ORIGINAL RESEARCH

Response of Soybean [*Glycine max* (L.)Merrill] to Irrigation at Different Growth Stages

SA Jaybhay [1]*, Philips Varghese[2], SP Taware[3], BD Idhol[4], BN Waghmare[5], DH Salunkhe[6]

10.18805/ag.D-4932

Abstract

A field experiment was carried out in rainy seasons of 2009, 2010 and 2011 to study the effect of irrigation schedules on yield, water use efficiency and other traits in soybean. Seven irrigation schedules consisted of irrigations at seedling stage (15–20 days after sowing), flower initiation stage, seed filling stage (20 days after flower initiation) and four different combinations of these 3 stages. Irrigation at flower initiation + seed filling stages produced the highest seed yield (3221 kg/ha). Maximum average values for seed index (14.59 g) and harvest index (50.87%) were recorded in this treatment. This treatment also recorded maximum net returns (₹ 44028/ha) followed by irrigation at seedling + flower initiation + seed initiation stages (₹ 42046/ha) and flower initiation stage (₹ 41880/ha). Control (no irrigation) had maximum water use efficiency (84.85 kg/ha/cm) followed by irrigation at flower initiation stage (83.30 kg/ha/cm). Studies indicated that irrigation to the soybean crop at flower initiation and seed filling stages helps to obtain the optimum yield and earn maximum net returns.

Keywords: Critical growth stages, Irrigation schedules, Seed yield, Water use efficiency.

Agricultural Science Digest (2019)

Introduction

Increase in the area under soybean (*Glycine max* (L.) Merrill) crop in Maharashtra state is due to awareness of the importance of this crop, good market rates and establishment of soybean processing industries. Maharashtra ranks second at all India level after Madhya Pradesh in terms of area, production, and productivity while India ranks at a fifth position at the global level. However, the productivity of soybean in India (1.12 t/ha) is low as compared to the world (2.86 t/ha) average productivity (AMIS, FAO 2019). There are several factors responsible for this gap in productivity.

Growing of soybean under rainfed conditions during *Kharif* season is one of the major factors resulting in low productivity. This crop is sensitive to moisture stress at different growth stages, and stress at any critical stages reduces the yield. Drastic yield reduction was reported by Muchow and Sinclair (1986) when there was moisture stress during seed filling stage. For judicious use of irrigation water, it is necessary to know the effect of irrigation at different growth stages on the yield of the crop as well as water use efficiency. However, there is meager information on this aspect under Maharashtra conditions for soybean hence; the present study was undertaken with the objectives to assess the response of soybean crop to irrigation at different critical growth stages, its effect on yield and its attributes, and its economics of production.

Materials and methods

An experiment was conducted during three rainy seasons (June to October) of 2009, 2010 and 2011 years in vertisol soil with 7.4 pH at Institute's research farm by using the seed of recently released soybean variety 'RKS 18'. The field experiment with net plot size 5 x 2.27 mL. was laid in randomized block design (RBD) with three replications, comprising the treatments viz., T_1: Irrigation at seedling stage, T_2: Irrigation at flower initiation stage, T_3: Irrigation at seed filling stage, T_4: Irrigation at seedling + flower initiation stage, T_5: Irrigation at seedling + seed filling stage, T_6: Irrigation at flower initiation + seed filling stage, T_7: Irrigation at seedling + flower initiation + seed filling stage and T_8: Control (no irrigation). Row to row and plant to plant distance was maintained at 45 cm and 5 cm, respectively. The basal dose of 20 kg N + 80 kg P_2O_5+ 20 kg K_2O per hectare was applied through di-ammonium phosphate, single super phosphate and muriate of potash, respectively. The crop was grown following all recommended package of practices. Irrigation was provided as per scheduled irrigation treatment maintaining 6 cm depth of the water during all three years. Irrigation as per schedule was not given when there was more than 40 mm rainfall within a week before the scheduled date of irrigation. The data were recorded on growth, yield and yield attributes like plant height (cm),

[1-6]Genetics and Plant Breeding Group, MACS Agharkar Research Institute, Pune, Maharashtra, India

Corresponding Author: SA Jaybhay, Genetics and Plant Breeding Group, MACS Agharkar Research Institute, Pune, Maharashtra, India, e-mail: sajaybhay@aripune.org

How to cite this article: Jaybhay, S. A., Varghese, P., Taware, S. P., Idhol, B. D., Waghmare, B. N., & Salunkhe, D. H. (2019). Response of Soybean [*Glycine max* (L.) Merrill] to Irrigation at Different Growth Stages. Agri Sci Diges, 39(2):132-135.

