EFFECT OF IRRIGATION ON THE GROWTH AND YIELD OF SOYBEAN (*Glycine max* L.) VARIETIES

By

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CERTIFICATE

This is to certify that the thesis entitled, ***"Effect of irrigation on the growth and yield of soybean (Glycine max L.) varieties"*** submitted to the Department of Agronomy, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of ***MASTER OF SCIENCE (M.S.)*** in ***Agronomy*** embodies the result of a piece of *bonafide* research work carried out by ***Shrin Rowshan Ara Jahan,*** Registration No. 25265/00373 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that the help or source of information, as has been availed of during the course of this investigation has duly been acknowledged by her.

Dated: 26. 06. 2006

Place: **Dhaka, Bangladesh**

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ABSTRACT

An experiment was conducted at the Agronomy Field of Sher-e-Bangla Agricultural University, Dhaka-1207 during the period from December, 2005 to April, 2006 to study the responses of soybean varieties to the time of irrigation. The experiment was carried out with three soybean varieties viz. Shohag, Bangladesh soybean-4 and BARI soybean-5 and five levels of irrigation viz. no irrigation, irrigation at elongation of main stem (EMS), irrigation at flowering (F), irrigation at pod development (PD) and one irrigation each at EMS+F+PD stages of crop growth. The experiment was laid out in split plot design with three replications.

The results showed that variety and irrigation level significantly influenced the growth, development, yield characters and yield of the soybean. Among the three varieties, BARI soybean-5 influenced plants to have maximum dry matter, number of branches plant^{-1}, pod length, number of seeds pod^{-1}, seed yield, stover yield, biological yield and harvest index. But the plant height and number of pods plant^{-1} were found highest in Bangladesh soybean-4. The grain yield status among the three varieties in this experiment was that the BARI soybean-5 out yielded Shohag and Bangladesh soybean-4, by 6.93% and 0.28%, respectively. Irrigation at EMS+F+PD stages increased yield with higher values of harvest index as the yield attributes like branches plant^{-1}, pods plant^{-1}, seeds pod^{-1}, pod length and 100- seed weight were higher. Application of irrigation at different times significantly

increased seed yield ranging from 23.94% to 96.92% compared to the control (no irrigation).

In most of the cases BARI soybean-5 coupled with irrigation at EMS+F+PD was found to be influenced for better growth and yield. The highest seed yield was found with the interaction of BARI soybean-5 with irrigation given at EMS+F+PD stages. This was achieved due to maximum number of branches plant^{-1}, number of seeds pod^{-1} and greater pod length. The higher yield attributes were achieved with abundant production of dry matter due to irrigation at EMS+F+PD stages.

ABBREVIATIONS

FULL NAME	ABBREVIATION
Agro-ecological Zone	AEZ
And others (at elli)	*et al.*
Bangladesh Agricultural Research Institute	BARI
Bangladesh Bureau of Statistics	BBS
Coefficient of variation	C.V.
Cultivar	cv.
Centimeter	cm
Dry matter	DM
Days after sowing	DAS
Degree Celsius	°C
Duncan's Multiple Range Test	DMRT
Food and Agricultural Organization	FAO
Gram	g
Harvest index	HI
Hectare	ha
Hour	hr
Kilogram	kg
Least significant difference	LSD
Meter	m
Millimeter	mm
Cumulative pan evaporation	CPE
Number	no.
National Seed Board	NSB
Per cent	%
Sher-e-Bangla Agricultural University	SAU
Square meter	m^2

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Chapter I

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INTRODUCTION

Oilseed is one of the major economically important groups of crops in Bangladesh. It is an energy rich crop and in terms of energy equation 1.0 g photosynthate produces 0.70 to 0.75 g cereal, 0.64 to 0.60 g pulses and 0.42 to 0.43g oil or fat. The energy content of oil is much higher than protein or carbohydrate. The oilseed contains 20 to 60 per cent oil, which is chiefly consumed as food and energy. Edible oil plays an important role for human nutrition. As a high energy food, edible oil is important for meeting the calorific requirement. Fats and oils act as carrier for fat soluble vitamins (A, D, E, and K) in the body and therefore, the presence of some fat or oil in the diet is essential for vitamin absorption (Wahab *et al.*, 2002).

Bangladesh cannot meet up her annual requirement of oil from the domestic production. Annually Bangladesh is producing 0.16 million tons of edible oil as against the requirement of 0.5 million tons (Wahhab *et al.*, 2002). The oil crop area in Bangladesh is gradually decreasing due to the replacement of oil crop area by HYV Boro rice. So, every year the government has to import oil and oilseeds mainly soybean, rapeseed and plam oil at the cost of huge amount of foreign exchange.

Soybean (*Glycine max*) is one of the good sources of high quality oil and protein can play an important role in solving the malnutrition problem of Bangladesh. Soybean is a crop which can produce high quality and highest quantity of protein (seed contains about 40% protein) per unit area. The oil content of soybean is about 20%, while all other pulses contain about 1-2% oil (Rahman, 1992). Soybean, such an excellent crop, if grown extensively may reduce the fat and protein deficiency in the country.

Despite of suitable climate and edaphic conditions, the yield of soybean is very low in Bangladesh. In Bangladesh, soybean is not yet a popular crop but soybean oil is very popular as cooking oil. Soybean can be used in various ways. It is also used as a pulse crop in this country. Soybean can be used for making nutritious food items like soyadal, soyakhechuri, soya pollao, soya bori, soyabiscuits, soyabread etc. (Khaleque, 1985; Mondal and Wahhab, 2001). Hence, soybean can be considered as an industrial crop. However, soybean can fix a considerable amount of nitrogen to the soil and can be a good crop in the rotation to enrich soil fertility.

Soybean is grown throughout the world with the largest production in the United States, Brazil, Peoples Republic of China, Mexico, Indonesia and Argentina. The world production of soybean in 1999 was 161.99 million tons from an area of 73.44 million hectares (FAO, 2000). In Bangladesh, in terms of area and production, soybean is such a minor crop concentrated only in few distinct locations. The total cropped area of soybean is only 5000 ha with the production stands at 4000 tons (Sattar *et al.,* 2005). Soybean yield varies from 1500-2000 kg ha^{-1} depending on variety and agronomic management practices. Improved variety and irrigation in particular can continuously improve the yield of soybean (Rabbani *et al.,* 2004).

Soybean cultivation is hindered due to lack of high quality seed. So, it is essential for us to produce quality seed. Irrigation applied at 20 + 40 + 60 days after sowing (DAS) increased plant height, leaf area index, crop growth rate, shoot dry weight, number of filled pods per plant, number of seeds per plant, seed yield and harvest index of soybean (Boydak *et al.*, 2004). Kazi *et al.* (2002) reported that the growth, yield components and oil content of soybean were significantly affected by irrigation frequencies. Considering the above points, an experiment was undertaken to study the responses of three varieties of soybean under different dates of irrigation. The objectives of the experiment are:

a) To find out the maximum yield of soybean varieties

b) To determine the appropriate time of irrigation for achieving higher yield of soybean, and

c) To study the response of soybean varieties under different time of irrigation.

Chapter II

REVIEW OF LITERATURE

Experimental evidences available from home and abroad reveal that plant and yield contributing characters of soybean are influenced by several factors of which time of irrigation is remarkable one. Some of the pertinent literatures have been reviewed below:

2.1 Effect of growth parameters

Khodambashi *et al.* (1990) stated the effects of irrigation from class A pan (I_1, I_2 and I_3 resp.) on the pattern of DM production and CGR in soybeans. They found that more DM was produced under I_2, but equal amounts were produced under I_1 and I_3. Rate of DM accumulation in irrigated treatments increased linearly from full flowering to early maturity.

Fernandes *et al.* (1997) stated that the more frequent irrigation showed higher leaf number, dry matter, leaf area and seed yield than those irrigated less frequently. The control (without irrigation) plants produced the lowest values of pod, leaf dry matter, leaf area and seed yield.

Tokoyoda *et al.* (1999) observed that plant height and number of tillers were generally greatest with normal irrigation and lowest in dry land conditions. Total plant dry weights at 86 days after sowing were highest with normal irrigation.

Ramasamy and Sankaran (2001) carried out field experiments during summer 1994 and 1995 to study the yield and physiological attributes of soybean cv co-1 under 2 irrigation regimes of 60.8 and 0.6 1W/CPE ratio. Irrigation at 1W/CPE ratio of 60.8 significantly increased the dry matter production (DMP), leaf area index, (LAI), leaf area duration (LAD), crop growth rate (CGR) and net assimilation rate (NAR) of soybean.

Kazi *et al.* (2002) conducted and experiment to study the impact of irrigation frequencies on growth and yield of soybean cv. Bragg. The irrigation frequencies were 2, 3, 4, 5 and 6 irrigation. It was observed that the growth and yield components were significantly affected by irrigation frequencies. Maximum plant height, more branches plant^{-1}, pods plant^{-1}, seed index and seed yield were found superior with the application of 6 irrigations followed by 5 irrigations, whereas, lowest number of irrigation decreased all the traits adversely.

Prabhakaran and Lourduraj (2003) conducted field experiments during summer (February-May) and southwest monsoon (June-September) seasons of 1996 and 1997 to study the growth and yield responses of soybean. They found that irrigation at 0.90 1W/CPE ratio in water depth (1W) to cumulative pan evaporation (CPE) significantly increased the plant height, leaf area index, dry matter production and grain yield. However, the root length of soybean was significantly reduced by irrigation at 0.90 1W/CPE ratio.

Hao *et al.* (2003) conducted experiments to find out effects of irrigation and fertilizer on soybean cv. Bei during 92-98 and 2000 in Heilongjing, China. They found that the effects of irrigation varied among the levels of fertilizer application and vice versa. The pods per plant, seeds per pod and 100 seed weight had positive correlations with soybean yield. Leaf area index and dry matter accumulation significantly increased with irrigation application.

Rabbani *et al.* (2004) studied 3 genotypes of soybean under different irrigation frequencies during November 2000 to February 2001 at Mymensingh, Bangladesh. The growth and yield parameters were evaluated from 30 to 90 DAS at 15 days intervals. Plant height, leaf area index, crop growth rate, shoot dry weight, number of filled pods plant^{-1}, number of seeds plant^{-1}, seed yield and harvest index were highest with irrigation at 20+ 40 + 60 DAS. The highest number of branches was obtained with irrigation at 20 + 40 + 60 DAS and 20 + 40 + 60 + 80 DAS. The chlorophyll content increased whereas the number of empty pods decreased with increasing irrigation frequency. The genotypes significantly varied in terms of growth attributes to various growth stages except shoot dry weight at 90 DAS.

2.2 Effect of Variety

Gopani and Kabaric (1970) found that seed yield in six soybean varieties were positively correlated with stem thickness, number of braches pod^{-1}, seeds pod^{-1}, days to flowering and days to pods formation.

Juneje and Sharma (1971) studied the correlation of eleven characters in 30 varieties of soybean and observed that these characters influenced the seed yield.

Chaudhary and Singh (1974) reported that seed yield was negatively correlated with seed size and number of seeds pod^{-1} but positively correlated with number of pods $plant^{-1}$.

Molhotra (1974) observed that the number of pods $plant^{-1}$ and seed yield had the highest co-efficient of genetic variation and predicted genetic advances as a percentage of the mean in 37 varieties of soybean. The study of the discriminate functions indicated that selection for the traits such as number of pods $plant^{-1}$, seeds $plant^{-1}$ and primary branches $plant^{-1}$ would be effective.

Singh *et al.* 1974 observed the variability in days to flowering and maturity, plant height and 1000-seed weight among 15 varieties of soybean. They also observed that Bossier, Devis and Bragg took 53, 44 and 42 days to lowering and 122, 109 and 116 days to maturity.

Lantican (1976) reported that the average number of days to flowering, yield, maturity and plant height of the variety Bragg at Laguna, Philippines were 29 days, 1.08 t ha^{-1}, 0.95 t ha^{-1} , 93 days and 60.0 cm in Thailand, 17 days, 1.42. t ha^{-1}, 83 days and 19.8 cm in Khmer Republic and 28 days, 0.56 t ha^{-1} , 79 days and 25.7 cm at Selangon, Malaysia.

Salehuzzaman *et al.* (1978) studied the components of phenotypic stability for yield and six other yield components (pod number plant^{-1}, pod weight plant^{-1}, seed number pod^{-1}, seed weight 10 pods^{-1}, seed number plant^{-1}, 100 seed weight) in 21 varieties of soybean grown in seven different environments. The varieties were Bargg, Lee-74, Hardee, TK-5, Imkjproved Pelican, Kao Shing, Biloxi, Wells, Panjab, Harosoy, UPSM-19, SJ-11 and SJ-2. The genotypes showed significant interaction with the environments for yield for all the characters. A major portion of the interaction was accounted for by the linear function of environmental means for yield and three of its components and growth had some considerable non linear function of environment. The genotypes improved Pelican, Biloxi, EC-11780 and Harosoy were found suitable for yield and favourable environments, whereas TK-5, Adelphia, and Forest were adapted to low yielding conditions.

Rahman and Haque (1978) found variation in yield and days to maturity in soybean. In three years, averaged over 33 trials of five varieties (namely Davis, L-74, Bragg, Clark and Williams) gave seed yield ranged 1660 - 1961 kg ha^{-1}.

Das *et al.* (1982) conducted an experiment with nine soybean cultivars involving six quantitative characters in both the winter and summer seasons. The result indicated that Bragg had higher seed yield, 100-seed weight and pods plant^{-1} than other varieties.

Konwar and Talukdar (1983) studied ten lines of soybean for seed yield plant^{-1} and five of its components at six sowing dates. They found that cv. PK 327 had average stability and high mean performance for 100 seed weight.

Nakamura *et al.* (1984) found that when soybeans were grown in dense, intermediate or sparse stand and were sown on 10 June, 6 July or 30 July the seed to pod ratio ranged between 2.65 and 3.39. Using data for six cultivars, correlations were calculated between the seed: pod ratio and 100-seed weight, 100-pod weight and seed yields. The highest correlation co-efficient was those obtained with seed yield.

In a field experiment, Biswas and Mondal (1986) observed significant differences among the five soybean genotypes regarding days to 50% flowering, days to 90% maturity, plant height, number of pods plant^{-1}, 100-seed weight and seed yield but there was no significant response in respect of number of seeds pod^{-1} and seed yield plant^{-1}. It was noted that Bragg gave the lowest yield.

Khaleker *et al.* (1991) observed in an investigation in India with two soybean varieties MACS 13 and Monetta that both plant height and seed yield were significantly increased with higher plant densities.

Chen *et al.* (1992) observed variation in yield of two soybean cultivars, Apache and Maple Arrow in two different types of soil. Rosalie clay soil, where yields were low due to moisture stress or low initial inorganic-N levels but on the more productive ormtown silty clay soil. Apache produced higher grain yield than Maple Arrow.

Mishra and Vyas (1992) found yield variation in soybean cultivars JS-2, JS72-44 and Punjab 1 of which JS-2 produced the maximum seed yield (1.13 t ha^{-1}).

Raut *et al.* (1992) worked with six promising cultivars (MSCS 13, MSCS 41, MACS 42, MACS 56, MACS 66 and MACS 92) to assess the stability for days to maturity and seed yield at five locations in India. They observed that MACS 57 was the highest yielding variety and was suitable as summer cultivar.

Mahajan *et al.* (1993) observed that seed yield was positively correlated with seed yield $plant^{-1}$, branches $plant^{-1}$, days to 50% flowering, days to maturity and plant height in 51 soybean genotypes gown in India during the Kharif season of 1990.

Singh *et al.* (1994) observed that seed yield $plant^{-1}$, showed high positive association with biological yield $plant^{-1}$, number of pods $plant^{-1}$ and days to maturity. They also observed that number of pods $plant^{-1}$ had strong correlation with biological yield $plant^{-1}$, harvest index while plant height showed high positive association with days to maturity.

Saad (1995) conducted in a field trial in Egypt in 1992-93 with soybean cultivars Evans, William 82, Clark, Crawford and Colombus. He observed that Clark produced the highest number of branches $plant^{-1}$, Colombus produced the highest number of pods $plant^{-1}$ and plant height while Crawford had the highest number of seeds pod^{-1}, seed weight and seed yield.

Wu *et al.* (1995) reported that seed yield was influenced by the seed to stem ratio, 100-seed weight, pods plant^{-1} and nodes main stem^{-1} in the high yielding varieties.

