Korean J. Crop Sci. 49(2): 131~135(2004)

Responses of Soybean Genotypes to Different Levels of Irrigation

M. F. Rabbani*, M. Ashrafuzzaman*†, A. M. Hoque, and M. Abdul Karim***

**Department of Crop Botany, Bangladesh Agricultural University, Mymensingh, Bangladesh*
***Department of Soil Science, Bangladesh Agricultural University, Mymensingh, Bangladesh*

ABSTRACT: To find out the responses of soybean genotypes in terms of different levels of irrigation with the aim of evaluating the growth, yield, and its optimum levels of irrigation, an experiment was conducted at the Field of Crop Botany Department, Bangladesh Agricultural University, Mymensingh during the period from November 2000 to February 2001. Five levels of irrigation viz. I_0: no irrigation, I_1: one time irrigation at 20 days after sowing (DAS), I_2: two times irrigation at 20 and 40 DAS, I_3: three times irrigation at 20, 40, and 60 DAS, and I_4: four times irrigation at 20, 40, 60, and 80 DAS and three genotypes of soybean viz. BS - 3, BS - 16, and BS - 60 were used in this experiment. The crop was grown in a split plot design having three replications. The plant height, leaf area index, crop growth rate, shoot dry weight, branches plant^{-1}, filled pods plant^{-1}, seeds plant^{-1}, seed yield, and harvest index were influenced significantly by irrigation and these were found to be highest at three times irrigation except branches plant^{-1}. The chlorophyll content increased but empty pods plant^{-1} decreased with increase in irrigation levels. Genotypes of soybean varied significantly in terms of growth attributes at various growth stages except shoot dry weight at 90 DAS. The genotype BS - 3 performed better compared to other genotypes and gave maximum seed yield.

Keywords: soybean genotypes, seed yield, chlorophyll content, irrigation, leaf area index, crop growth rate

Soybean is the number one source of vegetable oil in the world and contributes to more than 12% of the global protein from crop production (Sinha, 1977). The oil content of soybean is around 20% (Rahman, 1992). Seeds of soybean contain 44% protein with some essential amino acids and are considered as "meat of the orient". Moreover, as a legume crop, soybean can fix adequate quantity of atmospheric nitrogen which enriches soil fertility. According to an estimate about 800,700 metric tons of edible oil are needed every year to feed the people of Bangladesh while the indigenous production is only 277,700 metric tons (BBS, 2000). As a result, soybean oil imported meets the deficit.

†Corresponding author: (Phone) +82-2-871-1767 (E-mail) ashraf2568@yahoo.com
<Received October 16, 2003>

The congenial atmosphere is sustaining for soybean production area and yield is low due to lack of potential genotype released as variety and traditional cultivation techniques, especially improper scheduling of irrigation water and other crop management practices. However, soybean can be grown in Bangladesh both in the summer and winter seasons. In winter season, irrigation is one of the most important factors due to scanty rainfall and shortage of moisture that limits the use of fertilizers and other nutrients and consequently limits the growth, yield, and other yield contributing characters. Moreover, farmers of different areas of Bangladesh grow soybean without any recommended irrigation schedule, which results not only in the wastage of water but also decreases crop growth and yield. Higher yield of soybean in Rabi season could be achieved by proper irrigation schedule along with high potential variety under proper irrigation management. Moreover, in the recent years Bangladesh Coordinated Soybean Research Project has developed several genotypes of soybean. Considering the above factors, the present research work was undertaken to (1) evaluate the growth and yield performance of some soybean genotypes at different levels of irrigation and (2) find out optimum levels of irrigation.