Source of support: Nil

Conflict of interest: None

Submitted: 17/04/2019 **Accepted:** 04/06/2019

number of branches per plant, number of pods per plant, biological yield (kg/ha) and seed yield (kg/ha). Seed index (100 seed weight [(g)] of the harvested seeds from each plot was determined by drying the seeds under a temperature of 30–40°C until its weight became stable, the obtained values recorded as seed index values in grams (Zhang *et al*. 2015), Similarly, harvest index (%) was determined by dividing the seed yield with biological yield and multiplying it with 100. The oil content of individual seed sample was determined by using NMR 4000 Analyzer (Oxford, UK). Water use efficiency (kg/ha/cm) was determined by using formula given by Irmak (2011)and Jensen (1983) as: WUE (kg/ha/cm) = Crop yield (kg/ha) / Water required or used in the field (cm). The rainfall during cropping season was 468.3, 298.9 and 300.9 mm in 2009, 2010 and 2011, respectively. The data on Economics of the treatments was calculated in terms of net returns, by multiplying the seed yield of soybean (kg/ ha) with prevailing market price (₹/kg) minus cost of cultivation of soybean (₹/ha). Benefit: cost ratio was computed by dividing the gross returns (₹/ha) with the cost of cultivation (₹ /ha). Data were analyzed using standard variance techniques given by Gomez and Gomez, (1984).

Results and discussion

Growth Attributing Characters

The pooled data for three years (Table 1) show that the growth characters were significantly influenced by the irrigation schedule except for the number of branches per plant. Plant height was significantly highest in T_7 (irrigation at seedling + flower initiation + seed filling stages) and was at par with T_6 (irrigation at flower initiation + seed filling stages). Better plant height in these treatments can be attributed to the availability of sufficient water at seedling, flower initiation, and seed filling stages of crop growth. The results coincide with the findings of Aslam *et al*. (2002) and Kazi *et al*. (2002) who also observed a significant difference in plant height due to irrigation application at different growth stages of soybean. Similarly, in other studies, it was reported that irrigation at the important critical growth stages significantly enhanced the growth attributes like plant height compared to control (no irrigation) and stressed crop at different stages of growth (Korte *et al*. 1983 and Kadhem *et al*. 1985).

Yield and Yield Attributing Characters

Number of pods per plant, seed yield, seed index (weight of 100 seeds in grams) and harvest index were significantly influenced by irrigation schedules at different growth stages of the crop (Table 1). A number of pods per plant are an important attribute for determining the yield of legume crops. Data revealed significantly the highest number of pods per plant (35.3) when the crop was irrigated at seedling + flower initiation + seed filling stages (T_7) and it was significantly at par with irrigation at seedling + flower initiation stage (T_4) and flower initiation + seed filling stage (T_6). A maximum number of pods per plant in above treatments of irrigation could be ascribed to better growth and accumulation of more photosynthesis as a result of an adequate supply of water at the critical growth stages of the crop. These results are in corroboration with the findings of Meena *et al*. (2014) and Ali *et al*. (2009). Soybean crop irrigated at flower initiation + seed filling stages (T_6) produced maximum seed yield (3221 kg/ha) and was found at par with irrigation at seedling + flower initiation + seed filling stages (3138 kg/ha). All the seven irrigation treatments recorded significantly higher seed yield than control (2833 kg/ha). Availability of the optimum water for completion of growth, reproductive stages, and metabolic activities is the key yield-determining factor. The differences in the seed yield under various treatments might be due to the difference in a number of pods per plant produced and seed weight (seed index) observed. Higher seed yield under

Table 1: Effect of irrigation schedules on growth, yield and its attributes (three year's pooled data)

