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Yield of Soybean, Nutrient Uptake and Nutrient Availability in an Inceptisol as Influenced by Irrigation at Critical Growth Stages

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Abstract: A field study was conducted at Irrigation Water Management Farm, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India during *kharif* season of 2015-16. The experiment was laid out in a randomized block design with eight treatments and three replications. The treatments consisted of application of irrigation to soybean at different critical growth stages, *viz.,* No irrigation (T_1), one irrigation at branching, flowering and at pod filling stage, respectively (T_2 to T_4) and two irrigations at branching and flowering stage (T_5), two irrigations at branching and pod filling stage (T_6), two irrigations at flowering and pod filling stage (T_7) and three irrigations at branching, flowering and pod filling (T_8). Significantly higher grain and straw yield was obtained where three irrigations were given at branching, flowering and pod filling stage (30.43 q ha^{-1} and 55.92 q ha^{-1}, respectively) followed by two irrigations at flowering and pod filling stage (28.89 q ha^{-1} and 54.12 q ha^{-1}, respectively). The growth and yield contributing characters were improved with irrigations at critical growth stages of soybean. The highest nutrient availability of nitrogen, phosphorus and potassium in soil was 181.9 kg ha^{-1}, 17.1 kg ha^{-1} and 434.5 kg ha^{-1}, respectively was observed in no irrigation treatment at harvest. The highest nutrient uptake was observed in treatment of three irrigations at branching, flowering and pod filling stage was 200.26 kg ha^{-1}, 41.54 kg ha^{-1} and 84.02 kg ha^{-1} N, P and K respectively.

Key words: *Soybean, critical growth stages, nutrient uptake*

Introduction

Soybean (*Glycine max L. Merril.*) is an important oilseed crop. It is grown throughout the world with the largest production in United States, China, Brazil, Indonesia, Japan, Korea and Argentina. In India, the area under soybean is 108.83 lakh ha with total production as 104.36 lakh MT and productivity of 959 kg ha^{-1} (Anonymous 2014). Madhya Pradesh, Maharashtra and Rajasthan are the major soybean growing states. In Maharashtra, it is grown over an area of 38.00 lakh hectares with total production of 30.72 lakh MT with an average productivity of 808 kg ha^{-1} (Anonymous 2014). Soybean is generally grown during *Kharif* season all over India. In general, soybean crop is suffered due to water stress during the prolonged dry spells of monsoon which results in small grain size and reduces the dry matter accumulation which ultimately affects the productivity and Maharashtra is not an exception.

The western Maharashtra is characterised as semi-arid region. In this region, the evaporation is more and rainfall is less (520 mm) with intermittent dry spell. The nature of rainfall in this region is uncertain and erratic. The amount of water available is limiting day by day and under such conditions the farmers now preferring the crops having less water requirement such as soybean which is a short duration crop. Therefore, the application of supplemental irrigation at the sensitive crop growth stages is inevitable. Soybean responds well to irrigation though it is drought resistant crop. In irrigated soybean, biomass seed yield and yield components significantly increased (Sincik *et al.* 2008). Bachchhav (1990)

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reported that the plant height, number of leaves and leaf area of groundnut increased with increase in number of irrigations.

The non-irrigated plants or droughted plants at vegetative or flowering stages produce fewer pods and seeds. Daniel *et al*. 2002 reported that yields from a single irrigation (2.5 cm) is averaged approximately 20 per cent more than yield with no irrigation. Irrigation at full pod development stage increased seeds plant"1 and seed weight. From the above information, it is felt necessary to find out response of soybean crop to supplemental irrigation and nutrient uptake at critical growth stages. under scarce rainfall condition.

Material and Methods

A field experiment was conducted during *kharif* season of 2015-16 at the experimental Farm of Interfaculty Department of Irrigation Water Management, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra). Agro-climatically, the area falls under the scarcity zone of Maharashtra with annual rainfall of 520 mm which is mostly erratic and uncertain in nature. The soil (clay loam) had moisture retention at 15 and 33 kpa as 18.17 per cent, 36.84 per cent respectively with bulk density 1.25 Mgm^{-3}. pH 8.10, EC 0.30 dSm^{-1} and organic carbon 0.57 per cent. The initial fertility status of the experimental soil was low in available nitrogen (175.0 kg ha^{-1}), medium in available phosphorous (15.28 kg ha^{-1}) and very high in available potassium (448.0 kg ha^{-1}).

