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EFFECT OF IRRIGATION FREQUENCY ON GROWTH AND YIELD OF SOYBEAN

B. Sinha, M. Fahmida* and M. S. Rahman

Department of Agricultural and Industrial Engineering, Hajee Mohammad Danesh Science and Technology University, Dinajpur. Bangladesh
*Corresponding author: Email: maisha.fahmida@hstu.ac.bd ; Cell phone: +8801737415041
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ABSTRACT

A field experiment was conducted at the research field of HSTU, Dinajpur during November 2019 to March 2020 to find out the effect of irrigation frequency on the growth and yield of Soybean (*Glycine max* L.) cv. BARI Soybean-6. The experiment was carried out with a RCBD with four replications of irrigation treatments viz, $I_{0=}$ no irrigation (control), $I_{1=}$ one time at 20 days after sowing (DAS), $I_{2=}$ two times (20 and 40 DAS), $I_{3=}$ three times (20, 40, and 60 DAS). At 105 DAS the highest plant height (52.53 cm) was found from I_2 treatment and the shortest plant (45.82 cm) from I_0 treatment. The highest (5.91) leaf area index was obtained from the treatment of three irrigation (I_3) at 90 DAS and the lowest (5.1) leaf area index from the control (I_0). At the 90 DAS highest nodule number (9.208) and the lowest nodule number was (6.459) recorded from I_3 and I_0, respectively. The highest (90.09 g) fresh weight was obtained from the treatment I_2 at 90 DAS and the lowest (65.64 g) was recorded in I_0. I_3 produced the highest amount of dry matter of (29.50 g) and the lowest amount of dry matter production at harvest (20.67 g) in I_0 treatment. The highest seed yield was observed from I_2 (1.638 t ha^{-1}) which was statistically similar with I_3 whereas, the lowest obtained from I_0 (1.075 t ha^{-1}). The highest small stover yield was obtained from I_3 (1.759 t ha^{-1}) which is statistically similar to I_2 (1.754 t ha^{-1}) whereas the lowest was observed from I_0 (1.540 t ha^{-1}) which was statistically similar to I_1 (1.566 t ha^{-1}). The highest biological yield was found from I_2 (3.425 t ha^{-1}) which is statistically similar to I_3 and the lowest was obtained from I_0 (2.56 t ha^{-1}). The maximum harvest index was found from I_2 (47.71 %) and the minimum was obtained from I_0 (40.81 %). I_2 treatment showed more significant results than the other treatment I_0, I_1 and I_3. So, two times irrigation showed significant effect showed the highest yield of 1.638 t $ha^{-1.}$

Keyword: Irrigation, frequency, growth, soyabean, treatment, yield

INTRODUCTION

Soybean (*Glycine max* L.) Merrill) belongs to the family Fabaceae. It is one of the major oil seed crop as well as pulse crop of the world. Among the legume crops soybean contains the highest amount of protein and a good amount of other nutrients like calcium, phosphorus, iron, and vitamins with about 40 % proteins (Maphosa and Victoria 2016). The oil content of soybean is about 20 % while all other pulse contains about 1-2 % oil (Clemente and Cahoon 2009). It can be used as a pulse crop, can also be used for making nutritious food items like soya dal, soya khechuri, soya pollao, soya bori, soya biscuits, soya bread etc. (Mondal and Wahhab 2001). The

