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Irrigation Water Management for Bush Snap Bean Production

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Abstract. **The effect of various amounts of irrigation on vegetative growth and pod yield of bush snap beans (*Phaseolus vulgaris* L.) was investigated. The field experiments were carried out during 1985 and 1986, years of abundant and limited rainfalls, respectively. Evaporation from a National Weather Service type open pan (E_{pan}) was used to determine the timing and amount of irrigation. Vegetative growth was estimated from the number of leaves, leaf area, and leaf and stem dry weights. Irrigation significantly increased vegetative growth and pod yield. Pod yield/unit of irrigation water was maximum at 60% E_{pan}. Vegetative growth increased linearly from irrigation amounts of 0% to 100% E_{pan}, while pod yield enhancement ceased above 80% E_{pan}. The study suggested an irrigation schedule based on 80% E_{pan} for highest bush snap bean production.**

The importance of irrigation in maximizing yield of bush snap beans is well-documented (1, 5, 6, 10, 12–14). The soil water potential at which irrigation results in the highest pod yield depends on the soil type. It ranges from −25 kPa for loamy sand (14) and −50 kPa for loam (9) to −60 kPa for silty clay loam (6). Irrigation has also been shown to affect vegetative growth of snap beans (3, 5, 7). Millar and Gardner (8) found a 47% reduction in the rate of dry matter production due to a decline in soil water potential from −28 to −40 kPa. However, irrigation had little effect on growth of snap beans in Alabama, except when rainfall was less than 75% of normal (2).

Previous research has primarily focused on irrigation for once-over combine-harvested crops used for processing. Water needs of multiple hand-harvested crops grown for fresh consumption remained to be determined. The objective of this study was to evaluate the effect of different amounts of irrigation on growth and pod yield of multiple-harvest bush snap beans.

Field experiments were carried out during 1985 and 1986 at the Fort Valley State College Agricultural Research Station, Fort Valley, Ga., on a Dothan sandy loam soil (fine loamy, siliceous, thermic, Plinthic Paleudult). The soil had a bulk density of 1.6 $g \cdot cm^{-3}$, a wilting coefficient of 3.3%, and a field capacity of 13.1%. Bush snap bean ('Blue Lake 141') seeds were planted on 30 Apr. and 1 May during 1985 and 1986 in plots of four rows, 0.62 m apart; the seedlings were thinned to a final stand of nine plants/m. Evaporation from an open pan (E_{pan}), a method previously used satisfactorily for scheduling irrigation in vegetable crops (4,10–12), was used to determine the timing of irrigation and the amount of water applied under various treatments. During 1985, irrigation equalled 0% (control), 60%, 80%, and 100% E_{pan}. During 1986, an additional irrigation treatment of 40% E_{pan} was added. The plots were arranged in randomized complete block design and were replicated five times. Gypsum blocks installed at a depth of 20 cm in each irrigated plot were read before each irrigation and soil water potentials were computed. At 40%, 60%, 80%, and 100% E_{pan} irrigations, the soil water potential averaged −77, −40, −21, and −12 kPa, respectively. The amount of rainfall during the growing period was measured with a rain gauge. A 25 × 103 cm National Weather Service-type open pan was used to collect the evaporation data. Plots were irrigated with an overhead sprinkler system whenever evaporation exceeded rainfall by 25 mm. A rain gauge was installed in each irrigated plot to monitor the amount of water applied.

At pod initiation, five plants were harvested in the center row of each plot. The number of leaves on each plant was counted and total leaf area per plant was measured with a leaf area meter (Model AAM-5, Hayashi Denko Co., Tokyo). The stems and the leaves were dried separately to a constant weight in a forced-air oven at 70°C. Pods were harvested twice a week from 5-m lengths of two center rows over a 6-week period and the fresh weight of pods was recorded. Growth and pod yield data for 1985 and 1986 and the interaction between years and treatments were tested by analysis of variance. Thereafter, data were combined and analyzed by means of regression analysis.

The total rainfall (504 mm) during the 1985 growing season slightly exceeded the total E_{pan} (499 mm). However, rainfall patterns were sufficiently non-uniform to require one irrigation in May, six in June, and one in July. These irrigations resulted in 120, 160, and 200 mm of irrigation being applied for 60%, 80%, and 100% E_{pan} treatments, respectively. Total rainfall during the 1986 growing season was only 182 mm vs. an E_{pan} of 542 mm. Therefore, the amount of irrigation needed for the different treatments was higher in 1986 than in 1985. A total of 150, 225, 300, and 375 mm irrigation was applied for 40%, 60%, 80%, and 100% E_{pan} treatments, respectively.

Analyses of variance of the effect of different amounts of irrigation on number of leaves, leaf area, leaf dry weight, stem dry weight, and pod yield are given in Table 1. Leaf number varied from 13.2/plant at 0% E_{pan} to 24.6/plant at 100% E_{pan}. Leaf area ranged from 1372 cm^2/plant at 0% E_{pan} to 3835 cm^2/plant at 100% E_{pan}. An irrigation amount of at least 60% E_{pan} was required for significant increases in both leaf number and leaf area. Leaf dry weight increased significantly from 0% to 60% E_{pan}, but was greater in 1985 than in 1986. Stem dry weight increased with the amount of irrigation, but accumulation of stem dry weight was greater in 1986 than in 1985. Pod yield increased with the irrigation up to 80% E_{pan}. Pod yield per unit of irrigation water was maximum at 60% E_{pan}.