Rahman *et al.* (1996) reported that pods plant^{-1} branches plant^{-1} and 100-seed weight showed significant and positive correlation with seed yield, plant height , branches plant^{-1} and days to maturity. The number of pods plant^{-1} and seed pod^{-1} had with the highest correlation with seed yield.

Saka *et al.* (1996) studied with 11 determinate soybean genotypes and a wide range of seed sizes. They reported that the number of seeds plant^{-1} was negatively correlated with seed size and seed size was strongly correlated with pod width.

Sabbe and Delong (1996) in a field trial with eight soybean cultivars observed that cv. Hutcheson was the highest yielding cultivars.

Sridhara *et al.* (1998) conducted a field trial and found that number of branches plant^{-1} and number of pods plant^{-1} were the significant contributors of seed yield.

Taware *et al.* (1998) evaluated eight promising cultivars of soybean and found that an early maturity (MACS 63) cultivar gave the highest yield (2032 kg ha^{-1}).

El-Douby *et al.* (2002) used three soybean cultivars (G-35, G-111 and Crawford) which were sown on 1 May and 25 May in 1999-2000 in Egypt. They observed that mean plant height, number branches, pods and seeds plot^{-1}, weight of pods, seeds plant^{-1}, 100-seed weight and seed yield were highest in G-111 with sowing on 1 May.

Schoffel, *et al.* (2003) reported that yield components of soybean vary according to cultivar and sowing date. For the 3 cultivars, the number of pods plant^{-1} contributed most on the yield and there was a compensatory effect on the mass of 100 seeds in agreement with the variation in the number of pods plant^{-1} and/or the number of seeds per legume^{-1}, showing disposition to the stability of the yield. Among the three cultivars IAC 8-2 demonstrated less alterations on the yield among the sowing times, but in Dourados.

Lorenc and Pisulewska. (2003) conducted experiment to find out the effect of three nitrogen (N) fertilizer levels (0, 30 and 60 kg ha^{-1}) and microelements (B and Mo) on seed yield of two soybean cultivars (a large-seed cultivar Aldana and a small-seed cultivar Nawiko) over a 4-year field trials (1995-98) in Poland. They reported that a large-seed cultivar Aldana gave generally lower yields than a small-seed cultivar Nawiko and the latter one more affected by the adverse weather conditions. A significant interaction was detected between weather conditions, seed yield and yield structure. Consequently, the most favourable weather conditions, noted in 1995, resulted in the highest seed yields of the studied soyabean cultivars.

Gan *et al.* (2003) worked that soybean (*Glycine max* L. Merr). is one of the most important food and cash crops in China and a key protein source for the farmers in northern china. Previous experiments in both the field and greenhouse have shown that N2 fixation alone cannot meet the N requirement of maximizing soybean yield, and that N top-dressing at the flowering stage was more efficient than N top-dressing at the vegetative stages. The field experiment was conducted to study the effects of N applications at various reproductive stages on growth, N_2 fixation and yield of three soybean genotypes. The results showed that starter N at 25 kg ha^{-1} resulted in minimum yield, total N accumulation and total amount of N_2 fixed in all three genotypes. N top-dressing at 50 kg ha^{-1} at either the V_2 or R_1 stages, significantly increased N accumulation, yield and total amount of N_2 fixed in all three genotypes. However, N top-dressing at the same rate at either the R_3 or R_5 stage did not show this positive effect in any of the three genotypes. Thus, the best timing for N top-dressing during reproduction is at the flowering stage, which increased seed yield by 21% for Wuyin 9, 27% for You 91-19, and 26% for Jufeng, respectively, compared to the treatment without N top-dressing.

Pedersen and Lauer (2004) conducted field trials using an older soybean cultivar (Hardin) and two newer cultivars (Dekalb CX-232 nad Spansoy-250) including four growing seasons from 1997-2000. They observed yield component compensation gave similar grain yield among cultivars and planting date.

Khajouei *et al.* (2004) stated that the effects of irrigation and plant density on the seed yield and protein and oil content of soybean cultivars hobbit, Williams and Hill were determined in a field experiment conducted in Iran during 2000-01. They found that grain yield per plant and per hectare, as well as 100-seed weight were highest in cv. Williams and with 60 mm irrigation. Grain yield per plant, 100-seed weight and seed oil content decreased, whereas seed protein content increased with increasing plant density. Seed oil content decreased, whereas seed protein content increased with increasing irrigation regimes. Seed protein content was highest in cv. Hobbit.

Rabbani, *et al.* (2004) stated that the effetc of irrigation frequency on the performance of 3 soybean genotypes (BS-2, BS-16 and BS-60) were studied in Mymensingh, from November 2000 t0 February 2001. They found that the genotypes significantly varied in terms of growth attributes at various growth stages except shoot dry weight at 90 DAS. BS-3, which was superior in most of the traits, recorded the highest seed yield (2.3 t ha^{-1}).

Kargar *et al.* (2004) reported that in order to study the most effective traits and drought tolerance indices, and to introduce tolerant soybean genotypes in drought conditions, 49 soyabean genotypes were evaluated in Iran during 1999. Two levels of irrigation with 18 day (drought stress) and 8 day (control) intervals were considered after flowering of the 49 genotypes. Some traits such as days to the end of flowering, days to maturity, vegetative growth duration, plant height, root length, mean leaf area, number of nodes, branches and pods, yield per plot, 100-grain weight, oil, and protein content were evaluated. The yield per plot, plant height and number of pods per plant decreased under drought stress conditions. Yield reduction was due to flower abortion under drought stress treatment which led to a decrease in the number of pods and grains. The calculated correlation coefficients and tolerance indices (TOL, SSI, HARM, MP, GMP and STI) showed that STI and GMP were the best indices for selection of tolerant genotypes. The biplot display of 39 early maturing genotypes indicated 8 tolerant genotypes, namely Bonus, Kador, Union, Willams, line23 S.R.F450* Hobbit, L. 17, M.4 and Line29 S.R.F450* Hobbit.

2.3. Effect of time of irrigation on yield and yield contributing characters

Time of irrigation influences yield and quality of soybean to a great extent. It was reported that maximum seed yield was obtained in Lee-74 and improved Pelican variety of soybean with one irrigation after 30 and 45 days of sowing (Khair and Israil, 1977). Soybean yield was reported to be increased when irrigation was scheduled throughout the whole growth period followed in order by irrigation at seed swelling, germination and flowering compared with irrigated control (Lago *et al.*, 1981).

Yazdi and Saadati (1978) stated that seed yield was 1.25 t ha^{-1} with one irrigations before flowering and upto 4.21 t ha^{-1} with extra irrigations before and after flowering. Irrigation at the vegetative stage was important and at the end of flowering most important in increasing seed yield.

Ashley and Ethridge (1978) reported that irrigation when 60% of available soil water during the flowering or pod filling stage to maturity, increased in seed yield. They further reported that after no irrigation or receiving irrigation from the bloom stage on wards or from the pod-filling stage onwards, plants of Ransom were found to show greatest response to irrigation and for both treatments gave higher yields. Barni (1980) reported that soybeans cv. Santa Rosa were irrigated beginning at early flowering, later or at early pod filling or 10 days later. Irrigating during flowering decreased yields to a greater than irrigating, during pod filling.

Martin *et al.* (1979) reported that seed yield of soybean cv. Ransom with irrigate at growth after flowering and after pod set began stages were 2.06, 2.12 and 1.69 t ha^{-1}, respectively.

Shahidullah *et al.* (1979) reported that pod $plant^{-1}$ and seed yield $plot^{-1}$ was higher with single irrigation applied after 30 days of sowing.

Constable and Hearn (1980) reported that irrigations during late flowering and pod filling in soybean were necessary to ensure maximum seed yield (up to 3.5 t ha^{-1}). Stutte and Weiland (1981) stated that when soybean irrigated at late vegetative, flowering and early pod filling stages, seed yields of cv. Davis and Forrest were increased. Griffin and Habetz (1981) reported that soybean cv. Dare and Ransom irrigated at flowering, pod filling and flowering + pod filling. They found that cv. Dare had no response to irrigation possibly as a result of late sowing. But in cv. Ransom seed yields were an average of 7.3 bu $acre^{-1}$ higher at flowering and at flowering + pod filling than in plots without irrigation. Matheny and Hunt (1981) reported that when soybean irrigated at late flowering stage, irrigation increased yields by 86% compared with control plants and maximum seed yield was recorded 3.10 t ha^{-1} in this treatment.

Korte *et al.*, (1983a) experiment with no irrigation or one irrigation was applied at one or more of three reproductive stages: flowering (F), Pod elongation (P) or Seed emergence (S). They observed F irrigation increased the numbers of pods $plant^{-1}$ and seeds $plant^{-1}$, but caused a decrease in 100-seed weight, resulting in a little change in seed yield. P irrigation had no effect on 100 seed weight, but increased the numbers of pods $plant^{-1}$ and $seedsplant^{-1}$, resulting in a large increase in seed yield. S irrigation resulted in only slight increases in numbers of pods $plant^{-1}$ and seeds $plant^{-1}$, but greatly increased 100-seed weight, again leading to a large seed yield increase.

Griffin *et al.*, (1984) Conducted experiment with soybeans cv. Dare and Ransom where irrigation treatments were given no irrigation or irrigation at flowering, pod-filling and at flowering + pod-filling stages. They reported that in cv. Dare, irrigation increased seed yield from 47.1 bu ac^{-1} in no irrigation to an average of 49.1 bu $acre^{-1}$, corresponding values of cv. Ransom were 43.5 and 44.1 bu $acre^{-1}$ respectively. Marques and Lin (1983) reported that soybean cv. Parana was sown in rows 30, 60 or 90 cm apart at 250, 350 or 450 thousand plants per hectare. Plants were not irrigated during vegetative growth, flowering and pod development stages. They observed that irrigation had no significant effect on seed yield.

Drummond *et al.* (1984) reported that soybean cv. Braxton irrigated at the rate of 2 in at early flowering stage and a further 2 in at pod fill stage. Both gave significantly higher yields (42.2 bu $acre^{-1}$) than non-irrigated plants. Shahidullah and Islam (1983) reported that irrigation at 50% field capacity gave optimum results for all growth parameters studied, but all irrigation treatments gave markedly higher yields than no irrigation. Yields ranged from 380 kg to 601.5 kg ha^{-1} for a single irrigation treatment at flowering initiation and irrigation at 50% field capacity, respectively, compared with 238.5 kg ha^{-1} without irrigation.

Boquet *et al.* (1984) stated that irrigation increased seed weight pod^{-1}, 100-seed weight and seed yield when applied at during pod filling. Ramseur *et al.*, (1984) observed that when soybeans cv. Braton were irrigated (a) form the beginning of flowering or (b) no irrigation the average seed yield were 2.88 t ha^{-1} for (a) which were significantly higher than (b) (2.32 t ha^{-1}).

Griffin *et al.*, (1985) Stated that soybeans cv. Dare and Ransom irrigated during flowering, pod filling and flowering + pod filling stages they found that seed yields of Dare were increased by an average of 5.2 bu $acre^{-1}$ by irrigation at pod filling stage. They also stated that in further trials, soybean cv. Ransom was irrigated when plants were 10-12 inches high during mid late flowering and at during mid-late flowering and at mid-late pod filling when irrigation occurred at during mid-late flowering or at during mid-late flowering and at mid-late pod filling. Seed yields were 2.6 and 18.3 bu $acre^{-1}$ lower than in non-irrigated stands when irrigating continued at during mid-late flowering and at during mid-late flowering and at mid-late pod filling.

Griffin *et al.*, (1985a) Stated the soybean cv. Dare and Ransom were irrigated under no irrigation, irrigation at flowering, at pod filling and at flowering and + pod filling stages. The observed the cv. Dare showed higher grain yield (average 3.1 bu acre^{-1}) with irrigation at flowering and at flowering + pod filling than no irrigation and irrigation at pod filling. The cv. Ransom showed great response to irrigation and show higher yield average 6.3 bu acre^{-1} with irrigation at pod filling and at flowering + pod filling than the control (with no irrigation).

Griffin *et al.* (1985b) reported from another experiment that soybean cv. Dare and Ransom were irrigated at flowering, pod filling, flowering + pod-filling stages and a non-irrigated control was included for comparison. They found that Dare was 161 the yield of kg ha^{-1} higher than the control with irrigation at flowering +pod filling and that of Ransom was 168 kg ha^{-1} higher than the control at the same irrigation condition as Dare.

Marquez and Enriquez (1986) experiment with soybeans cv. G. 7.r –315 and irrigation applied at (a) flowering, (b) pod formation or (c) flowering +pod formation. They observed the mean seed yields for (a), (b), (c) were 2.42, 2.65 and 2.25 t ha^{-1}, respectively.

Griffin *et al.*, (1986) soybeans cv. Ransom were irrigated a) at flowering b) at pod-filling c) at flowering and at pod filling. D) left non-irrigated. Average seed yield was 41.8 bu acre^{-1} in (c) compared with 38.4 bu acre^{-1} in (d). In further trials cv. Ransom was irrigated (c) at growth stage V_6 (10-12 inches high), (f) at mid-late flowering or (g) at mid-late flowering and mid-late pod-filling. Irrigation only at (f) had no significant effect on seed yields. Irrigated at (c) yields were not significantly reduced because conditions were favourable later. When irrigation was increased average seed yields were reduced from 40.1 to 27.5 bu acre^{-1} in (f) and from 43.9 to 22.6 bu acre^{-1} in (g)

Svoboda (1988) stated that at irrigation applied before emergence, before flowering and after flowering or with out irrigation, seed yields were 20.96% higher in 1980 and 9.2% higher in 1981 with irrigation compared to without irrigation. He also observed that irrigation increased seed weight plant^{-1}, 1000-seed weight, seed weight pod^{-1}, number of seeds pod^{-1}.

Vasiliu (1988) reported that soybean seed yields ranged from 1.30 t ha^{-1} with no irrigation to 3.00 t ha^{-1} with irrigation to 50% field capacity up to the maturity of the last pods. Moraru *et al.* (1988) reported that soybean yields were lowest with no irrigation and highest with irrigation at 70% of field capacity at 0-80 cm depth or at 50% of field capacity before and at flowering and or at 50% of field capacity at 0-80 cm depth.

Irrigation was done during the vegetative, flowering, pod elongation, seed formation or seed ripening stages. Seed yields ranged from 2.6 to 4.3 t ha^{-1} (Khodambashi *et al.*, 1987. Schulze (1987) reported that soybeans that soybeans cv. Hobitt (determinate) and Williams (indeterminate), maximum seed yields were obtained with irrigation at flowering + Pod filling without irrigation during vegetative growth. Ritter and

Scarborough (1988) reported that irrigation in soybeans did not increase yields significantly over irrigating soybeans from flowering to maturity. The plants were irrigated at pod filling, flowering yields in Dare ranged 36.7% bu acre^{-1} from irrigation at pod filling, 39.5 bu acre^{-1} from irrigation at flowering and pod filling (Griffin *et al.*, 1989). Irrigations to 50% field capacity at flowering and fruit formation were most efficient in terms of seed yields (Coifan *et al.*, 1991). Irrigation during late flowering and pod filling, highest seed yield was obtained (5.60 t ha^{-1}) (Gaspari *et al.*, 1992). Irrigation during late flowering and pod filling stages were necessary for maximum yields (Tulucu *et al.*, 1991).

Gretzmacher and Wolfsberger (1991) reported that when irrigation at flowering and pod set stages the average yield increase was 68% from 1982 to 1989 with a maximum harvest of 3900 kg ha^{-1}. Rao and Reddy (1990) stated that irrigation at the vegetative phase, vegetative + flowering stages, vegetative + flowering + pod formation stages or vegetative + flowering + pod formation + seed development stage gave seed yields of 1.09, 1.15, 1.21 and 1.17 t ha^{-1}, respectively. Klik and Cepuder (1991) reported that a single irrigation either at flowering or 4 days later at the beginning of pod development gave a 14% increase of yields over control. They also found 23% increase of yield (3.38 t ha^{-1}) with irrigation (applied 4 times) over non-irrigation control.

Heatherly and Spurlock (1993) carried out field trials with soybean cv. leflore and At980 where irrigations were no irrigation and furrow irrigation stating at about growth stage R_1 (start of flowering) and at terminating of various stages up to R_6 (full seed). A single irrigation at R_2 did not significantly increase seed yield. All other treatments increased yield compared with no irrigation, irrigation applied up to mid-R_5 (seed-filling) increased yield by 1.86 t ha^{-1} in a dry year and by 0.61 t ha^{-1} compared with irrigation terminated at R_4 (full pod). In wet years, irrigation had a lesser or no effect on yield. In dry years, irrigation terminated at mid- or late R_2 or mid-R_5 gave the greatest yield increases per unit irrigation water applied while irrigation terminated in the seed filling period gave the highest net return.