The experiment consisted of eight treatments of irrigation at critical growth stages of soybean with three replications. The treatments are No irrigation (T_1), one irrigation at branching (T_2), flowering (T_3) and pod filling stage, (T_4) and two irrigations at branching and flowering stage (T_5), two irrigations at branching and pod filling stage (T_6), two irrigations at flowering and pod filling stage (T_7) and three irrigations at branching, flowering and pod filling(T_8). The sowing of soybean crop is carried out on flat bed having size 3.60 X 3 m at spacing of 45 X 5 cm during the *kharif* season of 2015 with variety Phule Agrani (KDS-344) developed by M.P.K.V., Rahuri The seed rate was 75 kg ha^{-1}. The recommended dose of fertilizer (50:75:00 N, P_2O_5 and K_2O kg $ha^{-1)}$ was applied as basal application through urea and single super phosphate. Recommended agro-management was adopted. The 60 mm of water was applied at each irrigation as per the treatment. The rainfall received during the experimental period was 141.5 mm.

The growth parameters of soybean *viz.,* plant height, number of branches per plant were recorded at 90 DAS and number of leaves per plant and leaf area at 60 DAS. The plant samples were collected at harvest and air dried in shade, oven dried at 65^{o}C, ground in a Willey Mill having stainless steel blades to pass through 40 mm mesh sieve and digested with H_2SO_4 and H_2O_2 (1:1) as per the procedure given by Parkinson and Allen (1975). Nutrient uptake was calculated by determining the N, P and K concentration in relation to dry matter production. The soil samples were air dried, processed and analysed for available NPK content in soil (Page *et al*. 1982). The statistical analysis was performed by using analysis of variance (ANOVA) for randomized block design as per Panse and Sukhatme (1985).

Results and Discussion

Growth attributing character

The growth parameters of soybean were significantly influenced by irrigation at critical growth stages (Table 1). Treatment (T_8) brought significant influence on plant height (85.3 cm), number of branches per plant (4.90) and number of leaves per plant (34.67) and leaf area (24.64 dm^2) over other treatments and minimum parameters were recorded in (T_1) might be due to application of irrigations at critical growth stages (branching, flowering and pod filling stages) of soybean resulted in development of congenial soil moisture status which helped in more uptake of nutrients and in-turn favourable plant growth. Ahmadi and Bahrani (2009) observed that not providing irrigation at critical stages reduced the soybean plant height and some other parameters.

Yield contributing characters

The significantly maximum number of pods $plant^{-1}$(104.33), weight of pods $plant^{-1}$(37.36g), weight of grains $plant^{-1}$ (24.0g) and hundred grain weight (11.72g) recorded in the treatment (T_8) where irrigation was applied at branching, flowering and pod filling stage over other treatments. Dominique *et al.* (2007) observed that no irrigation during critical growth stages reduces number of pods per plant. Higher reduction in weight of pods per plant was observed when irrigation was not given at flowering and pod filling stages. The no irrigation treatment (T_1) recorded lowest weight of pods per plant

Table 1 . Growth and yield contributing characters of soybean as influenced by different treatments

Tr. No.	Plant height (cm)	Number branches $plant^{-1}$ (g)	Number of leaves $plant^{-1}$	Leaf area dm^2/ plant	Number of pods $plant^{-1}$	Weight of pods $plant^{-1}$ (g)	Weight of grain $plant^{-1}$ (g)	Weight of 100 grains (g)
T_1	75.8	2.23	24.67	17.49	63.37	19.27	13.25	10.26
T_2	79.9	3.27	32.70	19.84	72.80	23.60	14.69	10.29
T_3	80.1	3.07	29.47	22.59	74.40	25.06	16.15	10.39
T_4	80.6	3.07	28.53	20.42	73.67	25.64	17.64	10.71
T_5	85.1	4.47	30.27	23.68	93.27	26.78	19.16	11.00
T_6	84.7	4.03	30.20	21.50	82.80	24.59	16.93	11.45
T_7	81.3	3.47	33.20	23.89	96.47	31.91	21.86	11.69
T_8	85.3	4.90	34.67	24.64	104.33	37.36	24.07	11.72
SE+-	5.36	1.69	0.32	0.70	5.36	2.15	2.04	0.34
CD at 5%	16.27	5.12	0.96	2.13	16.27	6.54	6.17	1.04

of soybean (19.27 g). These results are in conformity with those reported by Hassan *et al.* (2011). Smiciklas *et al.* (1992) reported the reduction in seed weight per plant when irrigation not given throughout the growth period. It ultimately reduces the weight of grains per plant. The reduction in weight of seeds per plant was observed when irrigation was not given at flowering and pod filling stages.