average seed yield of soybean at research level in Bangladesh is about 2.25 t ha^{-1} which is comparable to the world average yield of 3.5 metric tons (FAO 2003). The crop is cultivated about 130 million hectares of land and annual production is approximately 1100 metric tons in the world (FAOSTAT 2022). Soybean is grown in almost all parts of the world for human consumption, industry and animal feed (Boydak *et al.* 2002). It is the most important grain legume of the world and a new prospective crop for Bangladesh (Rahman *et al.* 2011). Soybean seed contains 40-45 % protein, 20-22 % oil, 20-26 % carbohydrate and a high amount of Ca, P and vitamins (Rahman *et al.* 2011). Malik *et al.* (2006) depicted that soybean oil is consisted of 85% cholesterol free unsaturated fatty acids. Per hectare yield of soybean in Bangladesh is only 1.2 t (BARI 2007) as compared to other soybean producing countries of the world like USA with seed yield of 3.5 t (James *et al.* 1999). Yield of soybean may be attributed to a number of reasons, viz., unavailability of seeds of high yielding varieties with good quality, delayed sowing, fertilizer management, disease and insect infestation, improper or limited irrigation facilities, weeds and others stress condition. Water stress imposed during pre-flowering and flowering stage reduced yield of soybean by 28 % and 24 % respectively (Gunton and Evenson 1980). Similarly various soybean cultivars show varying sensitivity to drought at their different developmental stages (Momen *et al.* 1979). Hao *et al.* (2003) conducted experiments to find out effects of irrigation and found that dry matter accumulation significantly increased with irrigation application. Irrigation and variety can play important role to increase yield of soyabean. Shortening of grain filling period due to water stress (Nakasathien *et al.* 2000). Montoya *et al.* (2017) found supplemental irrigation during the reproductive stage (R1–R8) was a positive effect on soybean growth. Reduction in leaf area reduces crop growth and thus affects biomass production (Brown *et al*. 1985). The total water requirement for maximum productivity varies between 450 and 800 mm, depending on weather conditions, crop management practices and cycle timing (Embrapa 2011). Field experiment was conducted during 2016 up to 2018 to determine the optimal irrigation regime of soybean (Glycine max L.) at Jimma Agricultural Research center under five irrigation treatments (Irrigation at 60% ASMDL, 80% ASMDL, ASMDL, 120% ASMDL and 140% ASMDL) (Admasu *et al.* 2019). For all these, objective of this experiment was to find the effect of irrigation frequency on growth and yield of soyabean with parameters like plant height, leaf area index, nodule production, total dry matter, harvest index, stover yield and biological yield.

MATERIALS AND METHODS

A field experiment was conducted at Research Field and Laboratory at HSTU during November 2019 to March 2020. Soil characteristics of experiment site at a depth of 0-15 cm were analyzed at the Regional Laboratory of Soil Resources Development Institute (SRDI), Dinajpur. Its field duration was about 100-110 days. The soil was sandy loam. Seed yield is about 1.80-2.10 t ha^{-1} (BARI 2011)**.** Four irrigation treatment was designed with four replications to find its effect.

Treatments: Here, I_0 = No irrigation, I_1= One irrigation at 20 days after sowing (DAS), I_2= Two irrigation at 20 days after sowing (DAS) and 40 days after sowing DAS, I_3= Three irrigation at 20 days after sowing (DAS), 40 days after sowing (DAS) and 60 days after sowing (DAS).

The experiment was laid out in RCBD design with four irrigation replications. The size of the individual plot was 4 m × 2.5m and total numbers of plots were 16. There were 4 treatments and 4

replications combinations. Each block was divided into 4-unit plots. Layout of the experiment was done in inter plot spacing of 0.50 m and inter block spacing of 0.75 m.

Land and seedlings preparation: The land of the experimental field was first opened on November 10, 2019 with a power tiller and exposed to the sunshine for 7 days. All the fertilizers were applied at BARI recommended dose as 60 kg ha^{-1} Urea, 175 kg ha^{-1} TSP, 120 kg ha^{-1} MOP, 115 kg ha^{-1} Gypsum (BARI 2007). Seeds were treated with Vitavex-200 @ 0.25% before sowing to prevent seeds from the attack of soil borne disease. Seeds were sown as per treatments of the experiment in 10 cm apart rows. The soybean plants were infested by hairy caterpillars (*Dlaerisia oblique*) and cutworm at early growth stage which was controlled by applying Sumithion 50 EC @1.01 ha^{-1}.Five sample plants were collected randomly from each plot.