MATERIALS AND METHODS

A field experiment was carried out at the field site of the Department of Crop Botany, Bangladesh Agricultural University, Mymensingh during the period from November 2000 to February 2001. There were five levels of irrigation I_0: non- irrigation, I_1: one time irrigation at 20 DAS, I_2: two times irrigation at 20 and 40 DAS, I_3: three times irrigation at 20, 40, and 60 DAS, and I_4: four times irrigation at 20, 40, 60, and 80 DAS. There were three genotypes of soybean, viz. BS - 3, BS - 16, and BS - 60. The experiment was laid out in a split plot design where irrigations were applied in the main plot and genotypes in the subplot with three replications. The plot size was 2.5 × 2 m. The one third of urea @ 50 kg ha^{-1} and full dose of triple super phosphate (TSP) @ 160 kg ha^{-1}, muriate of Potash (MP) @ 110 kg ha^{-1}, and gypsum @ 90 kg ha^{-1} were applied at the time of final land preparation. The rest two thirds of urea were top dressed in two equal installments at 30 DAS (vegetative stage) and at

50 DAS (flowering stage). Seeds were sown on 3 November 2000 in furrows of about 5 cm depth. The experimental plots were irrigated as per treatment with watering cane. Mulching was done to break the soil crusts after each irrigation at appropriate time. Weeding and other intercultural operations were done as and when necessary. The crop sampling was done at 15 days interval from 30 to 90 DAS. The harvested plants were washed in running tap water to remove soil and dried with a blotting paper. The data were collected for plant height, leaf area index, crop growth rate, shoot dry weight, chlorophyll content, yield, and yield components. Leaf area of each sample was measured by an electric leaf area meter (Licor-13000, USA). The chlorophyll content in 3rd and 4th leaves from the apex of the plants was measured in mg/g fresh weight according to Yoshida *et al.* (1976) at 30 and 45 DAS. All the data were statistically analyzed using the MSTAT - C computer package. The differences between pair of means were adjusted by Duncans Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Plant height

The plant height was affected significantly due to irrigations at different growth stages except 30 DAS (Table 1). The tallest plant was found in I_3 and I_4 treatment at 90 DAS and the shorter plant was in control. Generally, plant height increased with an increase in the frequency of irrigation. Plant height is associated with the expansion of cell and cell division which depends on physiological activities in presence of water supply. Variation in plant height was significant among genotypes and BS-16 produced the tallest plant throughout the growth period. The interaction effect between irrigation and genotype was not significant on plant height except 45 DAS (Data not shown).

Leaf area index

Leaf area index (LAI) increased up to 75 DAS and thereafter it declined rapidly (Table 2). LAI increased with increasing levels of irrigation. Increase in soil moisture resulted in increased turgor pressure in the cells and turgor forces played apart in the process of leaf expansion. Variation in LAI was significant. The LAI was highest in BS - 16 from 30 to 90 DAS except 45 DAS and the lowest was in BS - 3 throughout the growing period.

Crop growth rate

Crop growth rate increased up to 75 DAS and thereafter it declined rapidly because of leaf senescence (Table 2). Irrigations had higher efficiency on CGR over control. In general, CGR increased up to 3 times of irrigations. It may be assumed that the decreasing irrigation levels increased leaf senescence and ultimately decreased CGR. The variation of CGR values in different genotypes was significant in all growth stages. The CGR was highest in BS-16 and lowest in

Table 1. Plant height as influenced by different irrigation levels and the genotypes of soybean.

Treatments	Plant height (cm)				
	Days after sowing				
	30	45	60	75	90
Irrigation levels					
I_0	14.8	21.6c	26.7b	39.0c	45.6c
I_1	15.3	22.4b	27.9b	39.7c	46.8bc
I_2	15.0	24.5a	30.4a	43.5b	47.6b
I_3	15.4	24.8a	30.8a	46.0a	49.9a
I_4	15.4	24.5a	30.9a	46.1a	49.9a
LSD (0.05)	NS	0.53	2.07	1.96	1.72
Genotype					
BS-3	11.8b	20.2b	26.8b	37.7b	43.0b
BS-16	21.3a	31.2a	39.8a	56.2a	60.5a
BS-60	12.5b	19.4c	21.3c	34.7c	40.4c
LSD (0.05)	0.97	0.71	1.18	1.24	1.80

In a column, means with common letter (s) do not differ significantly whereas means with different letter (s) differ significantly.
NS = Not significant.
Levels of irrigation: I_0 = Control, I_1 = 20 DAS, I_2 = (20 + 40) DAS, I_3 = (20 + 40 + 60) DAS, I_4 = (20 + 40 + 60 + 80) DAS

Table 2. Leaf area index (LAI) and crop growth rate (CGR) as influenced by different irrigation levels and the genotypes of soybean.