Tusa *et al.*, (1994) concluded that water consumption during flowering and pod formation was a more decisive factor in obtaining high and constant yields than water consumption during vegetative growth. Pandely *et al.* (1995) stated that irrigating at an IW:CPE ratio of 0.7 at all growth stages gave the highest seed yield of 1.52 t ha^{-1} which was not significantly different from 1.44 t obtained with irrigation at an IW:CPE ratio of 0.5 at the vegetative and podding stages. Reduction in seed yield from normal irrigation to moisture deficit during flowering and pod filling was about 34% compared with about 22% with moisture deficit during flowering alone. Water stress at pod filling had less effect than at flowering (Sridhara *et al.*, 1997).

Sabbe and DeLong (1996) observed that seed yields of the irrigated crops were 2 or 3 times greater than the rainfed crops at Marianna and Rohwer, respectively.

Fernandes *et al.* (1997) conducted experiment with four irrigation treatments viz. T_1 – irrigation based on estimation of maximum evapotranspiration, T_2 and T_3 irrigation based on data from tensiometers located at 40 cm soil depth and T_4 (control) – only one irrigation during seedling emergence. The plants of the treatment with more frequent irrigation showed higher leaf dry matter, leaf area and yield of seeds than those irrigated less frequently. The control plants produced the lowest values of pod and leaf dry matter, leaf area and seed yield.

Chavan *et al.* (1998) carried out a field trial with soybean during 1995 in Maharashtra, India. Sowing was done on 5, 15 or 31 January or 15 February and irrigation was applied at cumulative pan evaporation of 50, 75 or 100 mm or every 10 days. They revealed that the optimum sowing date was 31 January and irrigation at every 10 days to crop sown on 31 January produced the highest seed yield (2.17 t ha^{-1}).

Deolankar *et al.* (1998) found that seed yield was highest with 37.5:75 kg N:P2O5 (1.98 t ha^{-1}) and was similar with irrigating at CPE of 75 (1.84 t) or 100 mm (1.74 t) or 100 mm (1.74 t) or at critical growth stages (1.75 t). Irrigating at CPE of 125 mm produced the lowest seed yield of 1.60 t.

Sabbe and DeLong (1998) conducted field trials with soybean at Marianna, Arkansas, USA in 1995, 97 and 1998. They used two irrigation treatments viz. no irrigation and irrigation and found drought in 1995 reduced unirrigated yields from 17.2 to 27.0 bushels acre^{-1} compared with 35.0 to 54.7 bushels acre^{-1} for irrigated crops. Corresponding yields for 1997 and 1998 were 27.9-48.5 and 49.0-57.4 bushels acre^{-1} and 18.5 to 33.9 and 50.0-60.7 bushels acre^{-1}, respectively.

Paslawar and Gawande (1998) conducted a field with soybean cv. PKV-I during 1995 in India. Sowing was done at densities of 2.2, 3.3 or 4.4 lakh plants ha^{-1} and irrigation was applied twice-no irrigation or protective irrigation. They reported that the increased with increasing density and were greater with irrigation than without irrigation.

Frederick and Camp (2001) carried out field trials to observe the effect of drought stress on both soybean (cultivars Northrup, King, Coker and S73-Z5) during 1998 and 1999 in south carolin, USA. They used three levels of drought-stress treatments (i) irrigation and no deep tillage (ii) deep tillage but no irrigation and (iii) no deep tillage or irrigation. Total seed yield, branch seed yield and the percentage of total seed yield on the branches were highest with irrigation, followed by the in-row subsoiled/no deep tillage treatment and the no irrigation no deep tillage treatment. Drought-stress treatment had no effect on mainstem seed yield. Branch seed number per square meter was highly correlated with branch seed yield ($r=0.994$; $P<0.0001$) and total seed yield ($r=0.989$; $P<0.01$) over both years and all levels of drought-stress treatment. The also found a close relationship between branch seed number per square meter and branch dry weight at harvest maturity (r=0.963; P<0.05), final branch length per square meter (r=0.994; P<0.05).

Kazi *et al.* (2002). stated that in a trial where irrigation frequencies were 2, 3, 4, 5, and 6 irrigations, the growth, yield components and oil content were significantly affected by irrigation frequencies. Maximum plant height, more branches plant^{-1}, pods plant^{-1}, seed index, seed yield (t ha^{-1}) and oil content (%) were found superior with the application of 6 irrigations followed by 5 irrigations. Whereas, lowest number of irrigations decreased all the traits adversely.

Boydak *et al.* (2002) conducted field experiment during 1998-1999 in Turkey in to investigate the effect of different row spacings and irrigation methods on yield and yield components of soybean cv. A3935. They observed the variation in yield at different irrigation methods was 28353 to 33238 kg ha^{-1}. The sprinkler irrigation produced the highest plant height, branch number plant^{-1}, node number plant^{-1}, pod number plant^{-1} and yield plant^{-1} was than the drip irrigation method.

Sweeney and Granade (2002) conducted field trial in USA, with soybean having four irrigation treatments viz. no irrigation, 2.5 cm at growth stage (R_1) to beginning to full bloom (R_2), 2.5 cm at full pod (R_4), 2.5 cm at full seed (R_6) and two planting dates viz. early and late June. They found yield was unaffected by irrigation when soyabean cultivars were planted in early June, but irrigation increased yield of late-June-planted soybean. They also observed yield increases from irrigation appear to be more related to increasing seeds plant^{-1} than seed weight. Selection of the timing of a single irrigation between growth stages R_1, R_6 may not result in large yield differences because all irrigation increased the number of seeds plant^{-1}. Irrigation at R_6 also increased average seed weight.

Sweeney *et al.* (2003). Carried out experiments to determine the effect of a single irrigation at different reproductive growth stages on yield quality of soybean (Glycine max L.) from 1991 to 1994. They found yields from a single irrigation at R4, R5, or R6 were similar and averaged approximately 20% more than yield with no irrigation. Irrigation at R4 increased seeds plant^{-1} whereas R5 and R6 irrigations increased weight seed^{-1}. Irrigation had minimal effect on seed protein and variable effect on oil content.

Hao *et al.* (2003) conducted experiment to find out the effects of irrigation and fertilizer on soybean cv. Bei 92-28 in 2000 at Heilongjiang, China. They found the effects of irrigation varied among the levels of fertilizer application and vice versa; pods plant^{-1}, seeds pod^{-1} and 100-seed weight had positive correlations with soybean yield, but the degrees of correlations of different treatments were varied. Leaf area index and dry matter accumulation significantly increased when irrigated and supplied with fertilizer. Irrigation increased the absolute absorption of N, P, K in seeds, although differences in the accumulation rates were observed.

Georgiev and Sabev (2003) Carried out an experiment during 1999-2001with soybean where initial irrigation was provided from early flowering to full flowering, the second irrigation was given at the late flowering stage and the third was provided from late pod formation stage to grain-filling stage. They obtained highest yield in absence of irrigation, when rainfall was adequate and well-distributed. They also found the grain yield increased by an average of 83% or 120 kg ha^{-1} under optimum irrigation and by 71% or 100 kg ha^{-1} under partial irrigation than without irrigation condition. They suggested that under conditions of limited water supply and expensive irrigation, the provision of partial irrigation to soybean was more economical and efficient.

Sabev, *et al.* (2003). Reported that the optimum irrigation regimes with 40 and 20% reduced irrigation rates resulted in an increase of energy efficiency by 16.1 and 15.3%, respectively, compared to non-irrigated treatment. Under disturbed irrigated regime, the coefficient of energy efficiency was highest for the treatment without first watering compared to the optimum one (1.307), followed by the treatments with application only of third, second and first waterings. The energy difference had the highest values for the treatments with the optimum irrigation regimes with 20 and 40% reduced irrigation rates (24.28 and 23.87 MJ da), followed by the treatments without first and second waterings compared to the optimum treatment (17.97 and 16.24 MJ da, respectively).

Boydak *et al.* (2004) conducted two experiments to study the effect of row spacing and irrigation intervals on yield, plant height, first pod height, branch plant^{-1}, node pod number plant^{-1} and seed yield plant^{-1} for 2 years in Harran, Turkey; where four row spacings (50-30, 70-30, 80-40, and 70-70 cm) and four irrigation intervals (3, 6, 9, and 12 day intervals) were used. They observed the seed yield reduced plant^{-1} with decreasing row spacing but led to an increase in yield per hectare. Yields were highest (3752.6 kg ha-$^{-1}$) at 50-30 cm row spacing and 6 day irrigation interval (3744.1 kg ha^{-1}) and were the lowest (3096.6 kg ha^{-1}) at the 70-70 cm row spacing and 12 day intervals (2752.4 kg ha^{-1}).

From the literature presented above, that the yield and yield attributes of soybean varied with the differences of varieties, irrigation levels and locations. So it is important to study the location specific response of variety and irrigation to yield and yield attributes of soybean.

Chapter III

MATERIALS AND METHODS

In this chapter the details of different materials used and methodology followed for this experiment are described.

3.1. Experimental site

3.1.1. Location

The research work was carried out at the field Laboratory of Agronomy Department of Sher-e-Bangla Agricultural University, Dhaka during the rabi season from December 2005 to April 2006. The experimental field belongs to the agro-ecological Zone of the Madhupur Soil Tract (AEZ-28). For better understanding about the experimental site are shown in the Map of AEZ of Bangladesh in Appendix-I.

3.1.2. Soil

The land was medium high and the soil of the experimental site belongs to Nodda soil series which is silty loam in texture with 29.97% sand, 54.86% loam and 15.28% clay particles. The soil was analyzed at Soil Resources Development Institute (SRDI) and found that soil is rich with Fe and other nutrients were to some extent lower compared to the critical level (Appendix-II).

3.1.3 Climate

Cold temperature and minimum rainfall are the main features of the rabi season. The monthly total rainfall, average sunshine hour, temperature during the study period (December 2005 to April 2006) are shown in Appendix III.

3.2 Planting material

The varieties of soybean used in this experiment were Shohag, Bangladesh soybean-4 and BARI soybean-5. The seeds of these varieties were collected from Bangladesh Agriculture Research Institute, Goydebpur, Gazipur. These released varieties have excellent seed quality and superior to existing Bragg and Davis varieties.

3.2.1. Shohag

Shohag was released in 1990 by National Seed Board. Life duration is about 95-100 days. Plant height is 36-42 cm. Flower colour is pinkish. Seed colour is cream. Seed size is medium. The variety is photosensitive. Seed yield is about 1.6-1.8 t ha^{-1}.

3.2.2. Bangladesh soybean-4

Bangladesh soybean-4 was released in 1994 by National Seed Board (NSB). At maturity, the plants attain at a height of 36-42 cm and its life duriation is about 95-100 days. Its flower is pinkish. The seed is small in size compared to other varieties and its colour is greenish yellow. The yield is about 1.6-2.5 t ha^{-1}.

3.2.3. BARI soybean-5

BARI soybean-5 was released by National seed Board (NSB) during 2002. Its field duration is about 95-115 days. Plant height is 40-60 cm. Flower colour is pinkish. Seed colour is cream. Seed size is medium. Seed yield is about 1.6-2.0 t ha^{-1}.

3.3. Experimental details

3.3.1. Treatments

The experiment consisted of the following treatments:

A. variety: 3

(i) V_1 = Shohag

(ii) V_2 = Bangladesh soybean-4

(iii) V_3 = BARI soybean-5

B. Irrigation: 5

(i) I_o = control (No irrigation)

(ii) I_1 = Irrigation at main stem elongation stage (EMS)

(iii) I_2 = Irrigation at flowering stage (F)

(iv) I_3 = Irrigation at pod development stage (PD)

(v) I_4 = Irrigation at EMS+F+PD stages.

3.3.2. Design and layout of the experiment

The experiment was laid out following two factors split plot design with 3 replications. irrigation was given in main plot and variety in the sub-plots. There were 45 unit plots in the experiment and the size of each unit plot was 4 m x 2.5m, the spacing between unit plots and blocks were 0.75 m and 1 m, respectively.

3.4 Procedure of the experiment

3.4.1. Land preparation

The land was first opened on 7 December 2005 with a power tiller. Final land preparation was done by country plough on 20 December 2005. The land was thoroughly prepared by four ploughings and cross ploughings followed by laddering in order to level the soil. Weeds and stubbles were removed from the field. Final layout was done on 21 December 2005 according to the design adopted.

3.4.2. Application of fertilizers

The plots were fertilized with urea, triple super phosphate, muriate of potash and gypsum at the rate of 60, 175, 120 and 115 kg ha^{-1}, respectively (BARI, 1995). All the fertilizers were applied at the time of final land preparation.

3.5. Sowing of seeds

Sowing was done on 22 December 2005. Seeds were sown in 30 cm apart rows and seed to seed distance was 6 cm. Furrows were made by hand rake and seeds were placed in the furrows by hand and then covered properly with soil.

3.6 Intercultural Operations

The following intercultural operations were done to ensuring the normal growth of the plant.

3.6.1. Weeding

The crop was weeded twice. First weeding was done 30 days after sowing (DAS) and second weeding done 45 DAS. Demarcation boundaries and drainage channels were also kept weed free.

3.6.2. Thinning

Two seeds were sown in each pit. One seedling was allowed to grow in each pit and excess seedling was thinout within 15-21 DAS.

3.6.3 Soil loosening

After each irrigation the compact soils of the irrigation treated plots were loosen by spading in between two rows.

3.6.4. Irrigation

Irrigations were done as per treatment mentioned in chapter 3.3.1.

3.6.5 Plant protection

The soybean plants were infested by hairy caterpillars (*Diacrisia obliqua*) and cutworm at early growth stage which were controlled by applying sumithion 50 EC @ 1.0 L ha^{-1}. Hand picking of infested leaves was also done as a control measure. Diseased or off type plants were uprooted as and when required but these were not recorded.

3.7. General observation

The field was frequently observed to notice any change in plant characters. The crop had been promising since the initial stage and it maintained a satisfactory condition till harvest.

3.8. Sampling and harvesting

Maturity of crop was determined when 95% of the pods became brown in colour. Ten plants were selected at random from each plot and uprooted before harvesting for recording necessary data. The whole plot was harvested at maturity on different dates i.e. harvesting started on 7 April 2006 and continued up to 10 April 2006. The harvested crops from each plot were tied up into bundles separately, tagged and brought to the clean threshing floor. The same procedure was followed for sample plants.

3.9. Threshing

The crop bundles were sun dried for four days by spreading them on the threshing floor. Seeds were separated from the stover by hand shelling.

3.10. Drying

Seeds and stover were cleaned and dried in the sun for three to four consecutive days. After proper drying of seeds to a moisture content of 16-18%, were kept in polythene bags.

3.11. Cleaning and weighing

Dried seeds and stover were cleaned and weighted plot wise. After that the weights were converted into kg ha^{-1}.

3.12. Collection of data

A. Crop growth characters

Ten plants in plot were selected and tagged. All the growth data (expect dry weight) were recorded from these 10 selected plants.

(i) Plant height (cm) at 15 day intervals starting at 30 DAS

(ii) No. of leaf plant^{-1} at 15 day intervals starting at 30 DAS

(iii) Dry weight of plant (g) at 15 day intervals starting at 30 DAS

B. Plant and yield contributing character

(i) Plant height (cm) (at harvest)
(ii) Number of breanches plant^{-1}
(iii) Pod length (cm)
(iv) Number of pods plant^{-1}
(v) Number of seeds pod^{-1}
(vi) 100 seed weight (g)

C. Yield and harvest index

(i) Seed yield (kg ha^{-1})
(ii) Stover yield (kg ha^{-1})
(iii) Biological yield (kg ha^{-1})
(vii) Harvest index (%)

3.13. Methods of recording data

3.13.1. Plant height (cm)

The height of sample plants (10) were measured from the ground level to the tip of main shoot. It was done 5 times such as 30, 45, 60, 75 and 90 DAS. In each time data were averaged and expressed in cm.

3.13.2. Number of leaf plant^{-1}

Total number of leaves for ten sample plants of each plot was counted in 5 times such as 30, 45, 60, 75 and 90 DAS. For each count mean value was determined and expressed in number of leaf plant^{-1}.