Harvesting: The plants of central 1 m^2 area were harvested by placing quadrate for recording yield data. Seeds were separated from the stover by hand machine and rubbing. After proper drying of seeds to a moisture content of 12 % were kept in polythene bags. Dried seeds and stover was weighed.

Crop growth parameters

The height of plants, leaf area index, fresh weight, dry weight, number of nodules was recorded at 30, 45, 60, 75, 90 and 105 DAS. The fresh weight and dry weight of the samples was weight using a sensitive digital electric balance. Three plants were collected randomly from the inner rows of each plot and dried separately for 72 hours in an electric oven set at 60^0C. All the pods of the preselected 3 sample plants in each plot were counted and averaged them to have pods $plant^{-1}$. One thousand sun dried cleaned seeds were counted randomly and weighted.

Yield and harvest index

Seeds obtained from harvested 1m^2 area of each unit plot were dried in the sun and weighed. Grain moisture content was measured by using digital moisture meter. Biological yield was calculated by using the following formula: Biological yield= Grain yield + straw yield.

Harvest index is the relationship between grain yield and biological yield. It was calculated by using the following formula: HI (%) $=\frac{\text{Grain Yield}}{\text{Biological Yield}} \times 100$

Statistical analysis

The data obtained for different characters were statistically analyzed following the analysis of variance techniques by using MSTAT-C computer package program. This was used to develop an integrated microcomputer program that will assist agricultural scientists in most of the steps involved in doing agricultural research-that is to generate experimental designs, manage and transform data, and analyze experiments from both a biological and economical perspective. The significant differences among the treatment means were compared by Duncan's Multiple Range Test (DMRT) at 5 % level of probability (Gomez and Gomez 1984). It is a post hoc test to measure specific differences between pairs of means.

RESULTS AND DISCUSSIONS

Crop growth parameters (Plant height)

The significant result was found in plant height of soybean by the irrigation date at different growth stages figure 1. At 30DAS I_2 produced the taller plant (14.20 cm) and I_0 produced similar (12.34 cm). At 105 DAS I2 produce taller plant (52.35 cm) and I_0 produce lowest plant height (45.82 cm).

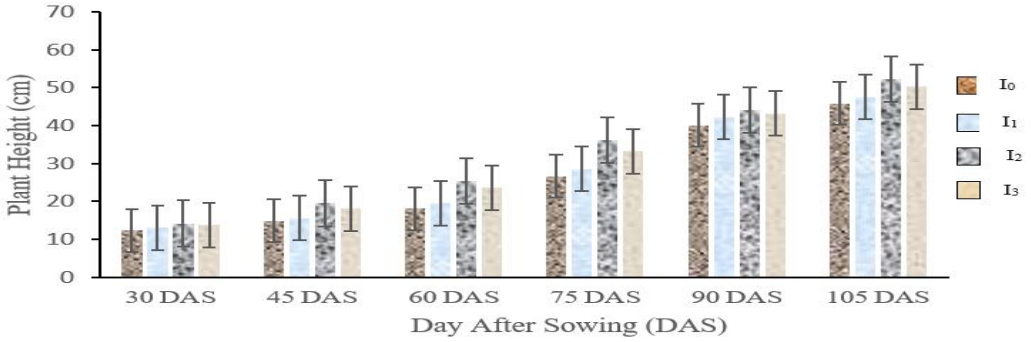

Figure 1. Effect of irrigation on plant height (cm) of soybean at different days after sowing **(**SE =0.3464, 0.7321, 0.8827, 1.411, 1.465 and 4.342 at 30, 45, 60, 75, 90 and 105 DAS, respectively

Kazi *et al.* (2002) conducted an experiment to study the impact of irrigation frequencies and observed that the growth and yield components are significantly affected by irrigation frequencies. Maximum plant height and more branches per plant were found with the application of 6 irrigations followed by 5 replications, whereas, lowest number of irrigations decreased the traits adversely.

