# Water consumption of bean plants (Phaseolus vulgaris L.) as affected by dates of sowing

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# WATER CONSUMPTION OF BEAN PLANTS (PHASEOLUS VULGARIS L.) AS AFFECTED BY SOWING DATES

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**Abstract:** The experiment was conducted during two successive seasons (1994 - 1995) to investigate the actual water consumption of snap bean plants as affected by two sowing dates, using two cultivars (Giza3 and Bronco), comparing with the calculated values based on the meteorological data of the region. The dates of sowing were the last week of January and the third week of February. Plants were grown in sandy volumetric lysimeters. The water was added according to irrigation schedule based on Penman equation. This work aimed to study the possibility of water use rationalization and to determine the crop coefficient (Kc) for snap beans for different plant's growth stages. The results showed that there were respectable differences in water consumption between the two dates of sowing. Considering the vegetative growth, it was reduced at the earlier date of sowing for both cultivars while the reproductive stages were not much influenced by sowing dates.

## INTRODUCTION

Legumes are a primary food source in many regions of the world. Beans are rich in protein and form part of the stable diet of the Egyptians and many other Middle Eastern countries. Egyptian Agricultural Ministry aimed to extend the cultivation of common bean because of its economical importance and that by increasing the cultivated area yearly by approximately 20%.

Both water and air temperatures play an important role in the production of common bean. The need of optimizing water consumption has received the attention of several investigators. Abd El-Gawad et. al., 1970 stated that there was a reduction in number of days required for horse-bean pods to reach their greatest length and greatest diameter from flower anthesis by delaying the time of sowing. Planting date that has an important role on bean production has been studied by many investigators (Stolk and Cools, 1993; Heij, 1989; Escalante et. al., 1989) who found that seed sowing from October to December showed a pronounced effect on number of pods per plant of climbing snap bean (*Phaseolus vulgaris*). Varga and K□szegi (1987) reported that in case of early sowing the main water consumption of snap bean plants falls on the cooler times, thus less water use can be expected. Recently, Anisa et. al., 1995 indicated that early planting decreased the number of days to the appearance of first flower of climbing bean plants cultivated under plastic houses in Qalubia Governerate. Early planting exhibited higher pod length and thickness in the two growing seasons. On the other hand, Singer et. al., 1996 pointed out that late sowing date (29th of Feb.) was more suitable for bean (*Phaseolus vulgaris* L.) growth and productivity compared to other earlier sowing dates.

## MATERIALS AND METHODS

The experiment was carried out in Faculty of Agriculture Ain Shams Univ. where seeds of bean (*Phaseolus vulgaris* L.) cultivars (Giza3 and Bronco) were sown at two dates, the last week of January and the third week of February in two successive seasons 1994 and 1995 in trays containing peat moss and vermiculite (1:1 v:v) mixture. At the fourth leaf stage the plants were transplanted to a sandy soil lysimeter.

The experimental design was a complete randomized block. Treatments (two cultivars and two sowing dates) were replicated four times. Each replicate consisted of two lysimeters; each had one cultivar. The lysimeter was a concrete tank (1 X 1 X 1 $m^3$) which was used for measuring the actual water consumption. Analysis of variance was conducted according to Snedecor and Cochran, 1980.

The irrigation schedule was calculated and applied for the certain period of cultivation using a computer model (Cropwat) designed by FAO based on Penman equation. The average of last 9 years meteorological data for the region was used to estimate the historical predicted Eto.

Each lysimeter received irrigation according to the schedule and was adjusted to ensure a drainage rate of 10-12%. Soil water tension at 30 cm depth was monitored with Stainless steel sensors (Mc-300 series soil moisture - temperature meter and soil cells). Daily water use values were cumulated until the cumulative use approximated the allowable water use value at which time irrigation was applied. General cultural practices were applied regularly according to M.O.A. recommendations.

## THE DATA RECORDED WERE AS FOLLOWS

### Water management measurements

(a) Soil water content was measured by two methods, Stainless steel sensors (Mc-300 series soil moisture - temperature meter and soil cells) and the Gravimeterical method. Stainless steel sensors were installed permanently to measure soil water content according to Coil, (1936) and Lutz (1944). Samples of soil in the 30 cm layer were taken and moisture content was measured, by drying at 105 C° for 24 hours and re-weighing until it reach a constant weight then the percentage of soil moisture was calculated by using the following equation:

$$\%\,\text{Soil moisture content} = \frac{\text{Weight before drying weight after drying}}{\text{Weight befor drying}} \times 100$$

(b) Water balance was calculated according to Shaw and Arbie (1959)
Where: Water balance = Water added - Water drained.