3.13.3 Dry weight of plant (g)

Shoot and root of 10 seedlings were collected and dried separately for 24 hours in an electric oven set at 65°C. The dry weight of the samples was taken using a sensitive digital electric balance. The mean weight was calculated to have individual plant weight and expressed in g.

3.13.4. Plant height at harvest (cm)

The height of 10 sample plants were measured from the ground level to the tip of main shoot and mean height was expressed in cm.

3.13.5. Number of branches Plant^{-1}

All the branches present on ten sample plants were counted and averaged to have number of branch plant^{-1}.

3.13.6. Pod length (cm)

The length of pod of 10 sample plants were measured and mean length was expressed in cm.

3.13.7. Number of pods plant^{-1}

All the pods that were born on all the ten sample plants of each plot were counted out to determine the average number of pods plant^{-1}.

3.13.8. Number of seeds pod^{-1}

Number of total seeds of ten sample plants from each plot was noted and the mean number was expressed per pod basis.

3.13.9. 100-seed weight (g)

One thousand sun dried seeds were counted at random from the seed stock of sample plants. Weights of 100 seeds were then recorded by means of a digital electrical balance.

3.13.10. Seed yield (kg ha^{-1})

Seed obtained from each unit plot were dried in sun and weighed out. The seed weight was expressed as kg ha^{-1} on 12% moisture basis. Grain moisture content was measured by using a digital moisture meter.

3.13.11. Stover yield (kg ha^{-1})

The stover plot^{-1} was dried separately and weights were recorded. These weights were converted to kg ha^{-1}.

3.13.12. Biological yield (kg ha^{-1}).

Seed yield and stover yield were altogether regarded as biological yield.

3.13.13. Harvest index (%)

Harvest index was calculated on the ratio of grain yield to biological yield and expressed as percentage. It was calculated by using the following formula (Gardner *et al.*, 1985).

$$\text{Harvest index (\%)} = \frac{\text{Seed yield}}{\text{Biological yield}} \times 100$$

Where, Biological yield = Seed yield + Stover yield.

3.14. Statistical analysis of data

Data were analyzed using the analysis of variance (ANOVA) technique and mean differences were adjudged by Duncan's Multiple Range Test (Gomez and Gomez, 1984) with the help of computer based statistical package programme, M-STAT. The mean differences among the treatments were compared by least significant difference (LSD) test at 5% level of significance.

Chapter IV

RESULTS AND DISCUSSION

The results of the present study have been discussed in this chapter. Experimental results pertaining to the effect of irrigation on the growth and yield of soybean varieties. The parameters considered were plant height (cm) number of leaf plant^{-1}, dry matter plant^{-1} (g), plant height at harvest (cm), number of branches plant^{-1}, pod length (cm), number of pod plant^{-}number of seed pod^{-1}, 100 seed weight (g), seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%). Results of the experiment have been presented in Tables 1 to 10 and Fig 1 to 8. The mean square values of the said parameters together with the sources of variation and their corresponding degrees of freedom have been shown in Appendices IV to VII.

4.1. Plant height

4.1.1. Effect of variety

At the early stage of growth up to 30 DAS, the growth of plants of the tested three varieties was slow. At this stage, among the three varieties Shohag showed significantly highest plant height (23.32 cm) and BARI soybean 5 showed the lowest height (21.29 cm). The rate of increase in plant height was higher from 30 DAS to 60 DAS, after that the values of plant height increased slowly up to 75 DAS and the highest plant height was attained at this stage for all the three varieties. After 75 DAS, the plant height reduced slightly for all the varieties. The reduction in plant height at later stage may be attributed to dry up and defoliation of dried leaves of the plant. Among the three varieties Bangladesh soybean-4 gave significantly highest plant height, 60.52, 68.14 and 57.79 cm at 60, 75 and 90 DAS, respectively (Table 1). The result coincides with the findings of Ponnuswamy *et al.*, (2001) who observed variations in plant height between varieties.

Table 1. Effect of variety on plant height of soybean

Variety	Days after sowing				
	30	**45**	**60**	**75**	**90**
Shohag	23.32	40.46	58.12	63.38	50.20
Bangladesh soybean-4	22.52	39.58	60.52	68.14	57.79
BARI soybean-5	21.29	39.59	52.36	55.87	49.66
LSD (at 0.05)	1.566	NS	2.897	4.074	4.180
CV (%)	5.38	6.47	7.18	7.84	6.10

NS = Not significant

4.1.2. Effect of irrigation

The effect of irrigation on plant height of soybean is presented in (Fig. 1). Significant differences of plant height were found in every stages of growth except at the early stage (up to 30 DAS). This may perhaps due to the slow growth rate and also for no irrigation application before this stage. Maximum plant height was observed in applied irrigation at EMS+F+PD treatments in all the stages of life cycle. The lowest plant height was found with no irrigation treatment (control) in every growth stages. The plant response in terms of height was found higher in the middle stage of growth (from 45 DAS to 60 DAS) because of better growth of this period. The results corroborates with the findings of Kazi *et al.* (2002).

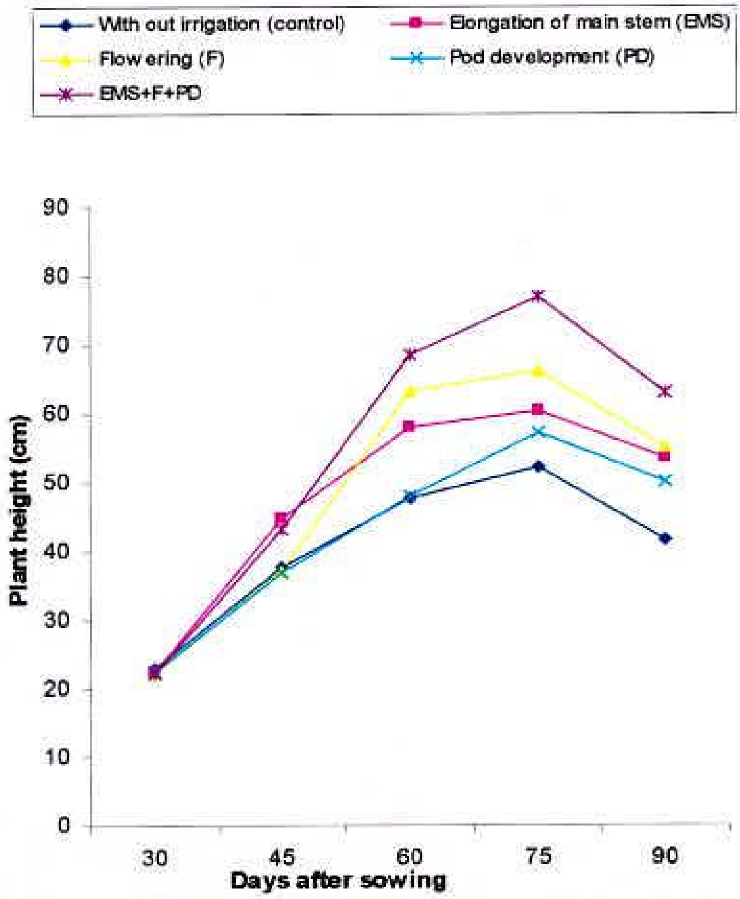

Fig.1. Effect of irrigation on plant height of soybean at different growth stages

4.1.3. Interaction effect of irrigation and variety

The interaction effect of irrigation and variety had a great effect on plant height of soybean (Fig. 2). In this study, the figure shows that at 30 DAS the tallest plant was found from the interaction between irrigation at flowering × Shohag flowed by irrigation at EMS + F + PD × Shohag, without irrigation × Shohag, irrigation at EMS × Bangladesh soybean-4 and the shortest plant was found at irrigation at F × BARI soybean-5. At 45 DAS stages, the highest height was observed in irrigation at EMS × BARI soybean-5 interaction. At 60, 75 and 90 DAS growth stages the tallest plants were found in the treatment irrigation at EMS + F + PD × Bangladesh soybean-4.

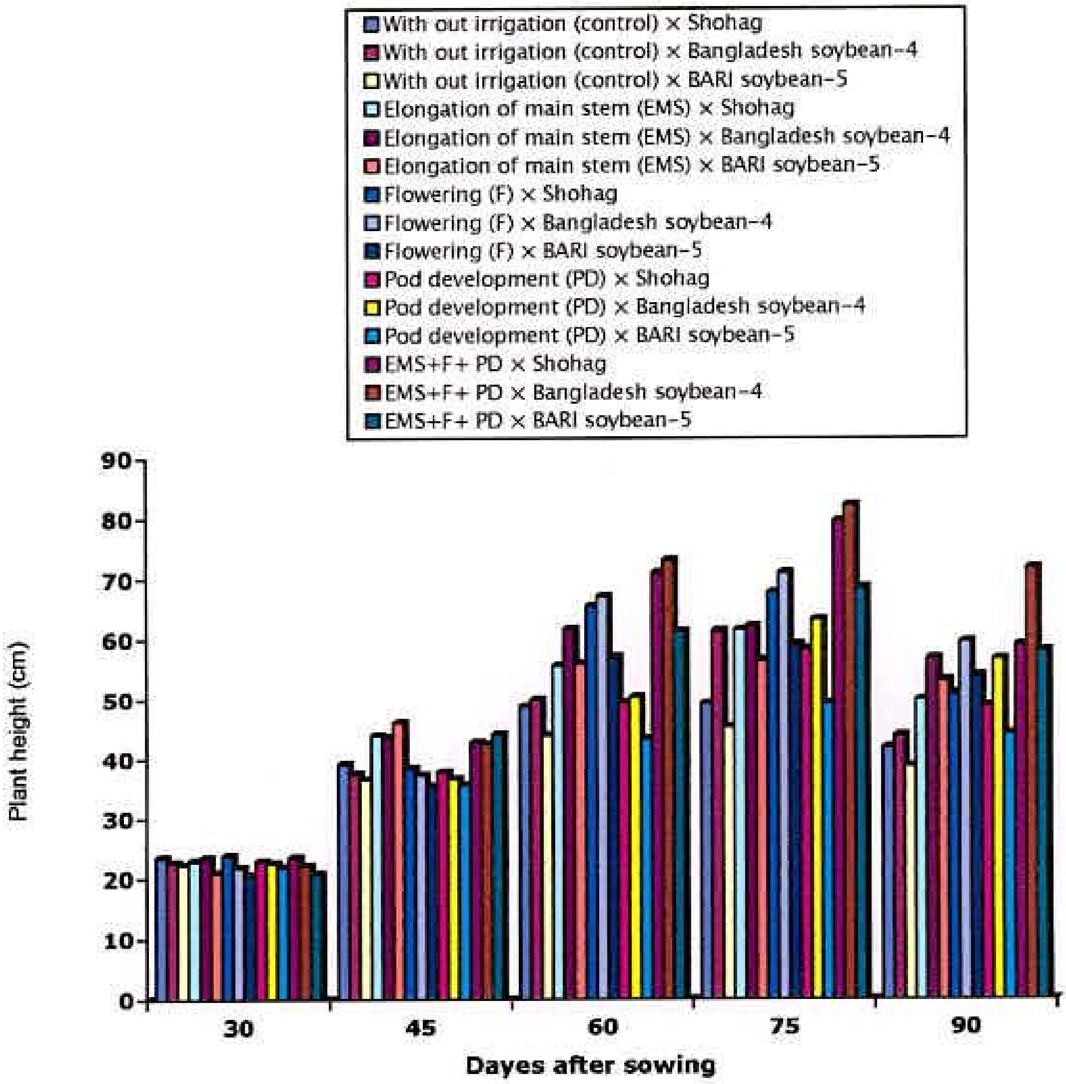

Fig.2. Interaction effect of irrigation and variety on plant height

4.2. Number of leaf plant^{-1}

4.2.1. Effect of variety

Significant variation was found among the varieties for number of leaf plant^{-1} at 45 DAS, 60 DAS and 90 DAS (Table 2). At 45 DAS Bangladesh soybean-4 produced significantly highest number of leaf plant^{-1} than other varieties. At 60 and 90 DAS showed the reverse result of leaf plant^{-1} than 45 DAS. In this two dates (60 DAS and 90 DAS) Shohag and BARI soybean-5 showed the higher leaf plant^{-1} than Bangladesh soybean-4. Saad (1995) observed similar result who reported variety clark produces the highest number of branches plant^{-1} compared with variety Evens, William-82, Crawford and Calombus.

Table 2. Effect of variety on number of leaf plant^{-1} of soybean

Variety	Days after sowing				
	30	45	60	75	90
Shohag	12.09	23.57	51.29	43.36	12.34
Bangladesh soybean-4	11.59	26.56	46.85	41.72	10.08
BARI soybean-5	11.52	21.39	52.33	44.52	11.88
LSD (at 0.05)	NS	2.073	4.049	NS	0.866
CV (%)	9.23	13.06	5.68	6.37	11.61

NS = Not significant

4.2.2. Effect of irrigation

The effect of irrigation on number of leaf plant^{-1} is presented in (Fig. 3). The figure indicates that at 45 DAS the highest number of leaf plant^{-1} was found from the applied irrigation at elongation of main stem period and that of lowest in applied irrigation at pod development period. At 60, 75 and 90 DAS the highest number of leaf plant^{-1} was found to produce from the irrigation applied at EMS+F+PD stages. It was also observed that the lowest number of leaves were produced in the control treatment (without irrigation) for all the growth stages.

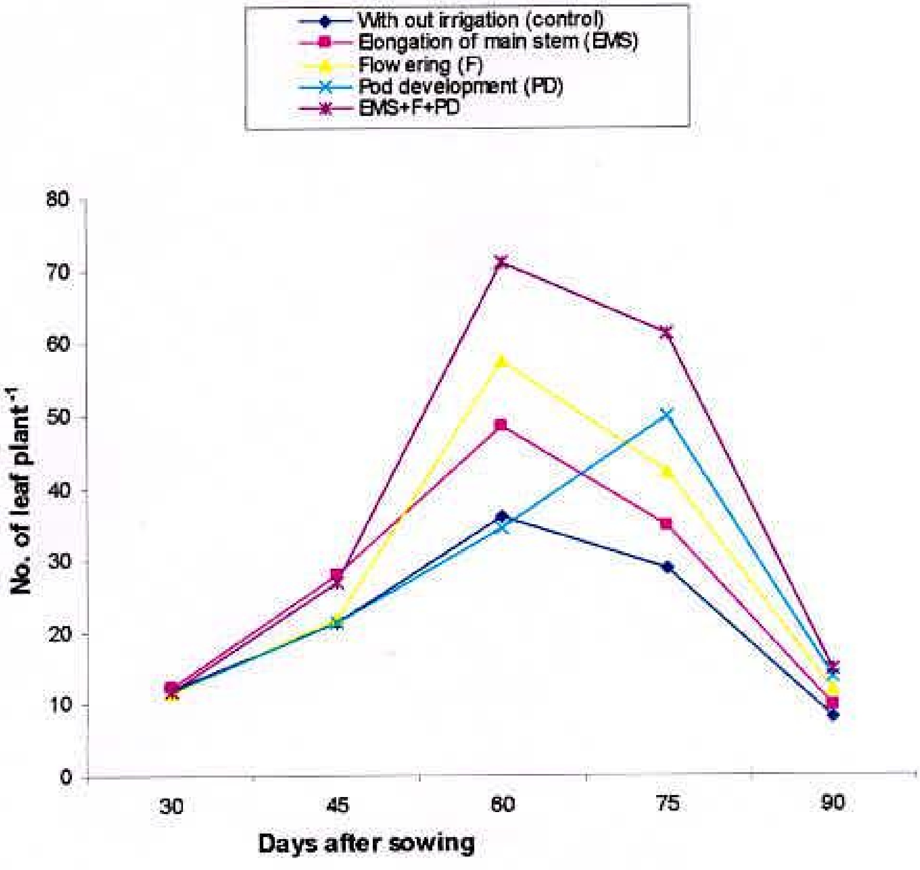

Fig.3. Effect of irrigation on number of leaf plant^{-1}

4.2.3. Interaction effect of irrigation and variety

The effect of interaction between irrigation and variety on number of leaf plant^{-1} was significant at different growth stages of soybean (Fig. 4). At 30 DAS the treatment without irrigation × Shohag produced the highest number of leaf plant^{-1} and that of lowest from the treatment irrigation applied at flowering × Bangladesh soybean-4. At 45 DAS the treatment elongation of main stem × Bangladesh soybean-4 produced the highest number of leaf plant^{-1} and the lowest number was found in the treatment irrigation at pod development × BARI soybean-5. On the other hand, the interaction treatment of irrigation at EMS+F+PD × BARI soybean-5 produced the tallest plant at 60, 75 and 90 DAS. However, the lowest number of leaf plant^{-1} was found from the treatment without irrigation × Bangladesh soybean-4 at the same growth stages.