Treatment	*Plant height (cm)*	*Branches/ plant*	*Pods/ plant*	*Seed yield (kg/ha)*	*Seed index (g)*	*Harvest index (%)*
T_1: Irrigation at seedling stage	58.69	3.2	30.7	2921	13.96	48.13
T_2: Irrigation at flower initiation	62.58	3.1	31.3	3079	13.60	49.96
T_3: Irrigation at seed filling	60.42	3.2	33.0	3045	14.58	48.47
T_4: Irrigation at seedling + flower initiation	63.04	3.4	33.9	2989	14.14	47.16
T_5: Irrigation at seedling + seed filling	61.53	3.2	33.0	3083	14.31	49.55
T_6: Irrigation at flower initiation + seed filling	62.76	3.3	34.2	3221	14.59	50.87
T_7: Irrigation at seedling+ flower initiation+ seed filling	64.83	3.4	35.3	3138	14.55	47.74
T_8: Control (no irrigation)	58.53	2.9	29.2	2833	13.68	47.76
SE (m) +	1.55	0.23	1.42	71.74	0.32	1.16
CD (p = 0.05)	2.22	NS	2.04	102.6	0.46	1.66

Table 2: Three year's pooled data on quality, water use efficiency and economics of soybean

Treatment	Oil content (%)	Oil yield (kg/ha)	Water applied (cm)	Total water use (cm)	Water use efficiency (kg/ha/cm)	Net returns ₹/ ha	Benefit: cost ratio
T_1: Irrigation at seedling stage	18.69	543	6.00	36.14	80.85	39404	2.80:1
T_2: Irrigation at flower initiation	18.78	578	6.00	36.96	83.30	41880	2.96:1
T_3: Irrigation at seed filling	18.61	563	6.00	37.06	82.16	40989	2.87:1
T_4: Irrigation at seedling+ flower initiation	18.47	550	6.00	39.87	74.98	39732	2.82:1
T_5: Irrigation at seedling+ seed filling	18.65	572	6.00	39.60	77.87	41255	2.86:1
T_6: Irrigation at flower initiation+ seed filling	18.65	598	6.00	40.25	80.03	44028	2.99:1
T_7: Irrigation at seedling+ flower initiation+ seed filling	18.52	578	6.00	43.40	72.30	42046	2.87:1
T_8: Control (no irrigation)	18.60	524	-	33.38	84.85	37342	2.76:1
SE (m) +	0.16	15.93	-	-	4.86	-	-
CD (p = 0.05)	NS	22.54			6.01	-	-

treatment flower initiation + seed filling stages and seedling + flower initiation + seed filling stages might be attributed due to the supply of optimum water during the various growth stages of the soybean crop. These results are in the conformity with the findings of Rahul *et al*. (2009) and Zou *et al*. (2017). Seed index was significantly low in control (T_8), irrigation at seedling stage (T_1) and flower initiation stage (T_2) than irrigation at the seed filling stage. The reduction in seed index might be due to the adverse effect of water stress on seed development at the seed filling stage. These results are in accordance with the findings of Ali *et al*. (2009). Maximum average seed index and harvest index were recorded in irrigation at flower initiation + seed filling stages (T_6).

Water Use Efficiency (WUE)

Soybean crop irrigated at different growth and reproduction stages recorded different water use efficiencies (Table 2). The control (no irrigation) recorded highest water use efficiency (84.85 kg/ha/cm) and was at par with irrigation at seedling stage (T_1), flower initiation (T_2), seed filling (T_3) and flower initiation + seed filling stages (T_6). The water use efficiency values of soybean crop increased by an increase in deficit irrigation treatments, i.e., in control and in rest of the treatments to which irrigation applied only at one critical growth stage. These results are in agreement with those of Ahmed and Mahmoud (2015) and Yaseen *et al*. (2014) who mentioned that increasing irrigation levels did not increase the water use efficiency (WUE). Irrigating the crop at flower initiation and seed filling stages resulted in maximum seed yield per unit of irrigation water applied, i.e., water use efficiency. These findings are in the conformity with the results of Demirtas *et al*. (2010).

Quality and Economic Aspects

Irrigation at different stages of growth had no significant effect on the oil content of soybean grains (Table 2). However, oil yield (kg/ha) was significantly influenced by irrigation schedules and maximum oil yield (598 kg/ha) was obtained with irrigation at flower initiation + seed filling stages (T_6). This was mainly due to a significant increase in seed yield in this treatment. The economics of the study revealed that the soybean crop irrigated at flower initiation + seed filling stages (T_6) recorded highest net returns (₹ 44028/ha and benefit: cost ratio 2.99:1) and it was followed by the treatment (T_7): irrigation at seedling + flower initiation + seed filling stages (₹ 42046/ha and benefit: cost ratio 2.87:1). Values for net returns (₹ 37342/ha) and benefit: cost ratio (2.76:1) was least under control (T_8) treatment owing due to low seed yield as the result of water stress during the critical growth stages of soybean.