The extra water was collected from the lysimeter at a depth of 90 cm and leached water calculated as a percentage of the actual water consumption.

(c) Calculated Reference Evapotranspiration during 1994-1995 using the meteorological data of Ain Sham Univ. meteorological station.

Actual water consumption and Total irrigation requirement.
Kc as derived value from the following equation:

$$Kc = \frac{ETc}{ETo}$$

Where Kc is Crop coefficient factor; ETc is the water consumption and Eto is the reference evapotranspiration as described by Doorenbos and Pruitt, 1984.

(d) Actual drained water from lysimeter and Actual leaching percentage.

## GROWTH MEASUREMENTS

Three plants were chosen randomly within the four replicates in each treatment in order to estimate the following parameters:

Plant height and Leaf's number were recorded every week; Leaf area ($cm^2$) was recorded at the end of season using a digital leaf area meter (LI - 300 Portable Area Meter) (LI - COR, Lincoln, Nebraska, USA); Total chlorophyll content (SPAD) was measured weekly using digital chlorophyll meter (model Minolta chlorophyll meter SPAD-501); Accumulated number of flowers per plant; fruit set percentage and number of pods per plant.

## RESULTS AND DISCUSSION

### 1. Water management

#### (a) Soil moisture content

A calibration of stainless steel sensors as an estimation of soil moisture content with the gravemeterical method is presented in Figure (1).

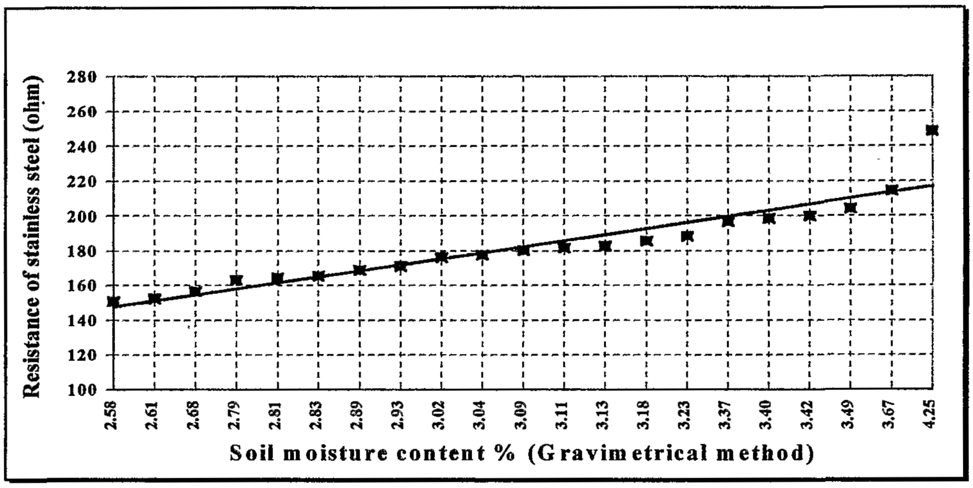


**Figure 1. Correlation between soil moisture content (%) and resistance (ohm) in soil.**

#### (b) Predicted and calculated reference crop Evapotranspiration

Eto was calculated as a derived value using climatic data obtained from the meteorological station at faculty of Agric. Ain Shams Univ. to test the predicted historical Eto derived from empirical formulae based on Penman equation during 1994-1995. Figure (2) presents a comparison between these two values for both two sowing dates. It is obvious that there was no significant difference between the two calculated values for both sowing dates, but it differed significantly from the predicted historical Eto.