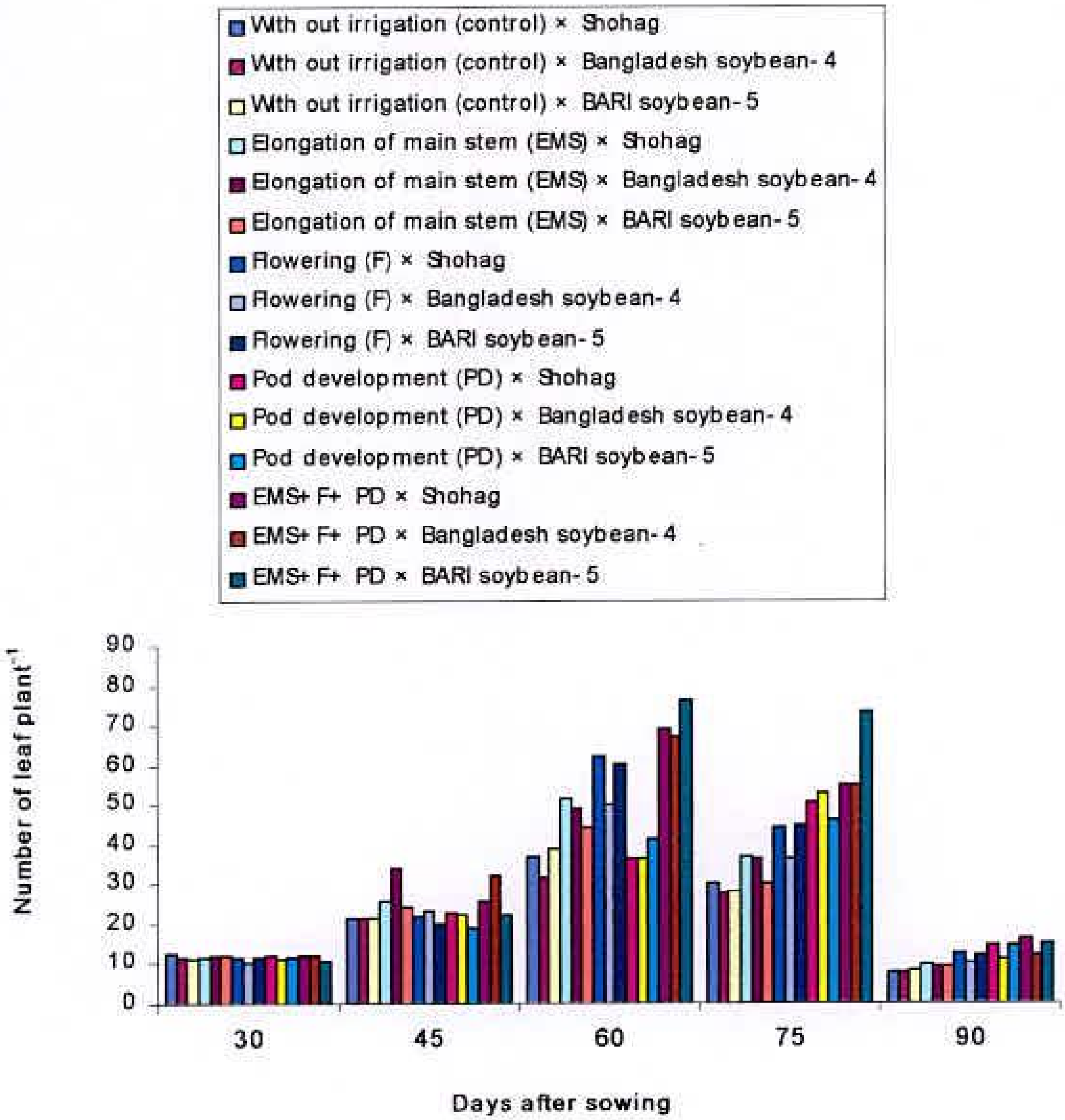

Fig.4. Interaction effect of irrigation and variety on number of leaf plant^{-1}

4.3. Dry matter plant^{-1}

4.3.1. Effect of variety

Dry matter production was significantly influenced at 5% level of probability by the varieties at 30, 45 and 60 DAS (Table 3). BARI soybean-5 produced significantly highest dry matter followed by Shohag at 30, 45 and 60 DAS. Bangladesh soybean-4 showed the lowest dry matter at 30, 45 and 60 DAS. Although dry matter production at 75 and 90 DAS was not significant but numerically, BARI soybean-5 showed higher amount of dry matter than other two varieties.

Table 3. Effect of variety on dry matter plant^{-1} of soybean

Irrigation	Days after sowing				
	30	45	60	75	90
Shohag	2.92	4.18	10.07	14.38	18.59
Bangladesh soybean-4	2.51	3.93	8.50	14.85	18.74
BARI soybean-5	3.03	5.66	11.46	16.04	20.09
LSD (at 0.05)	0.380	0.892	1.400	NS	NS
CV (%)	11.67	12.55	9.59	10.53	10.70

NS = Not significant

4.3.2. Effect of irrigation

Clear variations were found in dry matter plant^{-1} with different levels of irrigation among the growth stages (Fig. 5). At 45 DAS the treatment EMS+F+PD produced the highest dry matter (5.40 g) and the lowest dry matter (3.84 g) was found the treatment without irrigation (control). The treatment EMS+F+PD produced the highest dry matter at 60, 75 and 90 DAS (14.10 g, 20.47 g and 24.30 g, respectively) and next highest by the treatment elongation of main stem and flowering period. The lowest dry matter was found to produced from the treatment without irrigation at 60, 75 and 90 DAS.

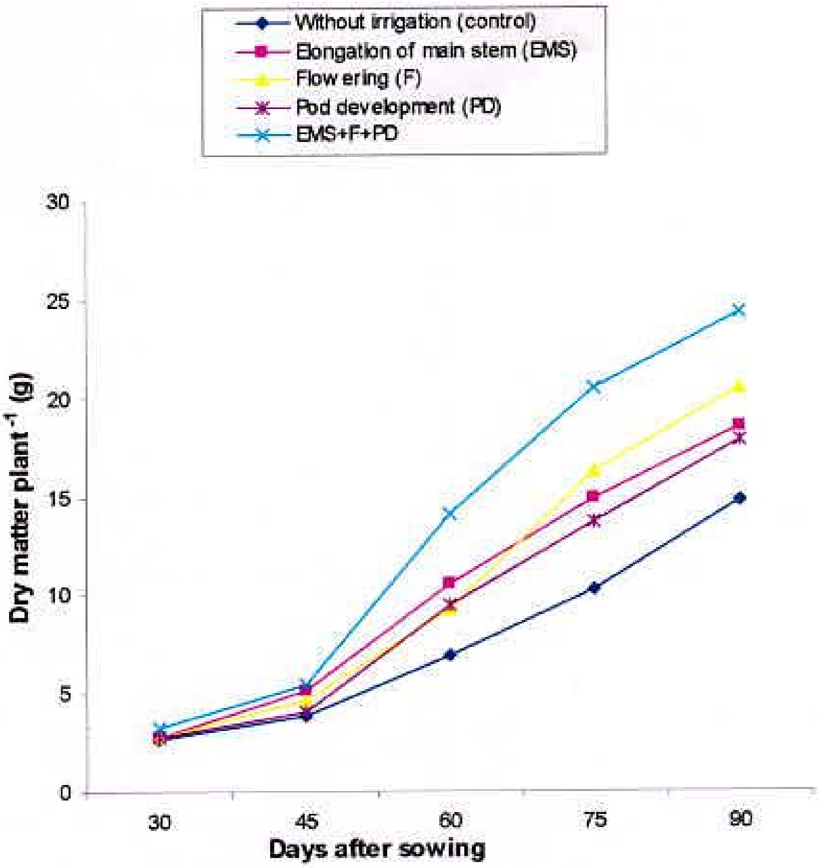

Fig.5. Effect of irrigation on dry matter plant^{-1}

4.3.3. Interaction effect of irrigation and variety

The interaction effect between irrigation and variety on dry matter production at different stages of growth has been presented in (Figure. 6). At 30 DAS the treatment irrigation at pod development × BARI soybean-5 produced the highest dry matter (3.41 g) and the lowest dry matter was found from the treatment irrigation at pod development × Bangladesh soybean-4. The treatment irrigation at EMS+F+PD × BARI soybean-5 produced the highest dry matter at 45, 60, 90 DAS and followed by the treatment irrigation at elongation of main stem × BARI soybean-5, EMS+F+PD × Shohag and EMS+F+PD × Bangladesh soybean-4. The lower levels of dry matter were found from the interaction treatments irrigation at pod development × Bangladesh soybean-4 at 30, 45 DAS and without irrigation × BARI soybean-5 at 60, 90 DAS.

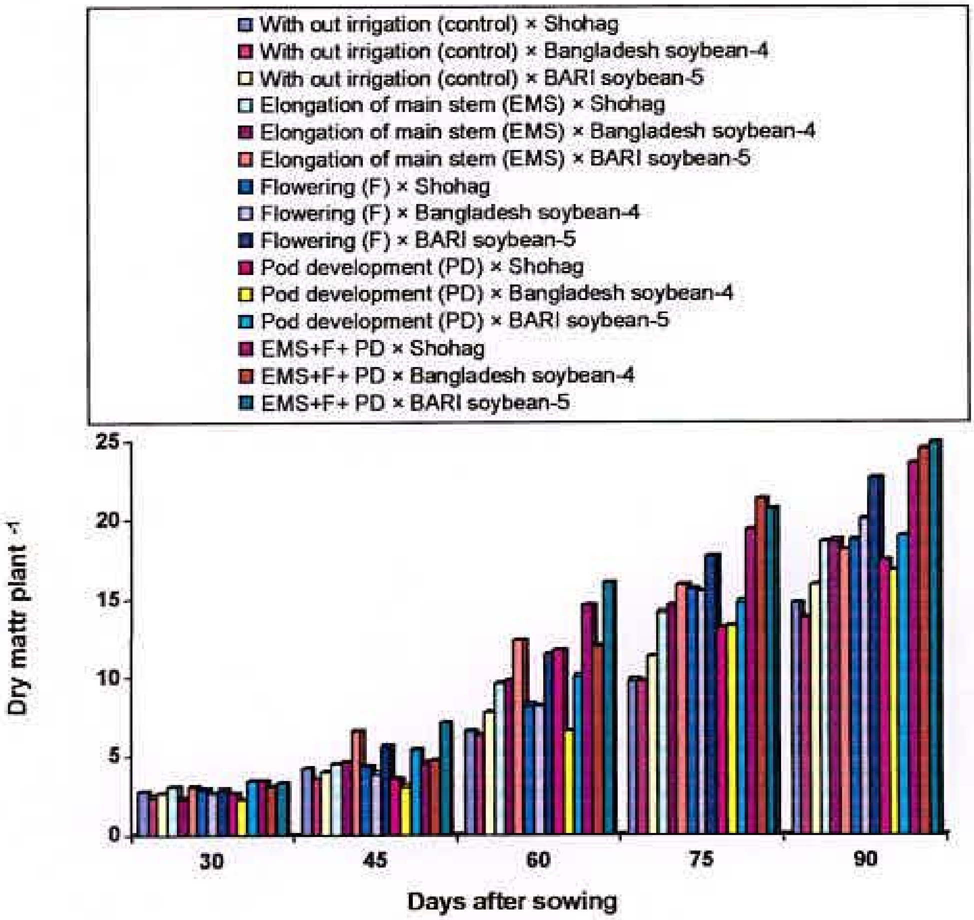

Fig. 6. Interaction effect of irrigation and variety on dry matter plant-1

4.4. Crop growth rate (CGR)

4.4.1. Effect of variety

Crop growth rate was significantly influence by the varieties up to 60 DAS (Table 4). At 45 DAS, BARI soybean-5 produced the highest CGR values (9.75 g m^{-2} d^{-1}) and Shohag produced the lowest CGR (4.69 g m^{-2} d^{-1}). But Shohag produced the maximum CGR (21.78 g m^{-2} d^{-1} and 15.58 g m^{-2} d^{-1}) at 60 and 90 DAS. For all the varieties crop growth rate was maximum in the beginning after that it increased with the advancement of crop growth period up to 60 DAS for Shohag and BARI soybean-5, and 75 DAS for Bangladesh soybean-4 and became declined at 90 DAS. The result in respect of CGR values corroborates with findings of Rabbani *et al.* (2004).

Table 4. Varietal response on crop growth rate (g m^{-2} d^{-1}) of soybean at different days after sowing

Variety	Days after sowing			
	45	60	75	90
Shohag	4.69	21.78	16.16	15.58
Bangladesh soybean-4	5.27	16.91	23.51	13.66
BARI soybean-5	9.75	21.47	16.30	14.98
LSD (at 0.05)	0.89	1.40	NS	NS
CV (%)	10.36	12.47	14.31	14.51

NS = Not significant

4.4.2. Effect of irrigation

Irrigation had a significant effect on CGR values (Table 5). The CGR values increased from the beginning of growth upto 60 DAS after that the values reduced upto 90 DAS with irrigation applied at EMS, PD and EMS+F+PD stages treatments. Incase of irrigation applied at F stage CGR increased upto 75 DAS and after that it reduced. It is interesting to note that CGR values of control treatment increased upto

90 DAS. However, irrigation applied at EMS+F+PD stage treatment showed the higher CGR value at 60 DAS. The result agreed with the findings of Kazi *et al.* (2002) who reported higher irrigation produces higher CGR values.

Table 5. Crop growth rate (g m^{-2} d^{-1}) of soybean at different DAS as influenced by different irrigation levels

Irrigation	Days after sowing			
	45	60	75	90
Without irrigation (control)	4.56	11.11	12.61	16.67
Elongation of main stem (EMS)	8.88	19.70	16.01	13.56
Flowering (F)	6.77	17.26	24.81	14.29
Pod development (PD)	4.55	19.98	16.25	15.03
EMS+F+PD	4.10	32.22	23.61	14.15
LSD (at o.05 level)	0.56	0.93	1.54	1.99
CV (%)	10.36	12.47	14.31	14.51

4.4.3. Interaction effect of irrigation and variety

All the combination of irrigation and variety showed differences on CGR values for all growth stages (Fig. 7). The figure shows that all the treatment combinations showed the higher CGR at 60 DAS except without irrigation × Shohag, without irrigation × Bangladesh soybean-4 and pod development × Bangladesh soybean-4. However, highest CGR at 60 DAS was recorded from EMS+F+PD × Shohag combination and at 75 DAS highest CGR was found with irrigation at EMS+F+PD × Bangladesh soybean-4 treatment combination. All the three varieties with control treatment increased CGR up to 90 DAS.