Treatments	Leaf area index					Crop growth rate (g m^{-2} d^{-1})			
	Days after sowing					Days after sowing			
	30	45	60	75	90	45	60	75	90
Irrigation levels									
I_0	0.57	0.91d	1.68b	2.36c	1.21	6.91	6.88c	10.46b	1.33
I_1	0.56	0.93cd	1.69b	2.43bc	1.27	6.97	6.78c	10.76b	1.54
I_2	0.56	0.96bc	1.75a	2.48ab	1.26	6.97	7.38b	10.62b	1.44
I_3	0.56	0.99b	1.76a	2.59a	1.28	7.18	7.35b	12.15a	2.00
I_4	0.57	1.06a	1.76a	2.58a	1.30	7.08	7.47ab	12.05a	1.64
LSD (0.05)	NS	0.03	0.05	0.11	NS	NS	0.28	1.26	NS
Genotype									
BS-3	0.49c	0.89c	1.47c	2.07c	1.23b	7.35a	7.89a	11.34b	1.89a
BS-16	0.62a	0.96b	1.91a	3.00a	1.37a	6.74c	7.79a	11.79a	1.46b
BS-60	0.57b	1.06a	1.82b	2.39b	1.26b	6.98b	7.02b	1048c	1.43b
LSD (0.05)	0.04	0.03	0.03	0.07	0.08	0.19	0.23	0.39	0.24

In a column, means with common letter (s) do not differ significantly whereas means with different letter (s) differ significantly.
NS = Not significant.

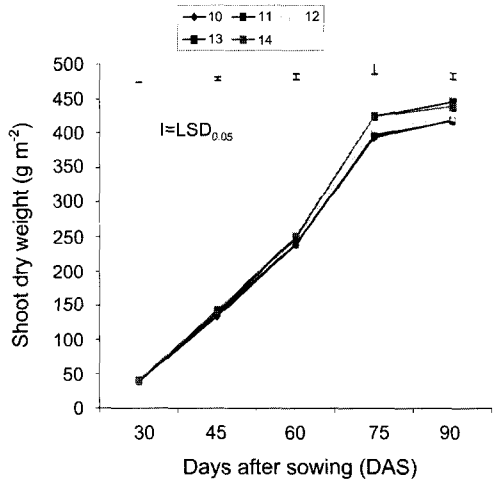

Fig. 1. Shoot dry weight of soybean genotypes as influenced by different levels of irrgation.

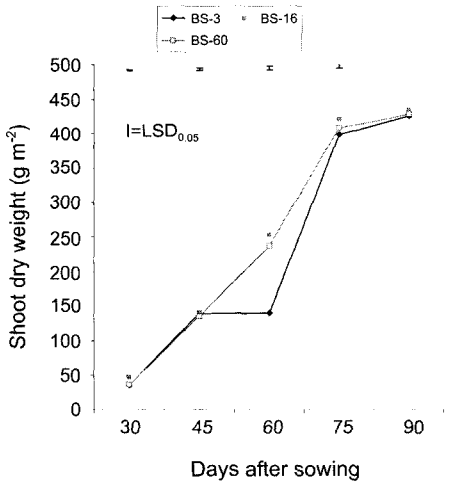

Fig. 2. Shoot dry weight of three soybean genotypes evaluated under trial.

BS-60 at 75 DAS. The interaction between irrigation and genotype was significant only at 90 DAS (data not presented).

Shoot dry weight

The shoot dry weight increased significantly with increasing irrigation levels except in I_3 and I_4 treatments at 75 and 90 DAS, respectively (Fig. 1). The highest shoot dry weight (445.87 g m^{-2}) was found in I_3 followed by I_4 treatment at 90 DAS and the lowest was in control. The increase in shoot dry weight probably resulted from the increasing nutrient uptake from the soil in adequate moisture condition. These results are in agreement with Nandan & Prasad (1998). The shoot dry weight progressively increased in terms of time in all genotypes. The BS-16 genotype showed the best performance in respect of shoot dry weight from 30 to 90 DAS over the other genotypes (Fig. 2).