From the experimental results, it can be concluded that flower initiation and seed filling stages are the critical growth stages of the soybean crop. Irrigations if applied when there is water stress condition at these stages will result in increasing seed yield of soybean and consequently good net returns per hectare can be obtained.

Acknowledgments

Authors are grateful to ICAR-Indian Institute of Soybean Research, Indore for funding and to Director, Agharkar Research Institute, Pune for facilities.

References

Ahmed, M.A., El-Sherif, and Ali, M.M.. (2015) Effect of deficit irrigation and soybean/maize intercropping on yield and water use efficiency. Int. J. Curr. Microbiol. App. Sci.4(12): 777-794

Ali A, Muhammad T, Muhammad A N, Asif T, Muhammad A, Allah W and Jami-Ur-Rehman. (2009). Effect of different irrigation management strategies on growth and yield of soybean. Pak. J. Life & Soc. Sci.7 (2): 181-4.

AMIS (Agricultural Market Information System), FAO, February 2019.

Aslam M, Naseer A, Khan and Siddique M. (2002). Soybean seed yield and its components as affected by different irrigation regimes at different reproductive stages. Pak. J. Agric. Res. 17(4): 309-13.

Demirtas C, Yazgan S, Candogan B N, Sincik M, Büyükcangaz H and Göksoy A T. (2010). Quality and yield response of soybean (Glycine max L. Merrill) to drought stress in sub–humid environment. African J. Biotech. 9(41): 6873-81.

Gomez KA and Gomez AA. (1984). Statistical Procedure for Agricultural Research, John Willey and Sons, New York.

Irmak Suat, Odhiambo Lameck O, Kranz William L and Eisenhauer Dean E. (2011). Irrigation Efficiency and Uniformity, and Crop Water Use Efficiency. Bio. Sys. Eng. 451. https://digitalcommons.unl.edu/biosysengfacpub/451

Jensen M E. (1983). Design and operation of farm irrigation systems. ASAE, Michigan, USA. pp. 827.

Kadhem F A, Specht J E and Williams J H. (1985). Soybean irrigation serially timed during stages R1 to R6. II. Yield component responses. Agron. J. 77:299-304.

Kazi B R, OadF C, Jamro V L, Jamil A and Lakho A A. (2002). Effect of irrigation frequencies on growth and yield of soybean.J. App. Sci.2(6): 661-662.

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

Meena D S, Narolia R S, Baldev Ram, Mahawar R K, Pratap Singh and Choudhary H R. (2013). Effect of Irrigation Levels on Yield and Water Productivity of Soybean under Vertisols. Soybean Research12(1): 69-76.

Muchow R C and Sinclair T R. (1986). Water and nitrogen limitations in soybean grain production. I. Field and model analyses. FieldCropsRes. 15: 143-56.

Rahul A, Jahan A K M, Karim S R A, and Mirza H. (2009). Growth dynamics of soybean (Glycine max L.) as affected by varieties and timing of irrigation. American-European J. Agron.2(2): 95-103.

Yaseen R, Shafi J, Ahmad W, Rana M S, Salim M and Qaisrani S A. (2014). Effect of Deficit Irrigation and Mulch on Soil Physical Properties, Growth and Yield of Maize. Environ. Ecol. Res.2, 122-137.

Zhang Yinghu, Jianbo He, Yufeng Wang, Guangnan Xing, Jinming Zhao, Yan Li, Shouping Yang, Palmer R G, Tuanjie Zhao and Junyi Gai. (2015). Establishment of a 100-seed weight quantitative trait locus–allele matrix of the germplasm population for optimal recombination design in soybean breeding programmes. J. Exp. Botany. 66(20): 6311–6325.

Zou Wenxiu, Xinchun Lu and Xiaozeng Han. (2017). Effect of irrigation regime on soybean biomass, yield, water use efficiency in a semi-arid and subihumid region in northeast China. Freseniu Environmental Bulletin 25(4): 1-11.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this license, visit http://creativecommons.org/ licenses/by/4.0/.© The Author(s) 2019

ISSN: 0976-0547 (Online), 0253-150X (Print), Naas Rating: 4.21