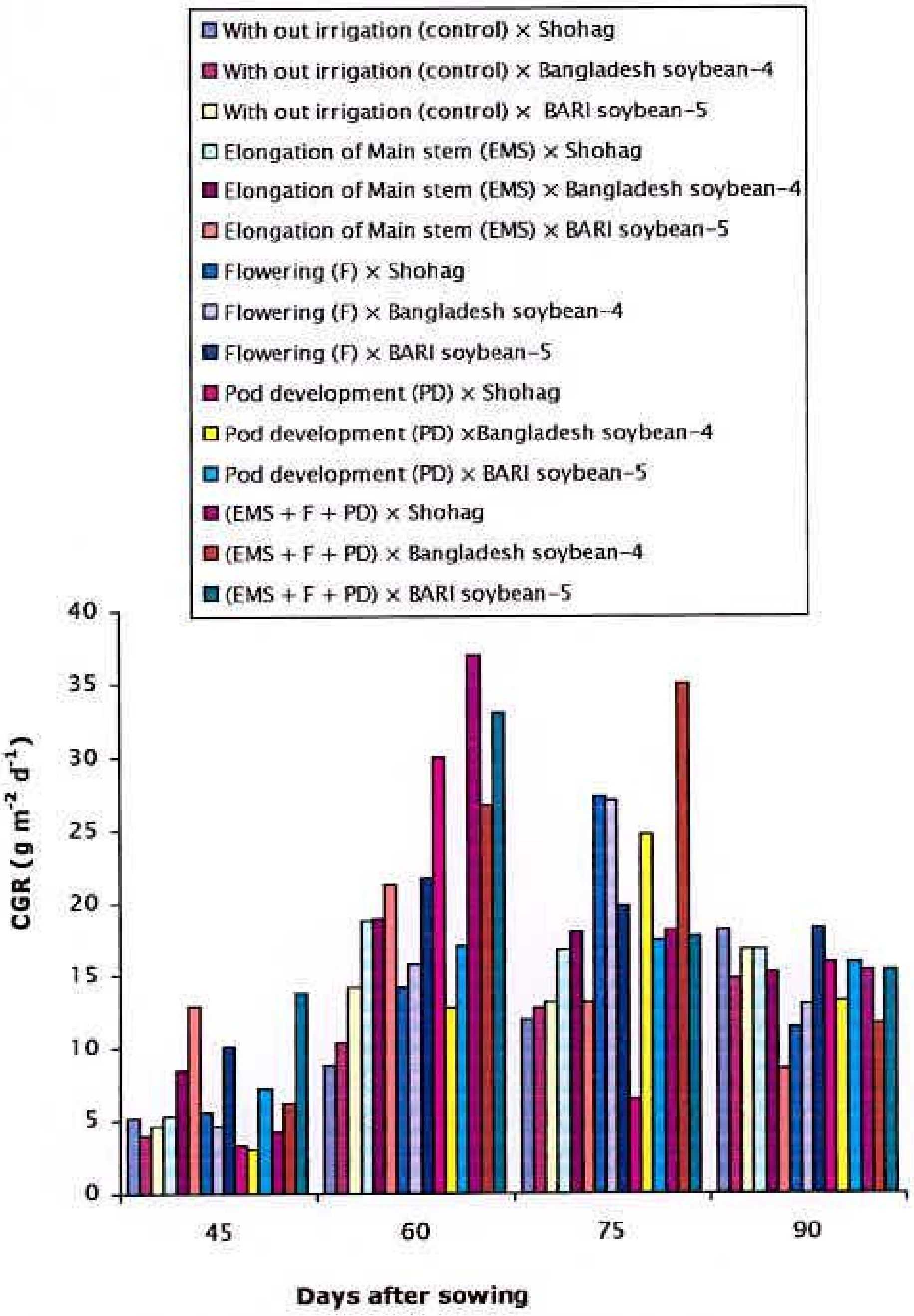

Fig.7. Interaction effect of irrigation and variety on CGR

4.5. Relative growth rate (RGR)

4.5.1. Effect of variety

Variety influenced RGR significantly at 45, 60 and 75, 90 DAS showed no significant (Table 6). At 60 DAS stage of growth, RGR was maximum and gradually declined with the earlier and advancement of crop age. Shohag produced the highest RGR values (0.058 and 0.020 g m^{-2} d^{-1}) at 60 and 90 DAS than Bangladesh Soybean 4 and BARI soybean-5.

Table 6. Varietals response on relative growth rate (g m^{-2} d^{-1}) of soybean at different days after sowing

Variety	Days after sowing			
	45	60	75	90
Shohag	0.02	0.05	0.02	0.02
Bangladesh soybean-4	0.02	0.05	0.03	0.01
BARI soybean-5	0.04	0.04	0.02	0.01
LSD (at 0.05)	0.89	1.40	NS	NS
CV (%)	16.48	13.96	24.21	25.35

NS = Not significant

4.5.2. Effect of irrigation

Different level of irrigation showed significant response on RGR values for all growth stages (Table 7). Maximum RGR values were found at growth stage of 60 DAS and there after declined. Applied irrigation at EMS+F+PD treatment gave the highest (0.64 g m^{-2} d^{-1}) RGR values. The result was supported by Fernandes *el at.* (1997) who reported more frequent irrigation showed higher RGR than less irrigation.

Table 7. Effect of irrigation on relative growth rate (g m^{-2} d^{-1}) of soybean at different days after sowing

Irrigation	Days after sowing			
	45	60	75	90
Without irrigation (control)	0.027	0.040	0.027	0.024
Elongation of main stem (EMS)	0.040	0.049	0.022	0.014
Flowering (F)	0.031	0.047	0.040	0.014
Pod development (PD)	0.022	0.059	0.027	0.019
EMS+F+PD	0.033	0.064	0.026	0.012
LSD (at 0.05 level)	0.56	0.93	1.54	1.99
CV (%)	16.48	13.96	24.21	25.35

4.5.3. Interaction effect of irrigation and variety

The interaction effect of irrigation and variety exerted significant effect on RGR values at different growth stages. Interaction effect of irrigation and variety were almost more or less similar in RGR values (Fig. 8). The highest (0.080 g m^{-2} d^{-1}) RGR values were found in the combination of Shohag with irrigation at EMS+F+PD treatment at 60 DAS. At the same growth stage the combination of Shohag with applied irrigation at pod development also gave the same (0.080 g m^{-2} d^{-1}) RGR values. The combination of irrigation at pod development × Shohag stage produced the lowest (0.010 g m^{-2} d^{-1}) RGR values at 75 DAS. This value was similar with the combination of EMS+F+PD × Bangladesh soybean-4 and EMS+F+PD × BARI soybean-5 treatment at 90 DAS.

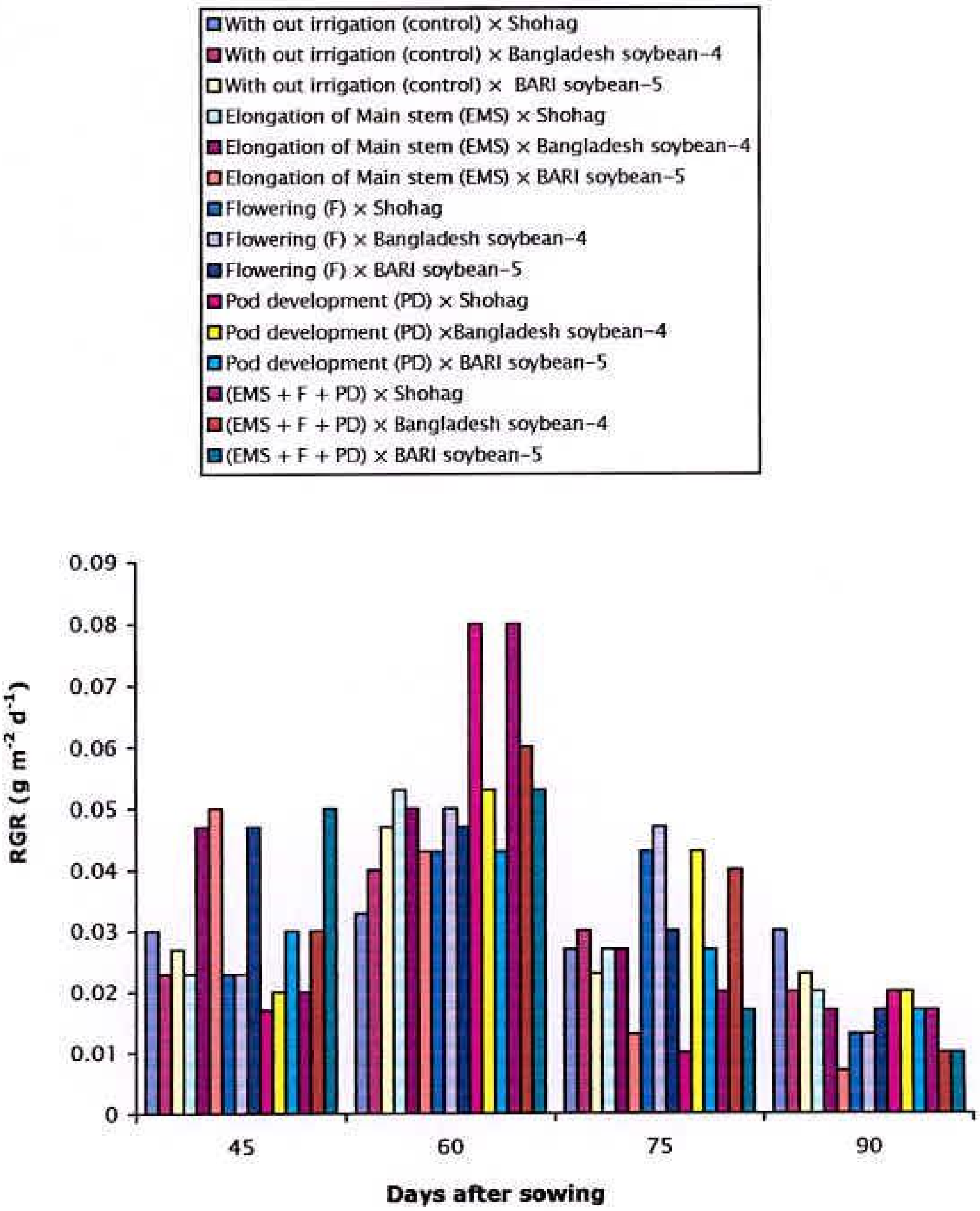

Fig.8. Interaction effect of irrigation and variety on RGR

4.6. Effect of variety on yield contributing parameter

4.6.1. Plant height (at harvest)

Plant height varied significantly due to variety (Table 8.1). The tallest plant (54.20 cm) was found in Bangladesh soybean-4 while the shortest plant (46.26) was found in BARI soybean-5. Similar observation was noted by Ponnushwamy *et al.* (2001) who observed that plant height differed between varieties.

4.6.2. Number of branches plant^{-1}

The number of branches plant^{-1} was affected not significantly by varieties (Table 8.1). But the highest number of branches plant^{-1} (6.71) was found in the variety BARI soybean-5 and the lowest number (5.97) was recorded with the variety Bangladesh soybean-4.

4.6.3 Pod length

Pod length exerted nonsignificant influence on variety (Table 8.1). Numerically highest pod length (3.42 cm) was found in BARI soybean-5 than Shohag (3.35 cm) and Bangladesh soybean-4 (3.25 cm).

4.6.4. Number of pod plant^{-1}

Number of pod plant^{-1} was significantly influenced by the varieties (Table 8.1). The highest number of pods plant^{-1} (36.72) was found in Bangladesh soybean-4 than varieties Shohag (21.34) and BARI soybean-5 (21.19). That means Bangladesh soybean produced 72.09% and 73.29% higher pod plant^{-1} than Shohag and BARI soybean-5, respectively. The result arrobrates with the findings of Saad (1995).

4.6.5. Number of seed pod^{-1}

Number of seeds pod^{-1} differed significantly due to varieties (Table 8.1). From the table it is evident that the highest number of seeds pod^{-1} (1.62) was obtained with the variety BARI soybean-5. The lowest number of seeds pod^{-1} (1.43) was observed by the variety Shohag which was similar with Bangladesh soybean-4 (1.49). This result is suppoted by Molhotra (1974).

4.6.7. 100 seed weight

Variety exerted significant variation on 100 seed weight (Table 8.1). The highest 100 seed weight (8.58 g) was obtained in Shohag which was statistically similar with BARI soybean-5 (8.41 g). The lowest 100 seed weight (5.18g) was obtained in the variety Bangladesh soybean-4 which was 39.63% and 38.41% lower than Shohag and BARI soybean-5, respectively. The result corroborates with the findings of Das *et al.* (1982).

Table 8.1. Effect of variety on plant and yield contributing parameter of soybean

Variety	Plant height (cm)	Branch plant^{-1} (no.)	Pod Length (cm)	Pod plant^{-1} (no.)	Seed pod^{-1} (no.)	100 seed weight (g)
Shohag	48.94	6.07	3.35	21.34	1.42	8.58
Bangladesh soybean-4	54.20	5.97	3.25	36.72	1.49	5.17
BARI soybean-5	46.26	6.70	3.41	21.18	1.61	8.41
LSD (at 0.05)	4.26	NS	NS	0.626	0.906	0.827
CV (%)	8.52	12.16	6.52	5.77	6.11	11.20

NS = Not significant

4.7 Effect of variety on yield

4.7.1 Seed yield

The seed yield varied significantly among the varieties (Table 8.2). The seed yield status among the three varieties in this experiment was that the BARI soybean-5 out yielded by 100.76 and 4.38 kg ha^{-1} (6.93% and 0.28% higher) than Shohag and Bangladesh soybean-4, respectively. But the seed yield between BARI soybean-5 and Bangladesh soybean-4 was significant. The variation in seed yield among the varieties may be attributed to the genetic make up of the varieties. The result agreed with the findings of BARI (2002) who reported that the variety BARI soybean-5 gave the higher yield than Bangladesh soybean-4 and Shohag.

4.7.2. Stover yield

The effect of variety was found to be not significant in respect of stover yield (Table 8.2). The stover yield ranged from 1723.66-1777.05 kg ha^{-1} among the varieties. Apparently the maximum stover weight (177.05 kg ha^{-1}) was recorded in BARI soybean-5 and the lowest (1723.66 kg ha^{-1}) was recorded in Shohag.

4.7.3. Biological yield

Biological yield differed not significantly due to varieties (Table 8.2). From the table, it is evident that the highest biological yield (3335.46 kg ha^{-1}) was obtained with the variety of BARI soybean-5 and that of lowest (3185.71 kg ha^{-1}) was observed by the Shohag variety.

4.7.4. Harvest index

Harvest index was not significantly influenced by varieties at 5% level of significance (Table 8.2). The highest harvest index (46.42%) was observed in BARI soybean-5. The second highest (46.26%) harvest index was found in Bangladesh soybean-4 and the lowest (45.38%) was obtained in Shohag.

Table 8.2. Effect of variety on yield of soybean

Variety	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Shohag	1454.05	1723.66	3185.71	45.37
Bangladesh soybean-4	1550.42	1770.83	3327.26	46.25
BARI soybean-5	1554.80	1777.05	3335.46	46.422
LSD (at 0.05)	53.30	NS	NS	NS
CV (%)	6.90	8.77	5.25	5.30

NS = Not significant

4.8. Effect of irrigation on yield contributing parameter

4.8.1. Plant height (at harvest)

Plant height was significantly influenced by time of irrigation at 5% level of significance (Table 9.1). In general, application of irrigation significantly enhanced plant height than control (without irrigation). However, the tallest plant (58.33 cm) was observed with irrigation applied at EMS+F+PD period. The shortest plant (41.01 cm) was obtained with no irrigation. The second highest (52.8 cm) plant was found to produce at irrigation applied at flowering stage which was similar with the irrigation applied at elongation of main stem stage (50.09 cm). This is result is supported by Boydak *et al.* (2004).

4.8.2. Number of branches plant^{-1}

Number of branches plant^{-1} was significant due to irrigation application. The highest branches plant^{-1} (7.80) was found with three irrigation application at EMS+F+PD period and the lowest number of branches plant^{-1} (4.8) was obtained in control treatment (without irrigation). The second highest branches plant^{-1} (6.94) was obtained with irrigation applied at pod development stage (Table 9.1). The findings in respect of number of branches plant^{-1} supported by Boydack *et al.* (2004).

4.8.3. Pod length

There was a significant difference on pod length in case of time of irrigation (Table 9.1). Irrigation applied at different times produced 6.03-32.62% higher pod length over control. The highest pod length (3.74 cm) was observed with three irrigations at EMS+F+PD applied plot. The shortest pod (2.83 cm) was obtained with control treatment (no irrigation).

4.8.4. Number of pod plant^{-1}

Number of pods plant^{-1} was significantly influenced by time of irrigation at 5% level of significance (Table 9.1). In general application of irrigation at different times significantly increased the number of pod plant^{-1} than control treatment. The highest increase (50.10%) was found to produce in three irrigation at EMS+F+PD applied treatment and the lowest increase (16.04%) was recorded in the irrigation treatment applied at elongation of main stem period. Similar trend of number of pods plant^{-1} due to times of irrigation was reported by Karte *et al.* (1983a) who noted a positive effect of time of irrigation on the production of number of pods plant^{-1}.

4.8.5. Number of seed pod^{-1}

Number of seeds pod^{-1} differed significantly due to times of irrigation (Table 9.1). Application of three irrigation at EMS+F+PD period showed the highest number (1.69) of seed pod^{-1}. The second highest number of seed pod^{-1} (1.54) recorded with irrigation treated plots (applied at flowering stage) which was statistically similar with irrigation applied at main stem elongation stage. However, control (without irrigation) plot showed the lowest (1.40) number of seed pod^{-1}. Variable effects of time of irrigation on number of seeds pod^{-1} was also supported by Svoboda (1988).