Chlorophyll content

Chlorophyll content showed increasing tendency with the increasing levels of irrigation. The highest amount of chlorophyll-a (1.08 mg g^{-1} fresh weight) and chlorophyll-b (0.89 mg g^{-1} fresh weight) was found in I_3 and total chlorophyll

Table 3. Chlorophyll content of soybean genotypes as influenced by different irrigation levels.

Treatments	30 days after sowing				45 days after sowing			
	Chl-a	Chl-b	Total chl. (a+b)	Chl (a/b)	Chl-a	Chl-b	Total chl. (a+b)	Chl (a/b)
	mg g^{-1} fresh weight				mg g^{-1} fresh weight			
Irrigation levels								
I_0	0.83	0.52	1.35	1.60	0.93bc	0.69bc	1.63bc	1.35a
I_1	0.83	0.52	1.35	1.60	0.93bc	0.69bc	1.63bc	1.35a
I_2	0.87	0.57	1.44	1.55	1.04ab	0.81ab	1.85ab	1.29ab
I_3	0.87	0.58	1.45	1.50	1.08a	0.89a	1.96a	1.23b
I_4	0.88	0.56	1.46	1.54	1.07a	0.88a	1.96a	1.22b
LSD (0.05)	NS	NS	NS	NS	0.11	0.11	0.23	0.07
Genotype								
BS-3	0.85ab	0.48b	1.33	1.80a	0.99	0.72b	1.72	1.39a
BS-16	0.78b	0.57a	1.34	1.38c	1.01	0.82a	1.82	1.24b
BS-60	0.91a	0.58a	1.48	1.56b	1.02	0.83a	1.85	1.25b
LSD (0.05)	0.09	0.05	NS	0.07	NS	0.08	NS	0.05

In a column, means with common letter (s) do not differ significantly whereas means with different letter (s) differ significantly.
NS = Not significant.

Table 4. Effects of irrigation on yield components and harvest index of soybean genotypes.

Treatments	Branches $plant^{-1}$	Filled pods $plant^{-1}$	Empty pods $plant^{-1}$	Pod length (cm)	Seeds $plant^{-1}$	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
Irrigation levels									
I_0	5.05b	24.18c	4.90a	3.74	52.52b	68.45	1.99	2.99	28.58b
I_1	5.12b	25.17c	3.31b	3.75	53.17b	69.98	2.01	3.00	28.64b
I_2	5.26ab	28.53b	2.75c	3.79	56.64b	67.61	2.02	3.11	29.79b
I_3	5.41a	33.54a	1.66d	4.05	70.41a	72.36	2.32	3.24	33.07a
I_4	5.42a	32.86a	1.90d	3.84	67.37a	71.26	2.30	3.17	32.28a
LSD (0.05)	0.23	2.60	0.51	NS	5.77	NS	0.25	NS	1.82
Genotype									
BS-3	5.68a	31.10a	2.77b	4.07a	62.31	74.96a	2.3	3.02	31.62a
BS-16	5.57a	27.26b	2.37b	3.62b	58.62	60.68b	1.95	3.25	30.36b
BS-60	4.51b	28.22b	3.64a	3.79b	59.13	74.15a	2.12	3.03	29.44b
LSD (0.05)	0.17	1.14	0.39	0.23	NS	3.65	0.31	NS	1.11

In a column, means with common letter (s) do not differ significantly whereas means with different letter (s) differ significantly
NS = Not significant

(1.96 mg g^{-1} fresh weight) was found in both I_3 and I_4 at 45 DAS. The ratio of chlorophyll-a and chlorophyll-b decreased with increase in irrigation levels and it was lowest at I_4 irrigations and the highest was in I_0 and I_1. These findings are in agreement with results of Begum & Paul (1993). The genotype BS-60 produced the highest chlorophyll-a (1.02 mg g^{-1} fresh weight), chlorophyll-b (0.83 mg g^{-1} fresh weight) and total chlorophyll (1.85 mg g^{-1} fresh weight) and these were lowest in BS-3. The ratio between chlorophyll-a and chlorophyll-b gradually decreased due to increase of chlorophyll-b than chlorophyll-a.

Yield components of soybean genotypes

The number of branches per plant was significantly increased with the irrigation levels (Table 4). The highest branches were recorded in I_3 and I_4 treatment and the lowest in control. These variations of branches were attributed due to

physiological activities in optimum soil moisture. The variation in branches per plant was significant in different genotypes and the highest was in BS - 3 and the lowest in BS - 60. The interaction effect on branches per plant was insignificant and I_4 x BS-3 resulted in the highest branches per plant (5.88).