The regressions of different variables on the amounts of irrigation are shown in Fig. 1 A–E. Leaf number, leaf area, and leaf and stem dry weight increased linearly with the amount of irrigation. An addition of 8.4% E_{pan} in irrigation was predicted to increase by one the number of leaves per plant. Every increment of 4% E_{pan} in irrigation was estimated to increase leaf area by 100 cm^2. According to the model, it required 18.2% and 15.4% E_{pan} irrigation to increase leaf and stem dry weights per plant by 1 g. Among the vegetative growth characteristics, leaf area was the most influenced by the amount of irrigation, with an R^2 value of 0.73. It was followed by number of leaves, stem dry weight, and leaf dry weight. The relationship between pod yield and the amount of irri-

Table 1. Analysis of variance design and statistical response to various irrigation amounts for leaf number, leaf area, leaf dry weight, stem dry weight, and pod yield of 'Blue Lake 141' bush snap beans.

Source	df	Leaf number	Leaf area	Leaf dry wt	Stem dry wt	Pod yield
Replications	4	NS	NS	**	NS	NS
Treatments	4	**	**	**	**	**
Year	1	NS	NS	**	**	**
Treatment × year	3[z]	*	NS	NS	**	NS

[z]Reflects four treatment levels in 1985 and five in 1986.
[NS,*,**]Nonsignificant and significant at the 5% and 1% levels, respectively.

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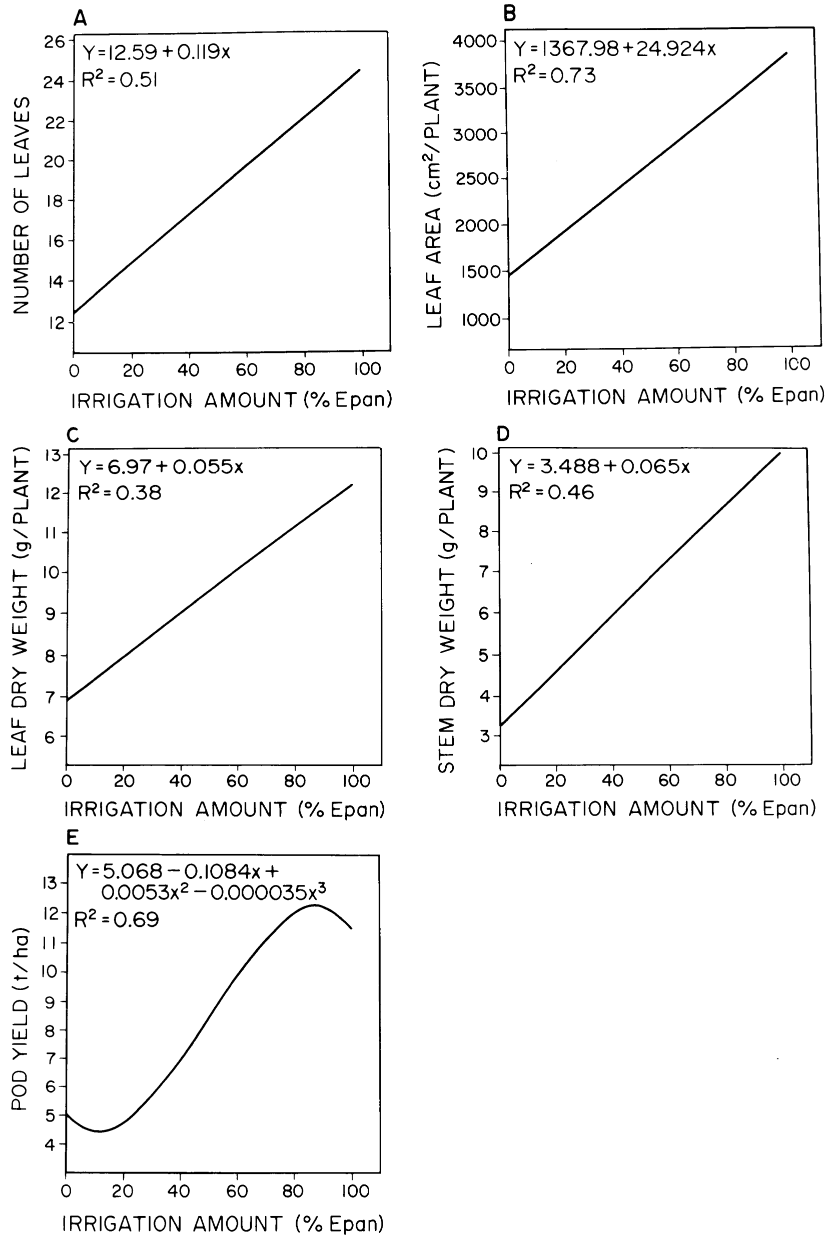

Fig. 1. Effect of various amounts of irrigation on (**A**) leaf number, (**B**) leaf area, (**C**) leaf dry weight, (**D**) stem dry weight, and (**E**) pod yield in 'Blue Lake 141' bush snap beans.

gation was best described by a cubic model (Fig. 1E). The quadratic portion of the model, where pod yield was positively correlated with the amount of irrigation, suggested that 13.7% E_{pan} would raise pod yield by 1 $t \cdot ha^{-1}$. An R^2 value of 0.69 indicated close relationship between irrigation and pod yield.

The study shows that irrigation effectively increased both vegetative growth and pod yield of bush snap beans. It also indicates that vegetative growth increase is linear in the 0% to 100% E_{pan} irrigation range, whereas gain in pod yield is linear with irrigation in the 20% to 80% E_{pan} range, but decreased when irrigation was 100% E_{pan}.

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