4.8.6. 100 seed weight

The effect of time of irrigation was not significant in respect of 100-seed weight (Table 9.1). The 100 seed weight recorded from irrigation applied plots ranged from 7.11 to 7.59 g. Apparently, the maximum 100-seed weight 7.59g was recorded with irrigation applied at EMS+F+PD stage treatment and the lowest (7.11g) with no irrigation treatment. This result agreed with the findings of Svoboda (1988).

Table 9.1. Effect of irrigation on plant and yield contributing parameter of soybean

Irrigation	Plant height (cm)	Branch $plant^{-1}$ (no.)	Pod length (cm)	Pod $plant^{-1}$ (no.)	Seed pod^{-1} (no.)	100 seed weight (g)
Without irrigation (control)	41.01	4.86	2.82	20.76	1.39	7.11
Elongation of main stem (EMS)	50.08	5.67	3.15	24.07	1.44	7.28
Flowering (F)	52.81	5.96	3.57	28.81	1.53	7.42
Pod development (PD)	46.28	6.94	3.41	27.26	1.49	7.52
(EMS+F+PD)	58.83	7.80	3.74	31.16	1.68	7.59
LSD (at 0.05)	4.130	0.7397	0.2132	1.483	0.092	NS
CV (%)	8.52	12.16	6.52	5.77	6.11	112

NS = Not significant

4.9. Effect of irrigation on yield

4.9.1. Seed yield

Different times of irrigation treatment had a significant influence on seed yield of soybean (Table 9.2). Application of irrigation at different times significantly increased seed yield ranged 23.94%-96.92% than the control (without irrigation). The highest increase (1035.28 kg ha^{-1}) was recorded with three irrigation at EMS+F+PD and the lowest increase (779.91 kg ha^{-1}) was found in single irrigation applied at EMS stage. However, single irrigation applied at flowering showed the second highest seed yield (1678.29 kg ha^{-1}). These results are in full compliance with those of Gaspari *et al.*

(1992), Moraru *et al.* (1988), Ramseur *et al.* (1984), who recorded increased seed yield with different times of irrigation. Seed yield increased with time of irrigation probably due to positive effect of time of irrigation for increasing number of pods plant^{-1}, number of seeds pod^{-1} and 100 seed weight as observed in the present study.

4.9.2. Stover yield

Stover yield was significantly influenced due to time of irrigation at 5% level of probability (Table 9.2). The table showed that the highest stover yield (2231.14 kg ha^{-1}) was obtained by irrigation applied at EMS+F+PD stages followed by 1828.83 kg ha^{-1} recorded with irrigation applied at flowering period. The lowest stover yield (1449.52 kg ha^{-1}) was obtained in no irrigation treatment. In general, application of irrigation significantly enhanced stover yield than control (without irrigation).

4.9.3. Biological yield

Different time of irrigation had significant influence on biological yield (Table 9.2). The highest biological yield (4342.09 kg ha^{-1}) was produced by irrigation applied at EMS+F+PD stages. The lowest (2518.13 kg ha^{-1}) biological yield was observed in no irrigation treatment. In general, application of irrigation significantly enhanced biological yield compared with no irrigation applied treatment. Irrigation application increased plant height and number of branches plant^{-1} which in turn probably contributed for higher biological yield for these treatments.

4.9.4. Harvest index

Harvest index varied significantly due to different times of irrigation treatments. The highest harvest index (48.70%) was observed by irrigation applied at EMS+F+PD period which was statistically similar with irrigation applied at flowering period (47.93%) and pod development period (46.28%). The lowest harvest index (42.42%) was observed with no irrigation treatment which was similar to irrigation applied at elongation of main stem (44.76%) stage. The results of present investigation showed higher harvest index value which was mainly due to higher seed yield in relation to biological yield (Fischer and Kertesz, 1976). Similar results were reported by Zebarth and Sheard (1992). In respect of biological yield.

Table 9.2. Effect of irrigation on yield of soybean

Irrigation	Seed yield ($kg\ ha^{-1}$)	Stover yield ($kg\ ha^{-1}$)	Biological yield ($kg\ ha^{-1}$)	Harvest index (%)
Without irrigation (control)	1068.60	1449.52	2518.13	42.42
Elongation of main stem (EMS)	1324.37	1624.22	2958.59	44.76
Flowering (F)	1678.29	1828.82	3513.12	47.93
Pod development (PD)	1423.25	1652.20	3082.12	46.27
(EMS+F+PD)	2104.28	2231.14	4342.09	48.69
LSD (at 0.05)	102.0	149.9	167.6	2.373
CV (%)	6.90	8.77	5.25	5.30

4.10. Interaction effect on yield contributing parameter

4.10.1. Plant height (at harvest)

Table 10.1. exerted significant variation on plant height due to interaction between time of irrigation and variety. The result showed that the tallest plant (61.90 cm) was found in irrigation at EMS+F+PD × Bangladesh soybean-4 treatment which was statistically similar with the interaction treatments of irrigation at flowering × Bangladesh soybean-4, irrigation at EMS+F+PD × Shohag, irrigation at EMS+F+PD × BARI soybean-5 and irrigation at elongation of main stem × Bangladesh soybean-4. However, the control irrigation showed lower level of plant height with all the three varieties. The lowest height was recoded with the treatment of no irrigation × Shohag.

4.10.2. Number of branches plant^{-1}

Significant variation was observed in number of branches plant^{-1} due to interaction effect of irrigation and variety (Table 10.1). The highest number of branches plant^{-1} (8.30) was found in irrigation applied at EMS+F+PD with BARI soybean-5. The lowest number of branches plant^{-1} (4.87) was found in no irrigation with Shohag variety. However, irrespective of varieties irrigation application increased the production of number of branches plant^{-1} than the control (without irrigation).

4.10.3. Pod length

There was a significant variation in pod length due to interaction effect of variety and time of irrigation and variety. The largest pod (3.84 cm) was found in the interaction of irrigation at EMS+F+PD × BARI soybean-5 fallowed by irrigation at EMS+F+PD

× Shohag, irrigation at flowering × BARI soybean-5, irrigation at EMS+F+PD × Bangladesh soybean-4, irrigation at pod development × BARI soybean-5 and irrigation at flowering × Shohag periods which produced statistically similar pod length with the highest one (Table 10.1).

4.10.4. Number of pod plant^{-1}

Interaction effect of irrigation and variety had significant influence on the number of pods plant^{-1} (Table 10.1). In general, irrigation application increased the number of pod plant^{-1} that was 18.60-158.41% increase over control (without irrigation) irrespective of varieties. Irrespective of irrigation application, Bangladesh soybean-4 showed higher number of pod plant^{-1} (ranged 29.23-43.00) than other two varieties Shohag (ranged 17.03-25.11) and BARI soybean-5 (ranged 16.02-25.36). Bangladesh soybean-4 produced the highest number of pods plant^{-1} (43.00) with irrigation at EMS+F+PD period and the lowest (16.02) number was recorded in BARI soybean-5 with control irrigation treatment. However, highest number of pod plant^{-1} (43.00) was counted in irrigation at EMS+F+PD × Bangladesh soybean-4 and that of lowest (16.02) was found in without irrigation × Bangladesh soybean-5.

4.10.5. Number of seed pod^{-1}

Significant influence was found on number of seeds pod^{-1} due to interaction of irrigation and variety (Table 10.1). Three irrigations at EMS+F+PD with all the varieties increased the production of number of seed pod^{-1} than control (no irrigation) as well as other irrigation × variety treatment except irrigation at flowering × BARI soybean-5 and irrigation at pod development × BARI soybean-5. However, the lowest (1.31) number of seeds pod^{-1} was counted in Shohag with without irrigation treatment.

4.10.6. 100 seed weight

The interaction effect of irrigation and variety on 100 seed weight was found significant (Table 10.1). Irrespective of irrigation treatment, significantly higher 100 seed weight was observed in Shohag (ranged 8.27-4.73g) and BARI soybean-5 (ranged 8.07-8.68g) than Bangladesh soybean-4 (ranged 5.02-5.42g). On the other hand, irrigation treatment increased seed weight than the without irrigation treatment for all the three varieties. However, the variety Shohag gave the highest 100 seed weight (8.7g) with irrigation applied at pod development period. The lowest 100 seed weight (5.10g) was found to produce in Bangladesh soybean-4 with irrigation applied at elongation of main stem.

Table 10.1. Interaction Effect of irrigation and variety on plant and yield contributing parameter of soybean

Irrigation × variety	Plant height (cm)	Branch plant^{-1} (no.)	Pod length (cm)	Pod plant^{-1} (no.)	Seed pod^{-1} (no.)	100 seed weight (g)
Without irrigation (control) × Shohag	39.30	4.86	2.91	17.03	1.30	8.26
Without irrigation (control) × Bangladesh soybean-4	44.06	4.16s	2.72	29.23	1.35	5.02
Without irrigation (control) × BARI soybean-5	39.66	5.56	2.84	16.02	1.53	8.06
Elongation of main stem (EMS) × Shohag	49.30	5.23	3.11	20.23	1.33	8.52
Elongation of main stem (EMS) × Bangladesh soybean-4	55.33	5.76	3.23	33.00	1.45	5.09
Elongation of main stem (EMS) × BARI soybean-5	45.63	6.03	3.10	19.00	1.55	8.22
Flowering (F) × Shohag	51.63	5.40	3.58	23.11	1.45	8.70
Flowering (F) × Bangladesh soybean4	58.90	6.00	3.40	40.02	1.51	5.12
Flowering (F) × BARI soyben-5	47.90	6.50	3.74	23.30	1.64	8.46
Pod development (PD) × Shohag	45.60	7.03	3.35	21.20	1.40	8.73
Pod development (PD) × Bangladesh soybean-4	50.83	6.67	3.33	38.36	1.48	5.21
Pod development (PD) × BARI soybean-5	42.43	7.13	3.56	22.23	1.60	8.62
EMS+F+PD × Shohag	58.90	7.83	3.78	25.13	1.65	8.68
EMS+F+PD × Bangladesh soybean-4	61.90	7.26	3.60	43.00	1.65	5.42
EMS+F+PD × BARI soybean-5	55.70	8.30	3.84	25.36	1.75	8.68
LSD (at 0.05)	7.15	1.28	0.36	2.56	0.15	1.39
CV%	8.52	12.16	6.52	5.77	6.11	11.30

4.11. Interaction effect on yield

4.11.1. Seed yield

The interaction effect of irrigation and variety on seed yield was significant (Table 10.2). The highest seed yield (2140.10 kg ha^{-1}) was obtained from variety BARI soybean-5 when irrigated at EMS+F+PD stages which was similar with the treatments irrigation at EMS+F+PD × Bangladesh soybean-4 (2136.38 kg ha^{-1}) and irrigation at EMS+F+PD × Shohag (2036.38 kg ha^{-1}). The lowest seed yield (1015.94 kg ha^{-1}) was obtained from variety Shohag with without irrigation applied treatment. The result indicated that the response of three varieties were different to different time of irrigation in the same location.

4.11.2. Stover yield

Significant influence was found on stover yield due to interaction of irrigation and variety (Table 10.2). Three irrigation at EMS+F+PD stages with all the varieties increased the production of stover yield than control (no irrigation) as well as other irrigation × variety treatment. However, the lowest (1430.86 kg ha^{-1}) stover yield was found to produce in BARI soybean-5 with no irrigation treatment.

4.11.3. Biological yield

The interaction effect of variety and irrigation on biological yield was found significant (Table 10.2). Higher biological, irrespective of irrigation time, was observed in BARI soybean-5 (ranged 2520.22-4412.85 kg ha^{-1}) and Bangladesh soybean-4 (ranged 2551.02-4406.93 kg ha^{-1}) than Shohag (ranged 2483.15-4206.51

kg ha^{-1}). On the other hand, irrigation treatment increased biological yield than the without irrigation treatment for all three varieties. The variety BARI soybean-5 produced the highest biological yield (4412.84 kg ha^{-1}) with irrigation applied at EMS+F+PD stages and the lowest biological yield (2483.15 kg ha^{-1}) was found in Shohag with control (no irrigation).

4.11.4. Harvest index

There was a significant variation in harvest index due to interaction effect of time of irrigation and variety (Table 10.2). The highest harvest index (48.97%) was found in BARI soybean-5 with irrigation at EMS+F+PD periods followed by irrigation at EMS+F+PD × Shohag, irrigation at flowering × Shohag, irrigation at pod development × Shohag, irrigation at elongation of main stem x Bangladesh soybean-4, irrigation at flowering × Bangladesh soybean-4, irrigation at pod development × Bangladesh soybean-4, irrigation at EMS+F+PD × Bangladesh soybean-4, irrigation at elongation of main stem × BARI soybean-5, irrigation at flowering × BARI soybean-5 and irrigation pod development × BARI soybean-5. These treatments also produced statistically similar harvest index with the highest one. The lowest harvest index (40.91%) was found in Shohag variety with control (without irrigation) treatment.

Table 10.2 interaction effect of irrigation and variety on yield of soybean

Irrigation × variety	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
With out irrigation (control) × Shohag	1015.93	1467.21	2483.15	40.91
Without irrigation (control) × Bangladesh soybean-4	1100.51	1450.50	2551.02	43.14
Without irrigation (control) × BARI soybean-5	1089.36	1430.86	2520.22	43.22
Elongation of main stem (EMS) × Shohag	1273.54	1642.70	2916.24	43.67
Elongation of main stem (EMS) × Bangladesh soybean –4	1353.06	1641.33	3024.39	44.74
Elongation of main stem (EMS) × BARI soybean -5	1346.52	1588.63	2935.15	45.88
Flowering (F) × Shohag	1563.78	1748.24	3312.03	47.50
Flowering (F) × Bangladesh soybean-4	1718.91	1837.91	3556.83	48.32
Flowering (F) × BARI soybean-5	1752.16	1900.33	3670.50	47.97
Pod development (PD) × Shohag	1380.61	1610.03	3010.64	46.16
Pod development (PD) × Bangladesh soybean-4	1443.62	1653.87	3097.13	46.60
Pod development (PD) × BARI soybean-5	1445.89	1692.71	3138.60	46.07
EMS+F+ PD × Shohag	2036.37	2150.13	4206.51	48.64
EMS+F+PD × Bangladesh soybean-4	2136.38	2270.55	4406.93	48.48
EMS+F+PD × BARI soybean-5	2140.10	2272.74	4402.84	48.97
LSD (at 0.05)	176.7	259.7	290.3	4.111
CV (%)	6.90	8.77	5.25	5.30

Chapter V

CONCLUSION

The study was carried out to find out the suitable variety and irrigation time for optimum yield of the soybean. The results are summarized below.

The rapid increase in plant height was observed from 30 DAS to 60 DAS. The variety Shohag produced the tallest plant in 30 and 45 DAS and Bangladesh soybean-4 produced the tallest plant in 60, 75 and 90 DAS. Significant variation was found in plant height for the irrigation levels. The maximum plant height was found from applied irrigation at EMS+F+PD treatment. Likewise, the plant height was found to be significant due to the interaction effect of variety and irrigation. Maximum plant height was found from the treatment combination of Bangladesh soybean-4 and applied irrigation at EMS+F+PD in 60, 75 and 90 DAS of the life cycle.

Total dry matter varied at all growth stages with different variety. BARI soybean-5 produced the highest dry matter at all growth stages. Significant variation was found in total dry matter plant^{-1} among the different levels of irrigation. Applied irrigation at EMS+F+PD treatment gave the best result in respect of dry matter.

In case of interaction effect, the treatment combination of BARI soybean-5 × EMS+F+PD produced the highest dry matter which seemed to be most effective treatment.

The highest number of leaf plant^{-1} (52.33) was found with the variety BARI soybean-5 at 60 DAS and the lowest (10.08) from the variety Bangladesh soybean-4 at 90 DAS. Maximum number of leaf was found from a plant when applied irrigation at EMS+F+PD in 60, 75 and 9o DAS. The lowest number of leaf plant^{-1} were found from control plots. On the otherhand, the interaction of BARI soybean-5 × EMS+F+PD treatment produced the maximum number of leaf plant^{-1} (76.40) at 60 DAS.

Number of branches plant^{-1} was also significantly affected by variety. BARI soybean-5 produced the highest number of branches plant^{-1} whereas Bangladesh soybean-4 produced the lowest. The applied irrigation at EMS+F+PD treatment supplied necessary soil moisture which subsequently increased the number of branches plant^{-1}. Treatment combination of BARI soybean-5 × EMS+F+PD found to be superior for producing more branches plant^{-1}.