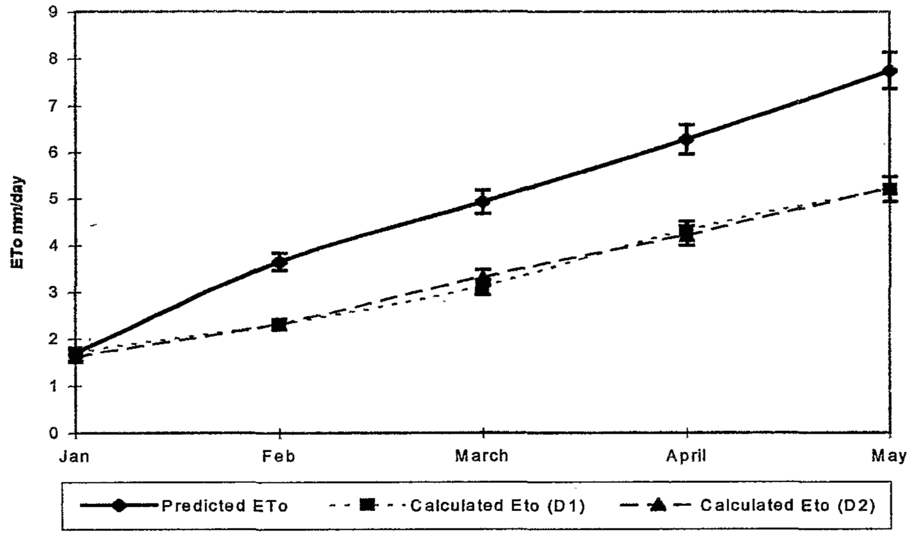


**Figure 2. Correlation between predicted histoeical Eto and Calculated Eto (during 1994-1995) in both dates of sowing.**
(D1= Early sowing date D2= Late sowing)

**(c) Etc (Water consumption)**

The data illustrated in Table (1) show that the daily ETc was associated with the plant development stage. The early sowing lead to a significant decrement in Etc compared with the late sowing through out the initial stage and the beginning of the development stage. That could be due to the low temperature during the early sowing date. There was significant difference between the two cultivars concerning the Etc and the statistical analysis showed significant difference between the actual and the calculated Etc in both sowing dates except for the early sowing date in the initial stage and the beginning of the development stage. There was continuos increment in the crop water consumption till the end of the mid-season stage, and it decreased by the harvest time.

**Table 1. Actual and calculated ETc during two dates of sowing for both cultivars**

| Plant growth stage | Early sowing date | | | Late sowing date | | |
|---|---|---|---|---|---|---|
| | Bronco (actual) | Giza3 (actual) | Calculated | Bronco (actual) | Giza3 (actual) | Calculated |
| Initial | 1.15 | 1.15 | 1.15 | 1.435 | 1.44 | 1.435 |
| development | 2.65 | 2.67 | 3.12 | 3.13 | 3.12 | 2.94 |
| mid season | 4.24 | 5.67 | 5.81 | 5.38 | 5.40 | 6.18 |
| late season | 4.80 | 4.786 | 6.25 | 6.15 | 6.13 | 6.79 |

**(d) Leaching percentage**

Data illustrated in Figure (3) show the actual leaching percentage in both sowing dates for both cultivars. Concerning that the assumed leaching percentage was 10-12% of the water added, there was no significant difference between the actual and the assumed leaching percentage. The actual leaching percentage, which was measured from lysimeter drain, was found that to be similar to that assumed (10-12%). This could be a result of the continuous effort to control irrigation water quantity so the leaching percentage would be in the range of 10-12% (El-Tantawy, 1993).

