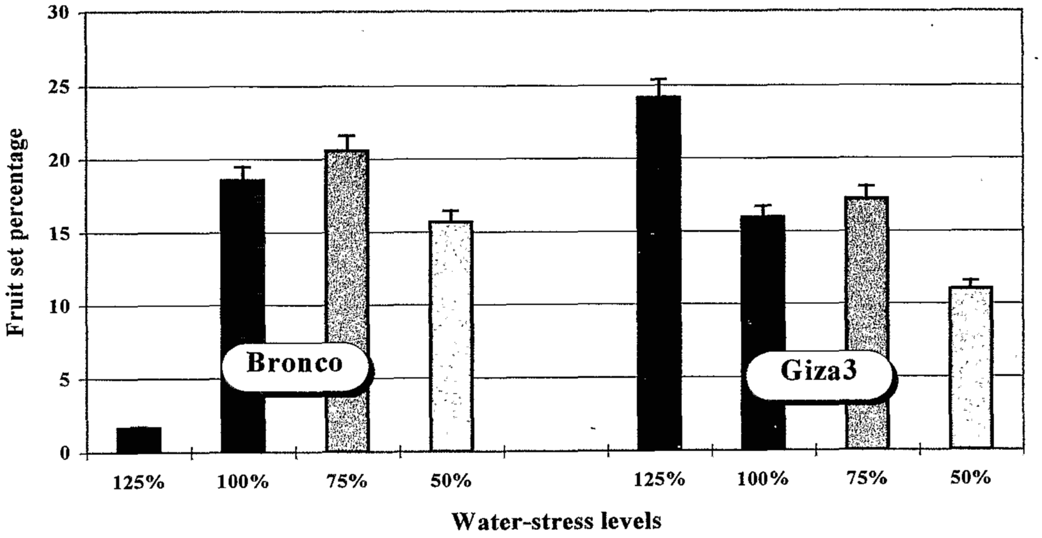

Figure 7. Effect of water-stress levels on fruit set percentage

Yield characters

a- Number of marketable pods produced by bean plants:

The number and weight of the marketable pods produced by bean plants through out the stress period was significantly affected by the interaction between the water-stress treatments and cultivars, as shown in table (1).

Table 1: Effect of some water stress levels on pods number and weight per plant

Treatments	Bronco		Giza3	
	No. of pods	Weight(gm)	No. of pods	Weight (gm)
125%	0.00	0.00	4.94	13.73
100%	3.44	11.55	5.56	16.45
75%	5.87	19.95	4.81	13.94
50%	2.25	4.72	3	6.9

There was an increase in number of marketable pods per plant with the increase of the amount of water up to a certain limit.

Bronco cultivar was more affected by the excessive water treatment (125% of field capacity) and did not produce a pronounced number of marketable pods where almost all the flowers had been abscised. That agreed with Radulovich (1990) who mentioned that the reduction of yield could be due to exposing the plants to a high moisture stress during the period from pod development to harvest. Otherwise it could be a result of water excess regardless of the timing of the stress treatment as pointed out by Lakitan et. al., (1992). Generally, both cultivars significantly differed from each other concerning their yield characters under water-stress conditions.

Moreover, It is evident that the high percentage of field capacity up to certain limit increased yield significantly. On the other hand, cultivars differed from each other concerning pod weight.

The most suitable treatment in order to reach the identical record was 100% of field capacity for Giza3 cultivar and 75% of field capacity for Bronco cultivar. These results are in agreement with Silberngel et. al., (1991).

b- Percentage of pod total fiber content

An increase in fiber content was observed as the amount of irrigation decreased. Fig. (8) represents one of the most important characters that determine the quality of snap bean pod, which is total fiber content (Silberngel et. al., 1991). As shown, it is obvious that the total fiber content of snap bean pod decreased with increasing water supply. Giza3 cultivar that treated with excessive water treatment had the lowest pod fiber content and almost reached the maximum percentage content described by Cselotel and Varga (1987). That could be due to high canopy temperatures rather than to water stress as Sistrunk et. al., (1989) has pointed out. The effect among treatments or between cultivars was significant.