Filled pods per plant were influenced significantly due to irrigations and different genotypes. The maximum filled pods per plant were recorded from I_3 treatment which was similar to I_4 and the lowest was in control. Availability of moisture decreases the rate of leaf and pod senescence and increases maturation period and number of filled pods. Genotype BS -3 produced maximum filled pods. Interaction effect was insignificant and I_3 x BS - 3 produced maximum number of pods per plant. There was a significant influence of irrigations on empty pods per plant and the highest values were found in I_0 while the least was in I_3 treatments. The maximum number of empty pods was recorded in BS - 60 while the minimum was in BS - 16. The interaction I_0 x BS - 60 had resulted highest empty pods per plant. The influence of irrigations on pod length was insignificant. Genotypes showed significant effect on the pod length and the maximum was found in BS - 3 while minimum was in BS - 16.

Seeds per plant increased with increase in irrigation levels and this increase was significant. Three levels of irrigation produced maximum seeds per plant while minimum was found from no irrigation. This result confirmed the findings of Korte *et al* (1983). Genotypes had no significant variation on seeds per plant. Thousand seed weight was insignificant due to irrigations. Genotypes BS - 3 showed maximum weight of thousand seeds while BS - 16 showed minimum weight.

Seed and stover yield

There was a significant influence of irrigations on yield of soybean genotypes (Table 4). Three levels of irrigation produced maximum seed yield (2.32 t ha^{-1}), which was followed by four levels of irrigation (I_4). The minimum seed yield of 1.99 t ha^{-1} was obtained from no irrigation (I_0). The results are in agreement with finding of Nandan and Prasad (1998). The significant variation on seed yield was found among genotypes (Table 4) and the BS - 3 showed supremacy in yield (2.30 t ha^{-1}) whereas the lowest was recorded from BS-16 (1.95 t ha^{-1}). Stover yield of soybean did not increase significantly due to irrigations (Table 4).

Harvest index

There was a significant influence of irrigations on harvest index of soybean and the highest value was found from I_3 treatment followed by I_4 treatment. The lowest was in control. Irrigated plants had the higher harvest index possibly due to higher seed yield. The variation of harvest index in different genotypes was significant and the highest value was in BS - 3 and lowest was in BS - 60 (Table 4).

CONCLUSION

The results indicate that the genotype BS - 16 yielded the best growth parameters but genotype BS - 3 produced maximum yield along with yield components in 3 irrigations at 20, 40, and 60 DAS. Since, seed yield is the prime objective of crop production, so it can be concluded that BS - 3 may be cultivated to get higher yield with 3 times of irrigation.

REFERENCES

BBS. 2000. Statistical Year Book of Bangladesh. Statistical Division, Ministry of Planing, Government of the Peoples Republic of Bangladesh.

Begum, F. A. and N. K. Paul. 1993. Influence of soil moisture on growth, water use and yield of mustard. J. Agron. Crop Sci. 170(2) : 136-141.

Korte, L. L., J. E. Specht, J. H. Williams, and R. C. Sorensen. 1983. Irrigation of soybean genotypes during reproductive ontogeny. II. Yield component responses. Crop Sci. 23(3) : 528-533.

Nandan, R. and U. K. Prasad. 1998. Effect of irrigation and nitrogen on growth, yield, nitrogen uptak,e and water-use efficiency of French bean (*Phaseolus vulgaries*). Indian J. Agril. Sci. 67 (11) : 75-80.

Rahman, L. 1992. Soybean: A potential oil and pulses crop in Bangladesh. Paper presented on Soybean Marketing Seminar at BRAC, Dhaka.

Sinha, S. K. 1977. Food legumes distribution, adaptability, and biology of yield. FAO plant production and protection paper 3, AGPC Misc/36.

Yoshida, S., D. A. Forno, J. H. Cock, and K. Gomez. 1976. Determination of chlorophyll in plant tissue. In: Laboratory manual for physiological studies of rice. 3rd edn., Int. Rice Res. Inst.: 43-45.