Pak. j. life soc. sci. (2009), 7(2):181-184

Pakistan Journal of
Life and Social Sciences

Effect of Different Irrigation Management Strategies on Growth and Yield of Soybean

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Abstract

In field experiment at Faisalabad, Pakistan conducted during August, 2005, the effect of different irrigation management strategies on growth and yield of soybean was investigated. The experiment comprised of eight irrigation practices of viz; rainfed, one irrigation at vegetative growth stage, one irrigation at flowering, one irrigation at pod formation, two irrigations at vegetative growth stage and at flowering, two irrigations at vegetative growth stage and at pod formation, two irrigations at flowering and at pod formation and three irrigations at vegetative growth stage, at flowering and at pod formation. Number of plants m^{-2}, number of pods per plant, number of seeds per pod and seed yield was significantly higher when crop was irrigated with three irrigations at vegetative growth stage, at flowering and at pod formation.

Key words: *Glycine max* L., irrigation scheduling, seed weight, seed yield.

Introduction

Soybean is the most important oil crop of world which contains about 18-22% cholesterol free oil with 85% unsaturated fatty acids and 40-42% protein (Anonymous, 2000). In Pakistan it is grown on an area of 1320 hectares and its production is 1898 tones with an average seed yield of 1438 kg ha^{-1} (Anonymous, 2004). In arid and semi arid regions of Pakistan, soybean production is often limited by a large variation in amount and distribution of rainfall. In Pakistan seed yield of soybean is very low as compared with its yield potential and the yield of other soybean growing countries. There are many factors limiting soybean production. Among these factors irrigation is of supreme importance. All the physiological processes of plant are directly and indirectly influenced by water status of plant. Water is essential for cell turgidity, which is related to photosynthesis, growth of cell, tissue and organs (Reddi and Reddi, 1995). Moisture stress in soybean reduced the number of nodes per plant, number of pods per plant, pod weight, number of seeds per pod and seed weight (Khodambashi *et al.,* 1988). Irrigation increased seed yield, 1000-seed weight and seed weight per plant (Kolarik 1990). Water stress imposed during pre-flowering and flowering stage reduced yield of soybean by 28% and 24% respectively (Gunton and Evenson 1980). Similarly various soybean cultivars show varying sensitivity to drought at their different developmental stages (Momen *et al.,* 1979). Keeping this in view, the present study was therefore, designed to determine the effect of irrigation management strategies on growth and yield of soybean at agro-climatic conditions of Faisalabad, Pakistan.

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Materials and Methods

A field experiment to evaluate the effect of different irrigation management strategies on growth and yield of soybean was carried out at the Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan on August, 2005. The Experiment was laid out in a randomized complete block design having three replications and a net plot size of 1.8 m x 5.0 m. The experiment comprised of eight irrigation practices of viz; rainfed, one irrigation at vegetative growth stage, one irrigation at flowering, one irrigation at pod formation, two irrigations at vegetative growth stage and at flowering, two irrigations at vegetative growth stage and at pod formation, two irrigations at flowering and at pod formation and three irrigations at vegetative growth stage, at flowering and at pod formation. The crop was sown at 30 cm spaced rows manually with single row hand drill, using a seed rate of 30 kg ha^{-1}. Plant to plant distance of 5 cm was maintained by thinning at early growth stages. Whole of the phosphorous at the rate of 75 kg ha^{-1} was applied at the time of sowing in the form of diammonium phosphate (DAP) while the nitrogen at the rate of 50 kg ha^{-1} was applied in the form of Urea in two splits, 1/2 at the time of sowing and remaining 1/2 of the nitrogen was applied with the respective treatment of irrigation. Hoeing was done to keep the crop free from weeds. All other agronomic practices were kept normal and uniform for all the treatments. Yield contributing parameters were recorded and the data collected was analysed statistically by

using Fisher's analysis of variance techniques and differences among treatment means were compared using least significant difference test at 5% probability level (Steel *et al*., 1997).

Results and Discussion

Plant population is a yield contributing parameter and has direct effect on the yield of a crop. It is evident from the data that there were significant differences among plant populations at different irrigation intensities. Significantly maximum number of plants (40.53 m^{-2}) was recorded when crop was irrigated at three different stages i.e at vegetative growth stage, at flowering and at pod formation which was statistically at par when crop was irrigated at two different stages i.e at vegetative growth stage and at flowering having a plant population of (40.09 m^{-2}). Significantly minimum number of plants (37.81 m^{-2}) were recorded when crop was stressed throughout the growing period. Plant population showed a decreasing trend with decrease in number of irrigations and water stress at early growth stages having adverse effect on plant population. This reduction in plant population can be attributed to mortality of crop plants due to water stress during the growth period of the crop. Different plant population of soybean with variable irrigation levels had also been reported by Dornbos (1989).

The number of pods per plant is an important variable for determining yield performance in leguminous crop plants. It is revealed from the data that all the treatments showed a significant difference in number of pods per plant. Significantly highest number of pods per plant (133.07) was recorded when crop was irrigated at three different stages i.e at vegetative growth stage, at flowering and at pod formation against the minimum value of (99.60) when crop was stressed throughout the growing period. Reduction in number of pods per plant is the result of water deficiency which has adverse effect on the development of reproductive parts of plants. Stress at vegetative stage results in less development of fruit bearing branches which ultimately affect the number of pods per plant. These results are in line with the findings of Stafford and Mc. Michael (1991) and Pandey *et al.,* (1984).