Grain yield

The significantly maximum grain and straw yields was recorded in T_8 (Table 2) where irrigation was applied at branching, flowering and pod filling stage (30.43 and 55.92 q ha^{-1}). The per cent decrease in grain yield over T_8 treatment was highest in T_1 (33.29 %) followed by T_2 (22.58 %) and T_4 (18.11 %). The rainfall at later stage recovered the growth and thereby increased yield was observed in T_3. The significantly maximum yield was noticed due to better soil moisture and nutrient availability. Westgate and Peterson (1993) reported that when irrigation was not applied at flowering and early pod development stage significantly increased the rate of pod abortion leading to decreased grain yield. The lowest grain yield was observed in no irrigation treatment (20.30 q ha^{-1}).

Water applied

The maximum water in form of three irrigations at branching, flowering and pod filling stage (T_8) was applied followed by irrigation in T_5, T_6 and T_7 (180 mm). The effective rainfall was occured at early growth stages of soybean growth (Table 2) followed by prolonged dry spell but rainfall occurred at maturity stage.

Water use efficiency

The water use efficiency decreased with increasing number of irrigations (Table 2). Maximum water use efficiency (33.83 kg $ha^{-1}mm^{-1}$) was observed in T_1 followed by one irrigation at flowering (21.19 kg $ha^{-1}mm^{-1}$). The lowest water use efficiency of 12.68 kg $ha^{-1}mm^{-1}$ was recorded in treatment T_8. Treatment T_1 saved 75 % water followed by T_2, T_3 and T_4 (50 %) and lower (25 %) water saving was observed in two irrigation treatments (T_5, T_6 and T_7 over $T_{8)}$. Karam *et al*. (2005) concluded that water use efficiency was not higher in treatment having higher grain yield as reduction in yield was less than reduction in water amount. The results indicate that irrigation at flowering stage did not affect much to water use efficiency but irrigation at branching and pod filling stage considerably decreased the water use efficiency.

Nutrient availability in soil

At harvest significantly maximum availability of nitrogen (181.9 kg ha^{-1}) was recorded in no irrigation (T_1), however, it was at par with $T_{5.}$ The lowest nitrogen availability (176.8 kg ha^{-1}) was observed in T_8 treatment.

Table 2. Yield and water use of soybean as influenced by different treatments

Tr. No.	Yield(q ha^{-1}) Grain	Straw	% decrease in yield over T_8	Irrigation applied (mm)	ER (mm)	Total water applied (mm)	WUE $kgha^{-1}$ (mm)	Water saving (%)
T_1	20.30	32.96	33.29	60	0	60	33.83	75.0
T_2	23.56	44.13	22.58	94.8	25.2	120	19.63	50.0
T_3	25.43	45.80	16.43	120	0	120	21.19	50.0
T_4	24.92	45.20	18.11	120	0	120	20.77	50.0
T_5	26.29	44.70	13.60	154.8	25.2	180	14.61	25.0
T_6	26.90	45.51	11.60	154.8	25.2	180	14.94	25.0
T_7	28.89	54.12	5.06	180	0	180	16.05	25.0
T_8	30.43	55.92	-	214.8	25.2	240	12.68	-
SE+-	1.15	2.42	_	-	-	-	-	-
CD at 5%	3.46	7.26	_	-	-	-	-	-

Table 3. Nutrient uptake and nutrient availability in soil as influenced by different treatments in soybean

Tr. No	Nutrient uptake ($kgha^{-1}$)			Nutrient availability ($kgha^{-1}$)		
	N	P	K	N	P	K
T_1	125.7	22.05	47.26	181.9	17.1	438.3
T_2	158.61	29.99	62.85	178.8	16.4	437.5
T_3	175.14	34.98	71.14	178.7	15.9	436.8
T_4	166.06	32.29	67.02	179.8	15.8	433.1
T_5	166.18	32.21	65.19	177.4	15.6	429.3
T_6	173.95	34.33	69.59	177.5	15.6	425.6
T_7	190.94	33.67	65.86	177.7	15.5	421.9
T_8	200.26	41.54	84.02	176.8	15.4	410.7
SE+-	7.80	3.03	3.07	0.83	0.28	5.34
CD at 5%	23.67	9.20	9.33	2.53	0.85	16.34

Sabale (1994) reported that the availability of nitrogen, phosphorous and potassium increased with decrease in frequency of irrigation.