Leaf area index

Leaf area or the surface area of green leaves produced by soybean plants per unit area of land was taken as an index of leaf area development. Leaf area index were estimated measuring the length and width of leaf and multiplying by a factor of 0.75 followed. The highest (5.91) leaf area index was obtained I_3 at 90 DAS and the lowest (5.1) leaf area index was recorded from I_0. This result agrees well with (Hao *et al.* 2003) who reported that the leaf area index significantly increased with irrigation application.

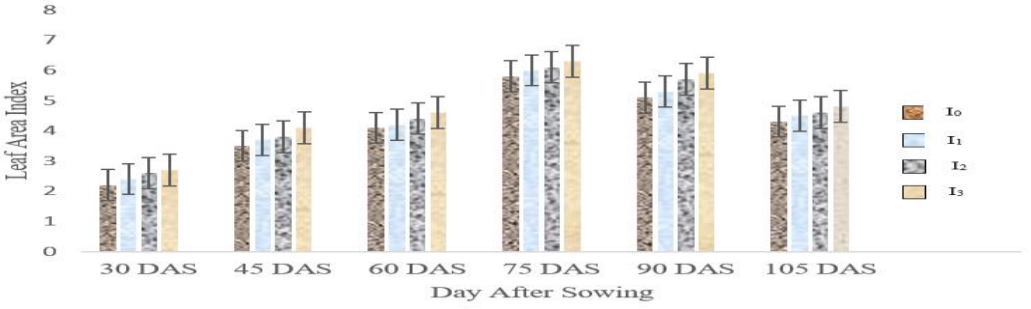

Figure 2. Effect of irrigation on leaf area index of soybean at different days after sowing (SE= 0.08175, 0.08566, 0.1032, 0.09047, 0.07350 and 0.1156 at 30,45, 60, 75, 90 and 105 DAS)

Nodule production

At the 90 DAS number of nodule is increased at the highest pick. Again, during harvest time it reduces to the starting level. In 30 DAS highest nodule number I_2 (3.41) which is statistically similar to I_3, I_1 and lowest nodule number in I_0 (2.035). In 90 DAS nodule number I_3 (9.208) and lowest nodule number I_0 (6.459).

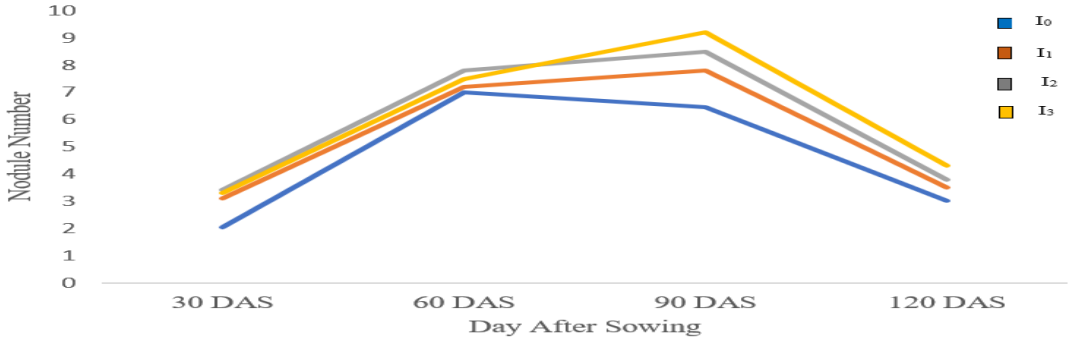

Figure 3. Effect of irrigation on nodule production of soybean at different days after sowing **(**SE =0.3040, 0.6936, 0.6774, 0.3277 at 30, 60, 90 and 120 DAS respectively).

Fresh weight

The fresh weight of the sample was taken using a sensitive digital electric balance. The mean weight was calculated and expressed in g plant^{-1}. Effect of irrigation method had significant influenced on the fresh weight of at different days after sowing figure 4. In 30 DAS the fresh weight was obtained same. In 60 DAS the highest value of the fresh weight got in I_3 (25.56 g). The highest (90.09 g) fresh weight was obtained from the treatment I_2 at 90 DAS and the lowest (65.64 g) fresh weight was recorded in I_0. This result supported well with Shahidullah *et al*. (1979) who reported that the nodules number significantly increased with irrigation application.