The longest pod length (3.41 cm) was found from the BARI soybean-5 and the lowest (3.25 cm) from the Bangladesh soybean-4. Maximum pod length was found when applied irrigation at EMS+F+PD treatment. The lowest pod length were found from control plots. On the other hand, the interaction of BARI soybean-5 × EMS+F+PD produced the maximum pod length (3.84 cm).

BARI soybean-5 produced more number of seed pod^{-1} than Bangladesh soybean-4 and Shohag. Among the irrigation treatments, irrigation applied at EMS+F+PD produced the highest number of seed pod^{-1} which was statistically higher from other irrigation level (elongation of main stem, flowering and pod development) and unirrigated control. The interaction treatment of BARI soybean-5 × EMS+F+PD produced the highest number of seed pod^{-1} (1.75).

The variety BARI soybean-5 which subsequently increased the seed yield ha^{-1}. The maximum seed yield ha^{-1} was found in the variety BARI soybean-5 which was 6.93% and 0.28% higher than Shohag and Bangladesh soybean-4, respectively. Maximum seed yield ha^{-1} was found from applied irrigations at EMS+F+PD, which was 96.92% higher than the yield obtained from the control (without irrigation). In case of interaction effect, BARI soybean-5 × EMS+F+PD treatment produced the highest seed yield (2140.100 kg ha^{-1}) compared to other interaction combinations.

Among three varieties the BARI soybean-5 produced the highest stover yield. Applied irrigation at EMS+F+PD treatment produced the highest stover yield. The interaction treatment of BARI soybean 5 × EMS+F+PD produced the highest stover yield than other combinations.

The highest biological yield was obtained from the variety BARI soybean-5 and Shohag produced the lowest biological yield ha^{-1}. Among irrigation levels, applied irrigation at EMS+F+PD produced the highest biological yield ha^{-1}. The interaction effect showed BARI soybean-5 × EMS+F+PD produced the highest biological yield, whereas, Shohag × control treatment produced the lowest biological yield.

The variety BARI soybean-5 had the highest harvest index. The irrigation treatment of irrigation at EMS+F+PD produced the highest harvest index and the combination of BARI soybean-5 × EMS+F+PD treatment was found to be best for harvest index in this study.

From the present study it may be concluded that irrigation levels and variety influenced the growth, yield and yield components of soybean. Among the irrigation levels, applied irrigation at EMS+F+PD gave the best result. Out of three tested varieties BARI soybean-5 was superior in all respect. The interaction effect of BARI soybean-5 with applied irrigation at EMS+F+PD was found most effective.

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APPENDIX

Appendix I: Map showing the experimental site under study

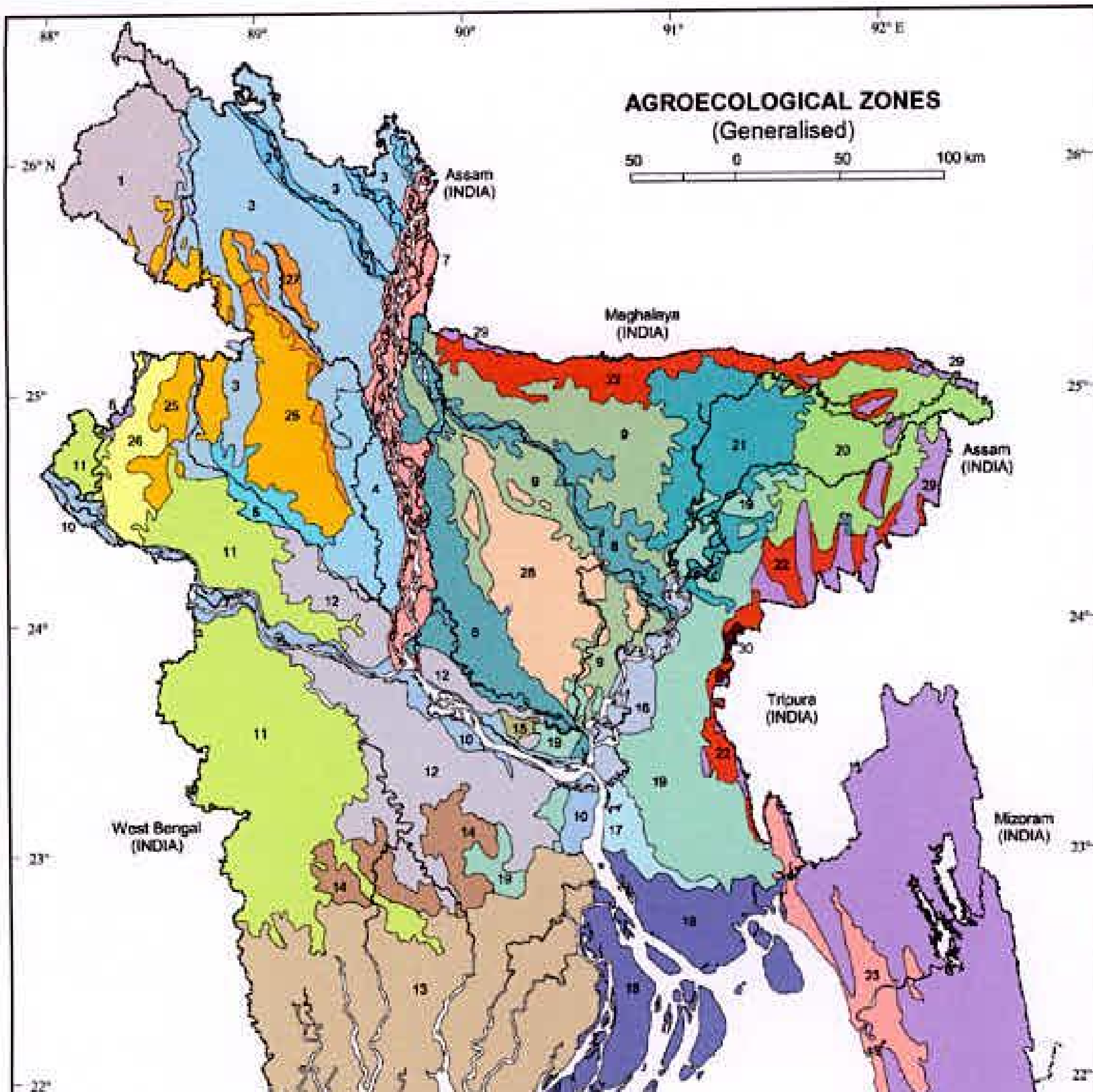

Fig. Map showing the experimental site under study

Appendix II: Physical and chemical characteristics of initial soil (0-15 cm depth)

A. Physical composition of the soil

Soil separates	(%)	Methods employed
Sand	36.90	Hydrometer methods (Day, 1995
Silt	26.40	-do-
Clay	36.66	-do-
Texture class	Clay loam	-do-

B. Chemical composition of the soil

Sl. No.	Soil characteristics	Analytical data	Methods employed
1.	Organic carbon (%)	0.82	Walkley and Black, 1947
2.	Total N (kg ha^{-1})	1790.00	Bremmer & Mulvaney, 1965
3.	Total S (ppm)	225.00	Bardsley & Lanester, 1965
4.	Total P (ppm)	840.00	Olsen and Sommers, 1982
5.	Available N (kg ha^{-1})	54.00	Bremmer, 1965
6.	Available P (kg ha^{-1})	69.00	Olsen and Dean, 1965
7.	Exchangeable K (kg ha^{-1})	89.50	Pratt, 1965
8.	Available S (ppm)	16.00	Hunter, 1984
9.	pH (1:2.5 soil of water)	5.50	Jackson, 1958
10.	CEC	11.23	Chapmen, 1965

Source: Soil Research Development Institute (SRDI)

Appendix III Monthly average of temperature relative humidity and total rainfall of the experiment site during the period from December 2005 to April 2006.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Maximum	Minimum	Mean		
2005	December	27.1	15.7	21.4	64	Trace
2006	Jan.	25.3	18.2	21.75	68	0
	Feb.	31.3	19.4	25.35	61	0
	Mar.	32.4	21.4	26.9	62	70
	April	34.4	24.1	29.25	66.5	91

Source: Bangladesh Meterological Department (climate division), Agargon, Dhaka-1212.

Appendix IV. Summary of variance (mean square value) on plant height, number of leaf plant^{-1} and dry matter

Source of variation	Degree of freedom	Plant height (cm)					No. of leaf plant^{-1}					Dry matter (g)				
		30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	3.683 NS	4.429 NS	22.592 NS	82.418 NS	19.181 NS	0.378 NS	9.475 NS	19.763 NS	9.714 NS	4.370 NS	0.028 NS	3.080 NS	0.420 NS	8.161 NS	22.796 NS
Factor A	2	15.66 *	3.873 NS	263.503 **	573.261 *	310.109 *	1.460 NS	100.918 *	127.064 *	29.704 NS	21.354 **	1.139 *	13.190 *	33.003 *	11.079 NS	10.239 NS
Error	4	2.385	10.51	8.166	63.678	16.997	0.483	7.479	15.947	16.150	0.730	0.141	0.775	1.906	7.780	5.197
Factor B	4	0.810 NS	124.3 **	778.407 **	813.411 **	548.200 **	0.819 NS	96.084 **	1877.51 **	1475.55 **	67.745 **	0.473 *	4.297 **	62.821 **	125.639 **	112.418 **
AB	8	1.128 NS	4.957 NS	13.183 NS	21.840 NS	24.379 *	1.372 NS	18.249 NS	45.258 **	116.439 **	3.133 NS	0.177 NS	0.982 *	4.823 **	0.964 NS	2.648 NS
Error	24	1.448	6.659	16.772	23.992	10.273	1.197	9.698	8.114	7.580	1.762	0.108	0.332	0.822	2.527	4.196

NS = Not significant

* = Significant at 5% level of probability

** = Significant at 1% level of probability

Factor A = Irrigation

Factor B = Variety

Appendix V. Summary of analysis of variance (mean square values) on CGR and RGR

Source of variation	Degrees of Freedom	CGR				RGR			
		45 DAS	60 DAS	75 DAS	90 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Replication	2	1.258 NS	7.554 NS	10.762 NS	9.965 NS	0.000 NS	0.000 NS	0.000 NS	0.000 NS
Factor A	2	115.187**	111.331*	265.235**	14.550*	0.001**	0.000*	0.001**	0.000 NS
Error	4	0.818	6.242	4.637	2.220	0.000	0.000	0.000	0.000
Factor B	4	35.583 **	530.862**	251.424**	12.929*	0.000**	0.001**	0.000**	0.000**
AB	8	12.738 **	71583**	88.456**	27.597**	0.000**	0.000**	0.000**	0.000*
Error	24	0.464	6.259	7.129	4.577	0.000	0.000	0.000	0.000

NS = Not significant
* = Significant at 5% level of probability
** = Significant at 1% level of probability
Factor A = Irrigation
Factor B = Variety

Appendix VI. Summary of analysis variance (mean square value) of yield attributes

Source of variation	Degree of freedom	Plant height (cm)	Branches plant^{-1} (no.)	Pod length (cm)	Pod plant^{-1} (no.)	Seed pod^{-1} (no.)	100 seed weight (g)
Replication	2	7.586 NS	2.038 NS	0.328 NS	1.437 NS	0.005 NS	3.079 NS
Factor A	2	244.734*	2.372 NS	0.099 NS	1194.894**	0.136*	55.231**
Error	4	17.720	0.629	0.104	0.382	0.008	0.666
Factor B	4	405.728**	11.714**	1.178**	149.544**	0.110**	0.329 NS
AB	8	6.260 NS	0.372 NS	0.033 NS	5.771*	0.003 NS	0.030 NS
Error	24	18.019	0.578	0.048	2.324	0.009	0.685

NS = Not significant

* = Significant at 5% level of probability

** = Significant at 1% level of probability

Factor A = Irrigation

Factor B = Variety

Appendix VII. Summary of analysis of variance (mean square values) on yield of soybean

Source of variation	Degree of freedom	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
Replication	2	8994.456 NS	91114.723 NS	106448.591 NS	26.740 NS
Factor A	2	48649.938*	12766.073 NS	106317.536 NS	4.740 NS
Error	4	5001.401	17542.788**	137662.335	5.879
Factor B	4	1390122.180**	794525.881 NS	4286814.664**	57.136**
AB	8	2085.863 NS	7123.833	15501.224 NS	1.255 NS
Error	24	10990.259	23745.355	29667.174	5.951

NS = Not significant

* = Significant at 5% level of probability

** = Significant at 1% level of probability

Factor A = Irrigation

Factor B = Variety

Plate -1: Field view of experimental plot (early stage)

Plate -2: Field view of experimental plot (without irrigation)

Plate -3: Field view of experimental crop (shohag)

Plate -4: Field view of experimental crop (Bangladesh soybean-4)

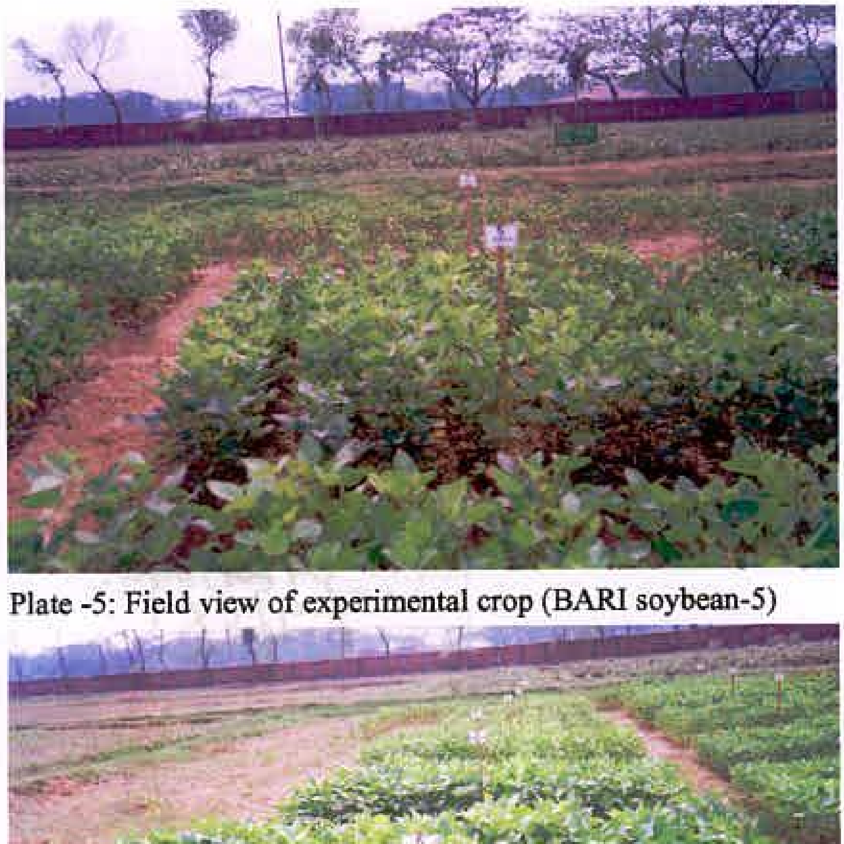

Plate -5: Field view of experimental crop (BARI soybean-5)

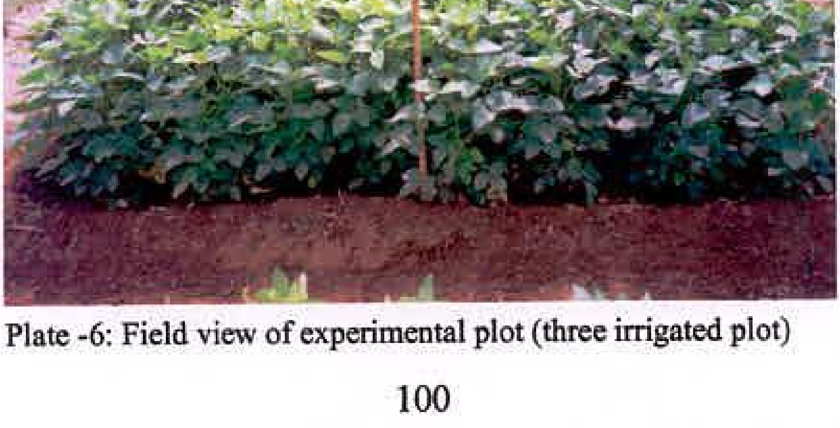

Plate -6: Field view of experimental plot (three irrigated plot)