The significantly maximum availability of phosphorous (17.1 kg ha^{-1}) was recorded in T_1 over other treatments at harvest; however, it was at par with T_2. The lowest phosphorous availability (15.4 kg ha^{-1}) was observed in T_8.

The significantly maximum availability of potassium (434.5 kg ha^{-1}) in soil was recorded in T_1 over other treatments (434.5 kg ha^{-1}) at harvest. However, it was at par with T_2, T_3 and T_4. The lowest potassium availability (416.9 kg ha^{-1}) was observed in T_8.

Conclusion

It can be concluded that irrigations at branching, flowering and pod filling stages recorded significantly maximum growth and yield contributing characters, grain and straw yield followed by at flowering and pod filling stages. So when only two protective irrigations are available then it should be applied at flowering and pod filling stage to obtain the maximum yield of soybean under limited irrigation.

References

Ahmadi M. and Bahrani M. J. (2009). Yield and yield components of rapeseed as influenced by water stress at different growth stages and nitrogen levels. *American-Eurasian Journal of Agriculture and Environmental Sciences* **5**, 755-761.

Anonymous (2014). www.sopa.org.

Bachchhav M.M. (1990). Efficacy of Jalshakti in water management of summer groundnut. M.Sc. Agri. thesis submitted to Mahatma PhuleKrishiVidyapeeth, Rahuri (M.S.), India (Unpublished).

Daniel W., Sweeney George, Granade V., (2002). Effect of a single irrigation at different reproductive growth stages on soybean planted in early and late June. *Irrigation Sciences* **21**, 69-73.

Dominique D., Tung L. and Roumet P. (2007). Identification of soybean plant characteristics that indicate the timing of drought stress. *Crop Science* **40**, 716-722.

Hassan M., Darvish F., Daneshian J., Normohammadi G. and Habibi D. (2011). Effects of water deficit stress on seed yield and antioxidants content in soybean (*Glycine max* L.) cultivars. *African Journal of Agricultural Research* **6**, 1209-1218.

Karam F., Masaad R., Sfeir T., Mounzer O. and Rouphael Y. (2005). Evapotranspiration and seed yield of field grown soybean under deficit irrigation conditions. *Agricultural Water Management* **75**, 226-244.

Page A.L., Miller R.H. and Keeney D.R. 1982. *Methods of Soil Analysis.* part **1** and **2.** Chemical and Microbiological properties. Second Edition, *Agronomy Monograph* **9**. ASA and SSSA, Madison, Wisconsin, USA.

Panse V.G. and Sukhatme P.V. (1995). Statistical methods for Agricultural workers, ICAR, New Delhi.

Parkinson J.A. and Allen S.E. (1975). An oxidation procedure for determination of nitrogen and other mineral nutrients in biological material. *Communications in Soil Science and Plant Analysis* **1**, 1-11.

Sabale P.T. (1994). Response of soybean (*Glycine max* (L.) Merrill) cultivars to irrigation levels under summer conditions. M. Sc. (Agri.) thesis submitted to Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S.), India (Unpublished).

Smiciklas K.D., Mullen R.E., Carlson R.E., Knapp A.D., (1992). Soybean seed quality response to drought stress and pod position. *Agronomy Journal* **84**, 166-170.

Sincik M, Candogan B.N., Demirtas C., Buyukcangaz H., Yazgan S., and Goksoy A. T., (2008). Deficit Irrigation of Soya Bean [*Glycine max (L.) Merr.*] in a Sub-humid Climate. *Journal of Agronomy and Crop Science* **194**, 200-205.

Westgate M.E. and Peterson C.M. (1993). Flower and pod development in water-deficient soybean (*Glycine maxL.Merrill.*). *Journal of Experimental Botany.* **258**, 109-1

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