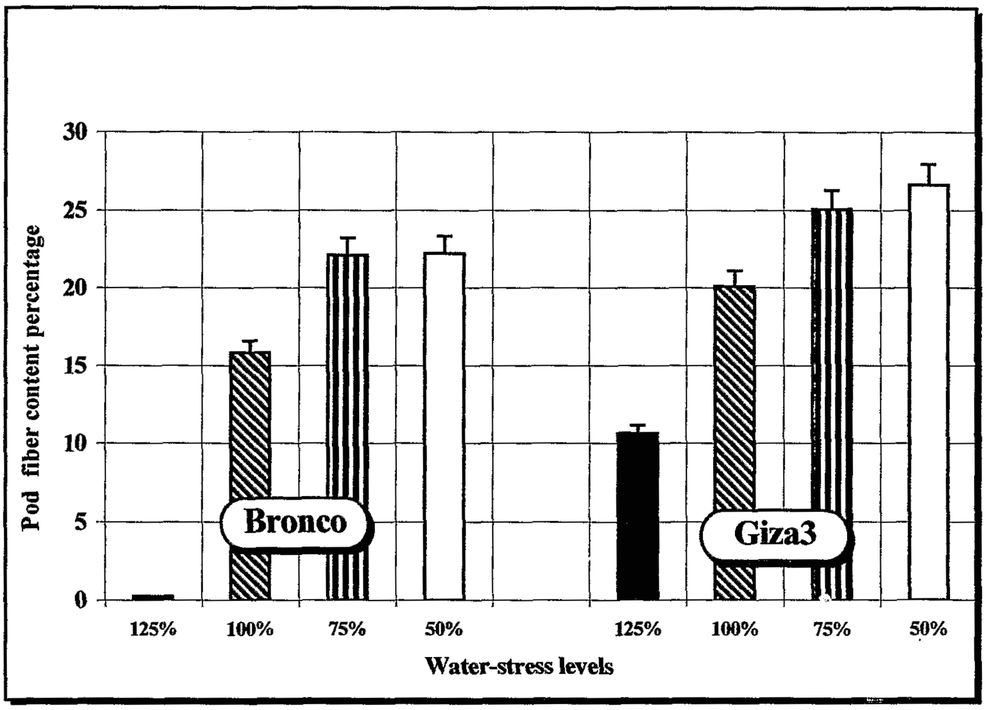

Figure 8 . Effect of water-stress levels on pod fiber percentage

c- Percentage of pod total protein content

The total protein content is the character that plays an important role in the nutritional value of the crop. It is obvious from fig. (9) that the total protein content increased with increasing water irrigation amount. This effect was significant especially for Bronco cultivar which showed the highest percentage of protein content when treated with 75% of field capacity and as mentioned before, the plants hardly produced any pods when treated with the excessive treatment so the total protein content could not be measured under this treatment. The interaction between water-stress treatments and cultivar was significance.

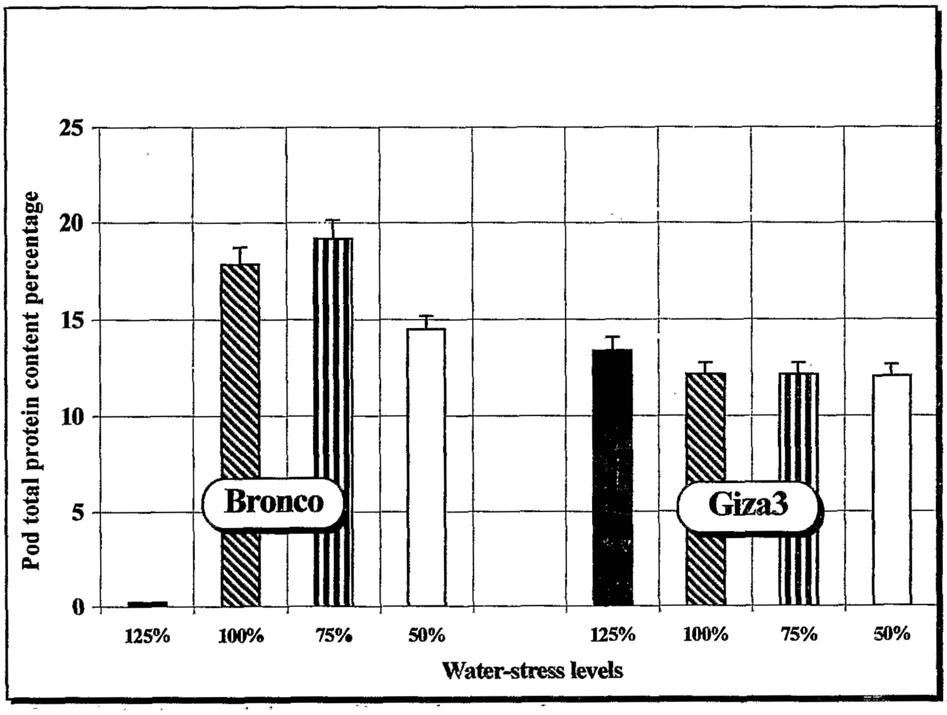

Figure 9. Effect of water-stress levels on pod total protein content

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