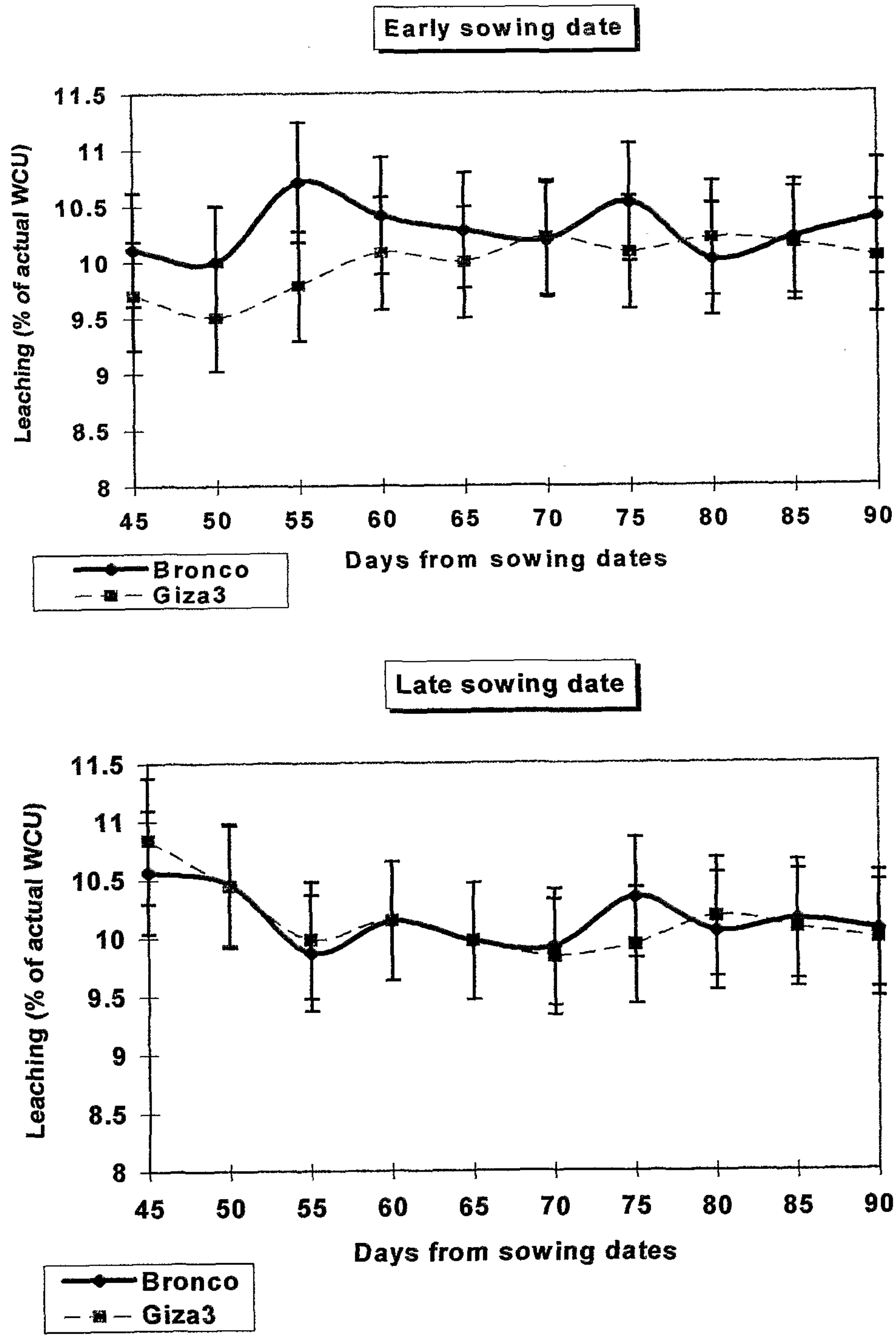


**Figure 3. Leaching percentage from actual water consumption for both cultivars during two dates of sowing.**

### (e) Drainage water

Figure (4) shows that there was a similarity between the calculated drained water and the actual amount of drainage measured from lysimeter. This indicates that the calculation of drainage water was close to the actual amount. (El-Tantay, 1993).