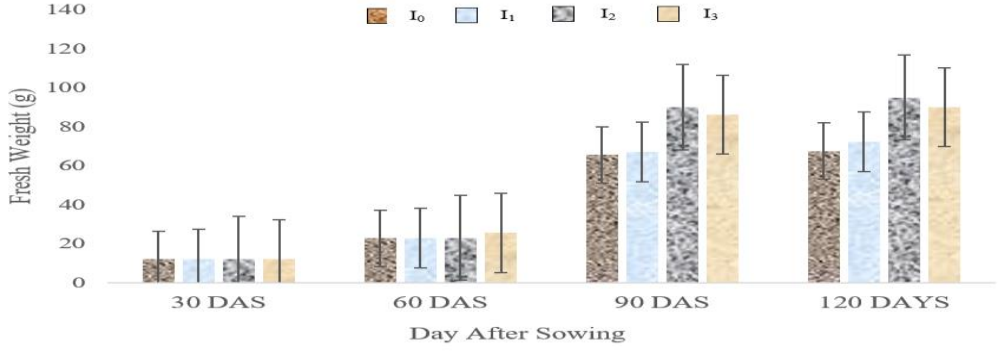

Figure 4. Effect of irrigation on fresh weight (g) of soybean at different DAS.

Total dry matter production

Total dry matter production (TDM) indicates the production potentials of a crop and high at first perquisite. Figure 5 shows in 60 DAS the highest value of the dry weight got in I_3 (8.57 g) and the lowest dry weight got from I_0 (6.56 g). At 90 DAS I_3 were produced higher amount of dry matter (29.50 g) and 20.67 g in I_0 treatment.

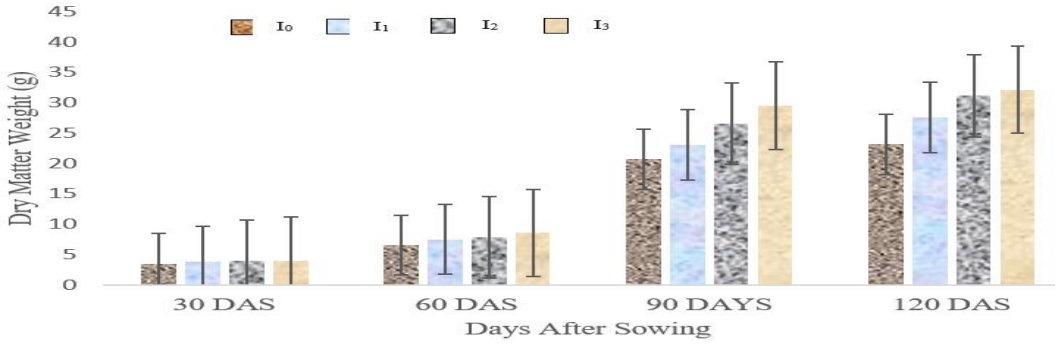

Figure 5. Effect of irrigation on total dry matter weight (g plant^{-1}) of soybean at different DAS.

Yield contributing characters

The pod length varied due to irrigation shown in Figure 6 and found I_2 treatment produced longer (3.057 cm) pod. The highest number of filled pod plant^{-1} (20.67) was observed from I_3 and the lowest was found in I_0 (12.83). Kazi *et al.* (2002) conducted an experiment to study the impact of irrigation frequencies and observed that the Filled Pods Plant^{-1} significantly affected by irrigation frequencies. The maximum number of seed pod^{-1} (32.30) was found from I_3 and the minimum number of seed plant^{-1} (15.75) at I_o. Hao *et al.* (2003) conducted experiments and found that increased with irrigation application. The maximum 1000 seed weight (103.9 g) was found from I_3 and the minimum 1000 seed weight (99.69 g) was produced from I_0. Mean separation was done using LSD at 5% probability level.