Number of seeds per pod is considered an important factor that directly imparts in exploiting potential yield in leguminous crops. It is evident from the data that number of seeds per pod was affected significantly. Significantly highest number of seeds per pod (2.16) was recorded when crop was irrigated at three different stages i.e at vegetative growth stage, at flowering and at pod formation against the minimum number of seeds per pod (1.72) when crop was stressed throughout the growing period. This reduction in number of seeds per pod is due to adverse effect of irrigation stress on the production of assimilates. Irrigation stress reduced the photosynthetic activity of crop plant resulted in less phototsynthates required by the sink, so there was less number of seeds per pod. These results are in line with those reported by the Deumier (1989).

Total number of seeds per plant is an important factor for determining the yield of leguminous crops. It is evident from the data that number of seeds per plant was affected significantly at different irrigation levels. Significantly highest number of seeds per plant (265.40) was recorded when crop was irrigated at three different growth stages i.e at vegetative growth stage, at flowering and at pod formation and not stressed at any critical stage against the minimum number of seeds per plant (171.40) when crop was stressed throughout the growing period. The variation in number of seeds per plant can be attributed to differences in number of pods per plant and number of seeds per pod. These results are in accordance with the findings of Hutchinson *et al.,* (1985).

Seed weight directly impact on the final yield of any crop. Data shows that the effect of irrigation stress at various growth stages was highly significant. Statistically similar results were shown by the soybean when irrigation was applied at three different growth stages (at vegetative growth stage, at flowering and at pod formation) and at two growth stages (at flowering and at pod formation) against the minimum 1000-seed weight (13.24gm) in case of control i.e when crop was stressed throughout the growing period. The reduction in 1000-seed weight might be due to less development of seeds under stress conditions. These results are in accordance with the findings of Hamid *et al.,* (1990) and Brown *et al.,* (1985).

Final yield is the combined effect of various yield components under particular environmental conditions. Thus any variation in them is liable to bring about variation in seed yield. It is evident from the data that the seed yield was affected significantly at different irrigation levels. Significantly maximum seed yield (1722.31 kg ha^{-1}) was recorded in treatment where crop was irrigated at three different stages i.e at vegetative growth stage, at flowering and at pod formation and not stressed at any critical stage, while minimum seed yield (859.69 kg ha^{-1}) was obtained when crop was stressed throughout the growing period. It is evident from the data that there was an increasing trend in seed yield with increase in number of irrigations. The difference in the seed yield among different irrigation levels –[]is because of variable crop stand at harvest, number of pods per plant, number of seeds per pod and variation in 1000-seed weight. These results are in line with the findings of Hamid *et al.,* (1990) and Doss *et al.,* (1990).

Harvest index is measure of physiological productivity potential of a crop. It is the ability of a crop to convert its dry matter into economic yield. Higher the values, more the production efficiency and vice versa. Data shows that the effect of irrigation stress at various growth stages was highly significant. Statistically similar results were shown by the soybean when irrigation was applied at three different growth stages (at vegetative growth stage, at flowering and at pod formation), at two growth stages (at flowering and at pod formation) and also same results were shown when crop was irrigated at vegetative growth stage + at flowering against the minimum value when crop was irrigated only at vegetative growth stage. These results are in accordance with the findings of Ahmad (1984) and Pandey *et al.*, (1984).

It is revealed from the data that various irrigation treatments showed significant differences in seed oil contents. Significantly maximum oil contents (25.72%) were found where crop was stressed throughout the growing period which was statistically at par with the treatment when crop was irrigated only at vegetative growth stage. By contrast significantly lowest oil contents (24.28%) were found in the treatment where no stress was given to the plants and was statistically similar to the treatment when crop was irrigated at flowering at pod formation. Seed oil contents decreased with increasing irrigation levels.

Soybean is more sensitive to drought during its reproductive development especially at flowering and pod formation stage. It is thus concluded that for soybean 3-irrigations are necessary, however if due to scarcity of water only two irrigations are available then these should be given at flowering and at pod formation stage.

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Table 1. Effect of Different Irrigation Management Strategies on Growth and Yield of Soybean.

Treatments	Plant population (m^{-2})	No. of pods $plant^{-1}$	No. of seeds pod^{-1}	Number of seeds $plant^{-1}$	1000-seed wt. (gm)	Seed yield	H.I. (%)	Seed oil contents
Control (rainfed)	37.81 f	99.60 h	1.72 f	171.40 h	13.24 d	859.69 f	42.59 ab	25.72 a
One irrigation at vegetative growth stage	39.22 cd	112.60 f	1.92 e	216.0 g	14.41 c	1223.09 e	37.67 c	25.59 ab
One irrigation at flowering	38.81 de	116.30 e	1.95 de	226.96 f	14.76 bc	1301.45 d	41.88 b	25.41 bc
One irrigation at pod formation	38.46 ef	109.60 g	1.98 d	236.0 e	14.85 bc	1348.51 d	44.27 a	25.29 c
Two irrigations at vegetative growth stage and at flowering	40.09 ab	123.40 c	1.99 cd	245.0 c	15.14 b	1488.11 c	41.81 b	25.16 c
Two irrigations at vegetative growth stage and at pod formation	39.52 bc	119.20 d	2.04 c	239.03 d	15.28 b	1442.55 c	41.40 b	24.75 d
Two irrigations at vegetative growth stage and at pod formation	39.81 bc	128.20 b	2.10 b	251.0 b	15.87 a	1618.86 b	44.58 a	24.47 e
Three irrigations at vegetative growth stage, at flowering and at pod formation	40.53 a	133.07 a	2.16 a	265.40 a	16.01 a	1722.31 a	44.26 a	24.28 e
LSD	0.6552	2.249	0.055	2.178	0.5312	68.70	2.053	0.2656