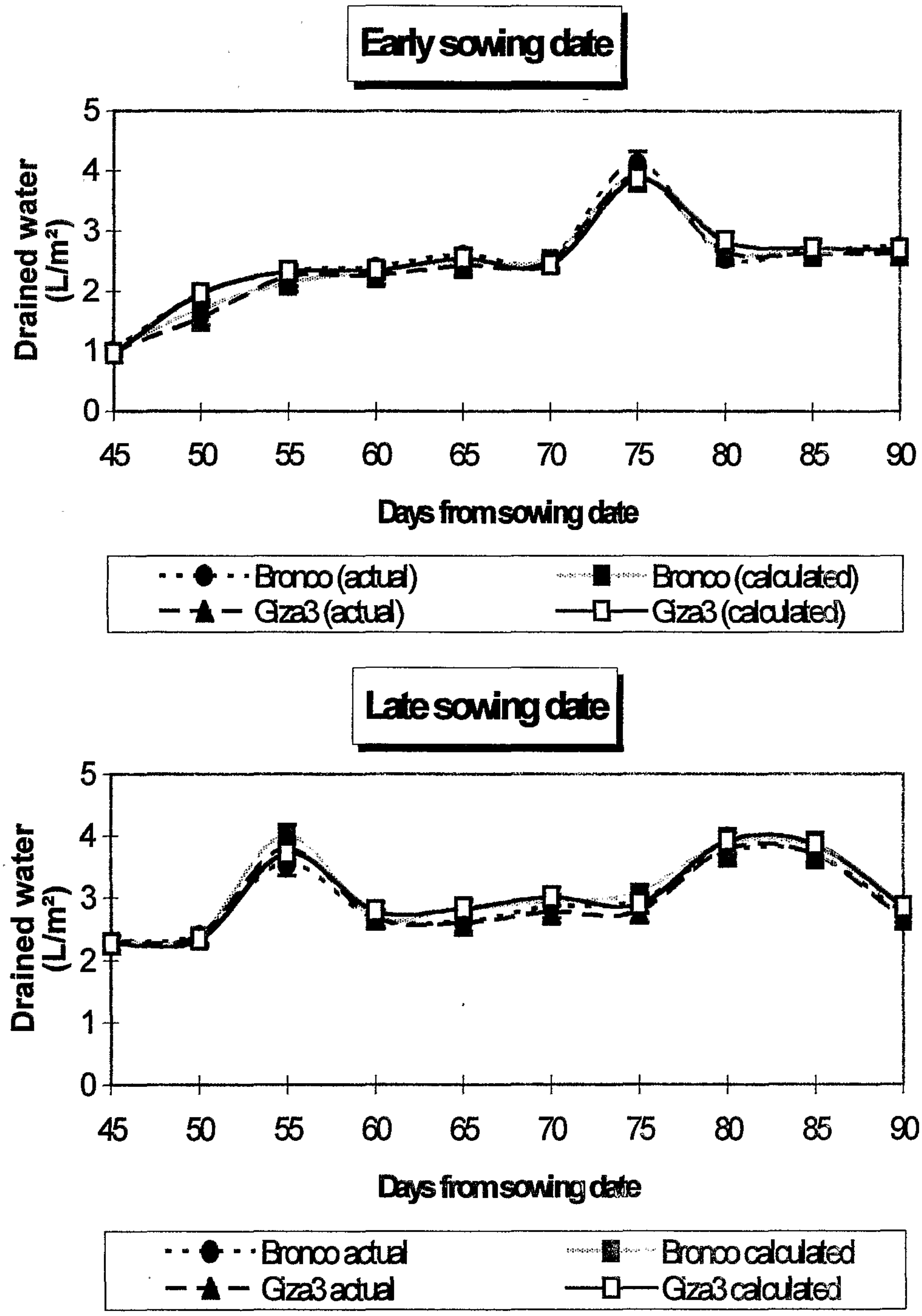


**Figure 4. Drained water of both cultivars during two dates of sowing**

**(f) Crop coefficient (Kc):**

Data presented in Table (2) illustrate the measured Kc of bean plants under the condition of this experiment during two sowings dates for both cultivars. It is obvious that the measured Kc during the early sowing date is low comparing with the late sowing date that resulted in higher water consumption during the late sowing date. On the other hand, generally it can be seen that Giza3 cultivar had higher Kc values than Bronco resulted in higher water consumption. This could be explained as a difference in the genetic characters between both cultivars.

**Table 2. Measured Kc for bean plants during two sowings dates for both cultivars**

| Plant stages | Earlier sowing dates | | | Late sowing dates | | |
|---|---|---|---|---|---|---|
| | Measured (Bronco) | Measured (Giza3) | Assumed | Measured (Bronco) | Measured (Giza3) | Assumed |
| Initial | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Development | 0.985 | 0.987 | 0.67 | 1.11 | 1.115 | 0.58 |
| Mid-season | 0.986 | 1.319 | 1.00 | 1.28 | 1.285 | 0.98 |
| Late-season | 0.922 | 0.92 | 0.93 | 1.18 | 1.178 | 0.91 |

**(g) Total irrigation requirement:**

As illustrated in table (3) the early sowing resulted in a reduction in the total irrigation requirement. That could be a result of low temperature effect on the root absorption ability as pointed out by Varga and K□ szegi, (1987). On the other hand, there was a significant difference between the calculated and measured total irrigation requirement that could be due to the higher predicted ETo which total irrigation requirement calculation based on.

**Table 3. Total irrigation requirement mm/m$^3$**

| Early sowing date | | | Late sowing date | | |
|---|---|---|---|---|---|
| Calculated | Measured (Bronco) | Measured (Giza3) | Calculated | Measured (Bronco) | Measured (Giza3) |
| 353.5 | 219.13 | 220.01 | 419.6 | 267.92 | 268.1 |

**Vegetative growth:**

Data presented in figures 5,6,7 and 8 show the effect of sowing dates on plant height; leaf number; total chlorophyll content and leaf area, respectively, of both cultivars Bronco and Giza3. Generally, the statistical analysis showed significant differences between both dates of sowing for all previous characters. Where plant height; leaf number; total chlorophyll content and leaf's area achieved a higher record in late sowing than in early sowing. On the other hand, there was a significant difference between both cultivars Bronco and Giza3 concerning all the previous characters, except for plant height for the earlier sowing.

It is obvious that Bronco cultivar had higher plant height than Giza3 under the ambient conditions of late sowing and vice versa. That could be explained as results of the warmest condition considering the late sowing date.

Also, Bronco cultivar was the superior than Giza3 concerning total chlorophyll content and the number of leaves, where Bronco had a larger leaf area resulted in a larger canopy. That could be due to the differences of genetic characters than the air temperature (Doorenbos and Pruit, 1984).

It could be concluded that late sowing fulfilled a significant vegetative growth than the earlier sowing, that agree with what obtained by Singer et. al., 1996.