Table 1. Effect of irrigation on yield contributing characters of soybean

Treatment	Filled Pods Plant^{-1}	Length of Pod	No. of Seed Pod^{-1}	1000-seed weight (g)
I_0	12.83 b	3.027 a	15.75 c	99.69 b
I_1	13.87 b	3.032 a	18.50 b	102.5 a
I_2	19.98 a	3.057 a	31.87 a	102.8 a
I_3	20.67 a	3.045 a	32.30 a	103.9 a
LSD	1.078	0.1045	1.856	1.535
CV%	43.78	21.46	45.38	12.20

Mean with the same letter are not statically significant, LSD = least significant difference, CV= Coefficient of Variation

Yield and harvesting index

The maximum yield of soybean (1.638 t ha^{-1}) was from I_2 and the minimum yield of soybean (1.075 t ha^{-1}) was produced from I_0. Kazi *et al.* (2002) also reported that the maximum seed yield was found superior with the application of 3 irrigations followed by 2 irrigations, whereas, the lowest number of irrigations decreased all the traits adversely. Constable and Heam (1984) found irrigations during late flowering and pod filling in soybean was necessary to ensure maximum seed yield (up to 305 t ha^{-1}).

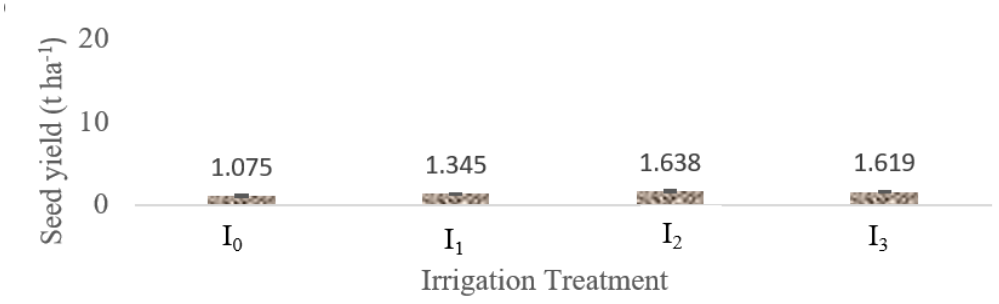

Figure 6. Effect of irrigation on seed yield (t ha^{-1}) of soybean at different days after sowing

Stover yield

The highest Stover yield was obtained from I_3(1.759 t ha^{-1} which is similar to I_2(1.754 t ha^{-1}) whereas the lowest was observed from I_0 (1.540 t ha^{-1}) and I_1 (1.566 t ha^{-1}). Norwal and Malik (1986) found that stover yield significantly increased with irrigation.

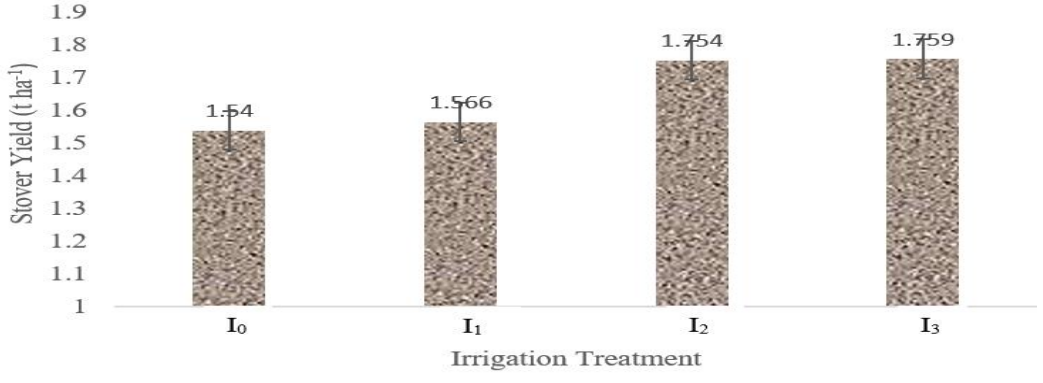

Figure 7. Effect of irrigation on Stover yield (t ha^{-1}) at different days after sowing.