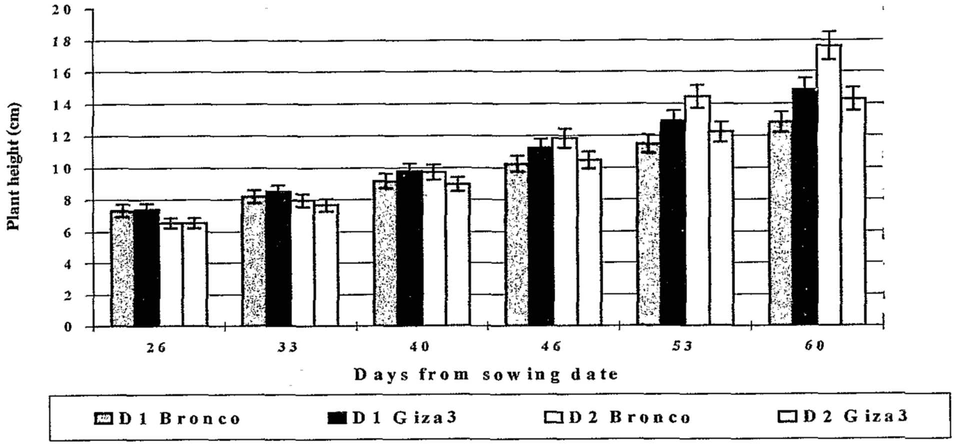


**Figure 5. Effect of sowing dates on plant height (cm²)**
(D1= Early sowing date D2= Late sowing)

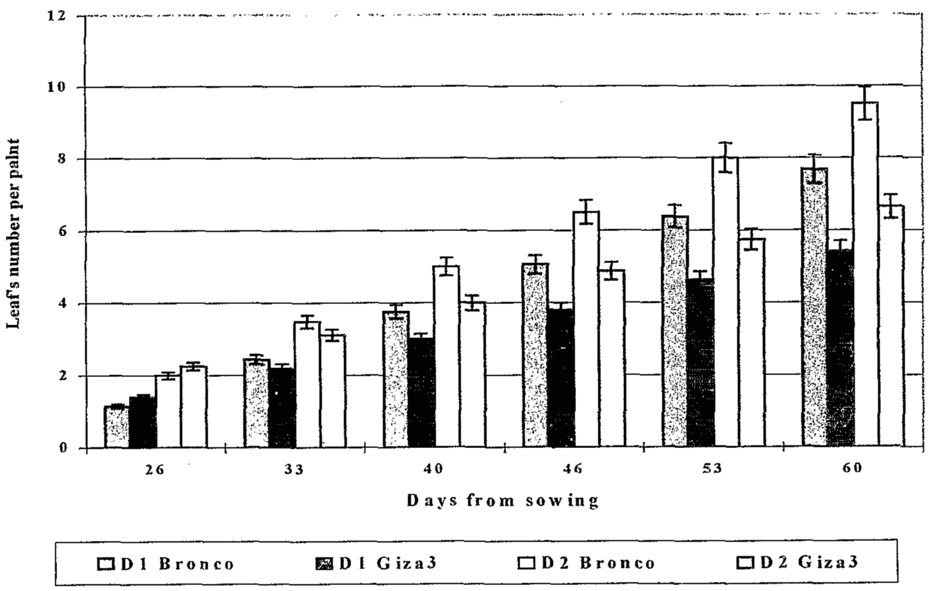


**Figure 6. Effect of sowing dates on leaf's number of per plant.**
(D1= Early sowing date D2= Late sowing)

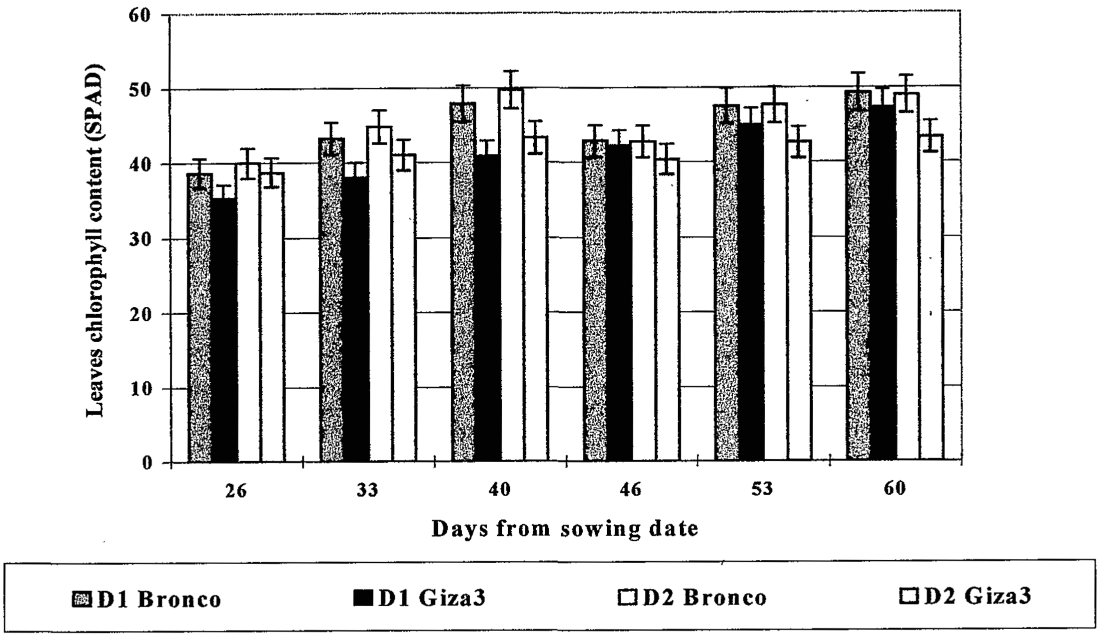


**Figure 7. Effect of sowing dates on total chlorophyll content (SPAD).**

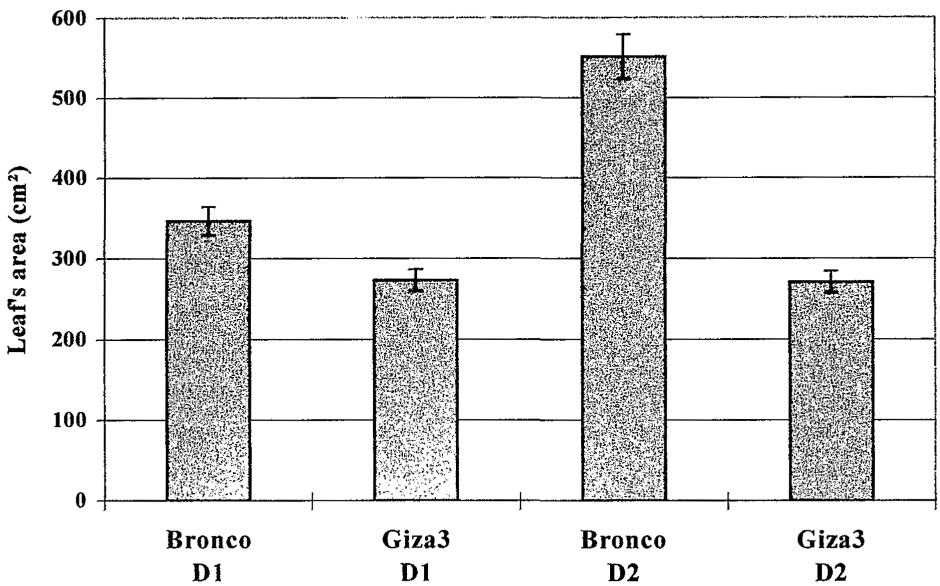


**Figure 8. Effect of sowing dates on leaf's area ($cm^2$)**
(D1= Early sowing date D2= Late sowing)

**Blooming and yield:**

**(a) The accumulated number of flowers per plant:**

The number of days to the appearance of first flower has been decreased by late planting date that is in a contrary with what Anisa et. al. (1995) has pointed out. As it is shown in figure 9 there were significant differences between the two sowing dates, where both cultivars produced a higher number of flowers at the earlier date compared with the late sowing. Both cultivars differed significantly from each other during the dates of sowing. Bronco cultivar produced significantly higher number of flowers than Giza3 cultivar.

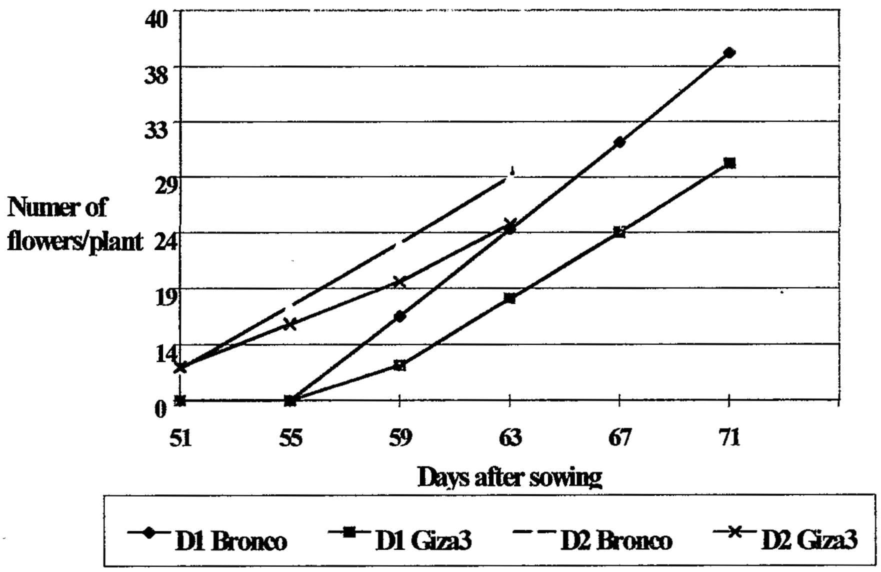


**Figure 9. Effect of sowing dates on number of flowers per plant**
(D1= Early sowing date D2= Late sowing)

**(b) Number of pods per plant:**

Figure 10 illustrates the effect of sowing dates on the number of pods per plant. There was a significant difference between both sowing dates where the plant produced a higher number of pods in the earlier sowing than the late sowing, that agree with what Stolk and Cools (1993); Heij (1989); Escalante et. al., (1989) had obtained. Cultivars also differed from each other where Giza3 had a higher number of pods per plant than Bronco cultivar in earlier sowing and visa versa. That could be a result of genetic characters of both cultivars, which make Giza3 cultivar more productive under low temperature condition, and Bronco cultivar needs a warmer condition for higher pods' production.

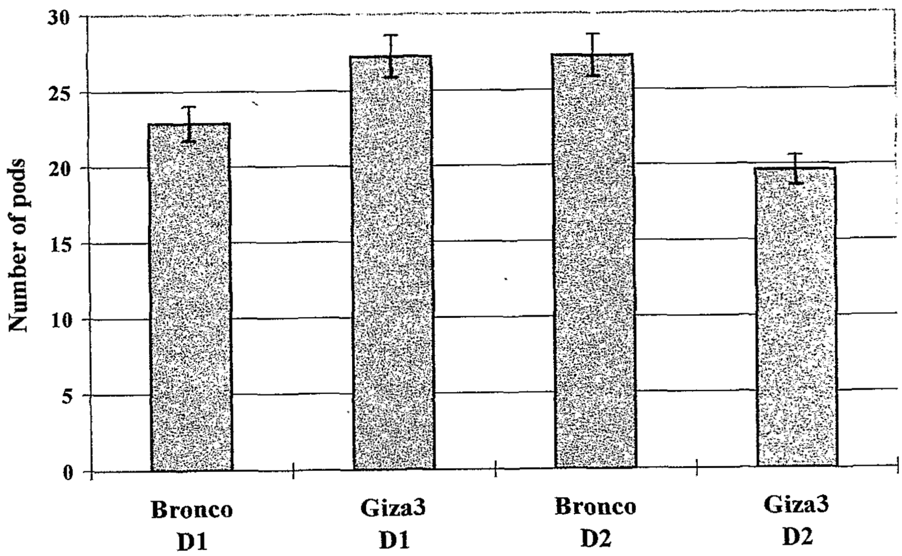


**Figure 10. Effect of sowing dates on pods number per plant**
(D1= Early sowing date D2= Late sowing)

**(c) Fruit set percentage:**

Table (4) shows that early sowing date resulted in an early fruit setting by approximately 8 days. Concerning the differences between cultivars, Giza 3 cultivar had a higher fruit set percentage compared with Bronco cultivar at the first sowing date. In contrary Bronco cultivar was significantly higher than Giza3 cultivar in fruit set percentage at the late sowing date. It could be concluded that late sowing date was much suitable for Bronco cultivar than the earlier sowing date and visa versa.

**Table 4. Fruit set percentage for bean plants during two sowings dates for both cultivars**

| | Earlier sowing dates | |
|---|---|---|
| Days from blooming | (Bronco) | (Giza3) |
| 29 | 79 | 90 |
| Late sowing dates | (Bronco) | (Giza3) |
| 37 | 93 | 76 |

Generally it could be concluded from the results obtained, that early sowing resulted in a decreasing in evapotranspiration, and hence lower water consumption due to a decreasing in vegetative growth which reflected to the yield. It is worthy mention that early sowing resulted in an early yield due to early fruit set by approximately 4 days. These results agreed with Abd El-Gawad et. al., 1970; Stolk and Cools, 1993; Heij, 1989; Escalante et. al., 1989 and Varga and K□szegi, 1987.

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