Biological yield

Irrigation frequency had significant effect on biological yield. The highest biological yield was found yield was found from I_2 (3.425 t ha^{-1}) which is statistically similar to I_3 and the lowest was obtained from I_0 (2.56 t ha^{-1}). Shahidullah *et al.* (1979) who reported that biological yield significantly increased with optimum irrigation frequency.

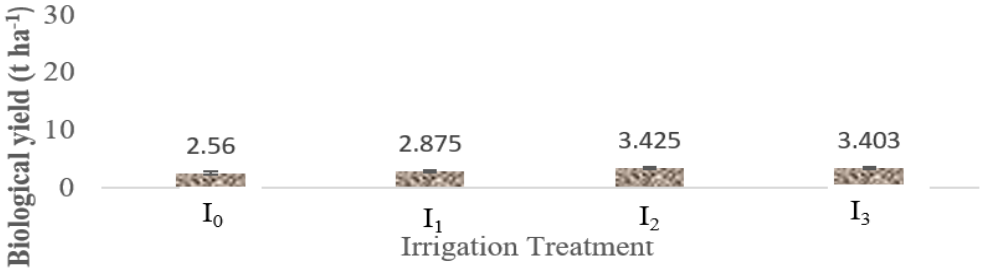

Figure 8. Effect of irrigation on biological yield (t ha^{-1}) of soybean at different days after sowing.

Harvest index

Irrigation shows significant effect on harvest index. Numerically the highest harvest index was observed from I_2 (47.71 %) which is statistically similar to I_3 and minimum was found in I_0 (40.81 %).

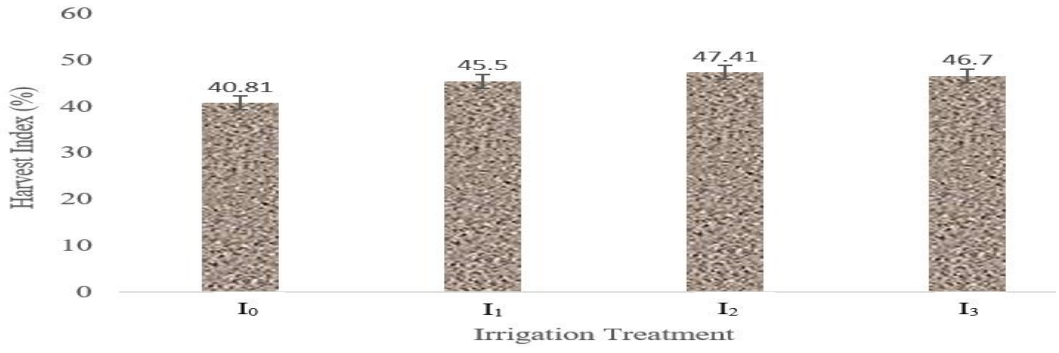

Figure 9. Effect of irrigation on harvest index (%) of soybean at different days after sowing.

CONCLUSION

The experiment was carried out with a split plot design with four replications of irrigation treatments. Data were analyzed using MSTAT-C computerized package program. The mean differences among the treatments were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance. From the overall result, the tallest plant and highest fresh weight was obtained from I_2 treatment. The highest leaf area index, higher amount of dry matter and height nodule number was obtained from I_3 at 90 DAS. Results showed that the highest seed yield was

observed from I_2 and lowest was in I_0 treatment. From the obtained result, there is a significant difference among treatments on soybean grain yield and water productivity. water scarcity is the most critical constraint for the development of agriculture in arid and semi-arid climates. Hence, effective use of available water with appropriate irrigation scheduling has a significant implication on irrigated agriculture and overall crop production.

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