

Effect of irrigation regimes and nitrogen on yield, oil content and nutrient uptake of soybean (*Glycine max*)

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ABSTRACT

An experiment was conducted during the rainy season (*kharif*) of 1993 and 1994 to study the effect of irrigation regimes and nitrogen on yield and quality of soybean [*Glycine max* (L.) Merr.]. The treatments comprised 5 irrigation regimes [irrigation at 0.4, 0.6 and 0.8 irrigation water : cumulative pan evaporation (IW : CPE) ratio and crop growth stages along with control] in 1993 and 4 irrigation regimes (irrigation at 0.6, 0.8 IW : CPE and crop growth stages along with control) in 1994 and 4 nitrogen levels (20, 40, 60 and 80 kg N/ha). The seed, stover, oil and protein yields of soybean were significantly higher under 0.8 IW : CPE ratio. The maximum oil and protein contents in soybean seeds were recorded when the crop was irrigated at 0.8 IW : CPE ratio, while minimum in the control (rainfed). The N and P uptake in seed and stover and the total uptake were maximum under 0.8 IW : CPE ratio. However, the chlorophyll content of leaves was gradually decreased with increase in irrigation regimes. Application of nitrogen up to 60 kg/ha increased seed, stover, oil and protein yields of soybean. However, the oil content of seeds was maximum when the crop was fertilized with 20 kg N/ha, and it decreased at 60 kg N/ha. Conversely the protein content of the seeds was increased with increasing levels of N up to 60 kg N/ha. The N and P uptake both by seed and stover and total uptake significantly increased with the increase in N up to 60 kg/ha. The chlorophyll content of leaves was found maximum at 80 kg N/ha when estimated at 60 days after sowing.

Key words : Soybean, Irrigation regime, Nitrogen, Yield Quality, Nutrient uptake

Soybean seed being very rich in protein (42%) and oil (21%), requires large amount nitrogen for its growth and development which is not meet fully by the plant through symbiosis. As such its nitrogen requirement is high (Tanaka,

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1986). Application of nitrogen increases the yield, protein content and nutrients uptake by soybean crop (Hasnabade *et al.*, 1990; Naidu and Pillai, 1991). Since an information pertaining to the effect of irrigation regimes and nitrogen on the yield, quality and nutrient uptake of soybean is meagre, especially in Rajasthan, the present investigation was carried out on these aspects.

MATERIALS AND METHODS

A field experiment was conducted during the rainy season of 1993 and 1994 at the research farm, Rajasthan College of Agriculture, Udaipur. The soil of the experimental site was clay loam in texture, medium in total nitrogen (0.07%), available P_2O_5 (17.0 kg/ha) and high in available K_2O (296.30 kg/ha), with pH 8.28. It was moderate in moisture-retention capacity. The experiment was laid out in split-plot design where 5 irrigation regimes (irrigation at 0.4, 0.6 and 0.8 IW : CPE ratio and crop growth stages along with control) in 1993 and 4 irrigation regimes (irrigation at 0.6, 0.8 IW : CPE ratio, crop growth stages and control) in 1994 formed the main plot and 4 nitrogen levels (20,40,60 and 80 kg N/ha) were allotted to subplot treatments with 4 replications. The IW : CPE ratios were maintained by scheduling irrigation at cumulative pan evaporation values of 150, 100 and 75 mm respectively, keeping depth of irrigation water (IW) as 60 mm. The effective rainfall was estimated.

Irrigation at crop growth stages (branching, flowering, pod filling and doughS) was applied whenever moisture

stress was noticed. Required amount of water (treatment-wise), measured through constant head flow method, was applied at each irrigation, keeping irrigation efficiency 80%. The total rainy days were 19 and 38 in 1993 and 1994 respectively. Total amount of rainfall received during crop-growth period of 1993 and 1994 were 443.7 mm and 668.6 mm respectively. A uniform basal dose of 50 kg P_2O_5 /ha and the nitrogen (as per treatment) was applied in furrows before sowing. Soybean 'Gaurav' @ 80 kg seed/ha was sown in rows 30 cm apart on 4 July and 28 June during 1993 and 1994 respectively. During 1993, number of irrigations applied in different moisture regimes, i.e. 0.4, 0.6 and 0.8 IW : CPE ratios and during crop growth stages were 2, 3, 4 and 4 respectively, whereas during 1994 number of irrigations at 0.6 and 0.8 IW : CPE ratios and crop growth stages were, 1,2 and 2 respectively.

RESULTS AND DISCUSSION

Irrigation regimes

Irrigation regimes had significant effect on seed and stover yields of soybean (Table 1). Irrigation applied at IW : CPE ratio and at crop growth stages gave significantly higher seed and stover yields over the rainfed treatment. The highest seed yield was recorded at 0.8 IW : CPE ratio which was significantly superior to irrigation at 0.4 IW : CPE ratio in 1993 and 0.6 IW : CPE ratio in 1994. However, the former remained at par with irrigations given at crop-growth stages. Irrigation at an IW : CPE ratio of 0.8 and at crop-growth stages increased the seed yield by 47.80 and 39.90%, respectively, over the rainfed

Table 1. Effect of irrigation regime and nitrogen on chlorophyll content, seed and stover yields of soybean

Treatment	Chlorophyll content (mg/g)*		Seed yield (q/ha)		Stover yield (q/ha)	
	1993	1994	1993	1994	1993	1994
<i>Irrigation regime</i>						
No irrigation	1.62	1.44	11.86	15.45	22.31	40.25
0.4 IW : CPE	1.62		17.69		31.82	
0.6 IW : CPE	1.60	1.45	18.05	17.12	36.38	43.76
0.8 IW : CPE	1.52	1.42	19.80	20.58	39.58	47.12
Growth stages	1.50	1.41	18.11	20.10	39.47	46.69
CD (P = 0.05)	0.097	NS	2.10	1.92	4.98	4.67
<i>N (kg/ha)</i>						
20	1.39	1.31	14.92	16.83	31.80	41.54
40	1.57	1.38	16.46	18.27	33.68	44.30
60	1.65	1.49	18.71	19.68	35.34	46.95
80	1.68	1.54	18.32	18.47	34.83	45.43
CD (P = 0.05)	0.071	0.063	1.43	1.39	2.61	3.70

*Recorded at 60 days after sowing

treatment. The results confirm the finding of Martin *et al.* (1994).

Variation in irrigation regime caused significant effect on N and P uptake by crop (seed, stover and total) (Table 2). Irrigating the crop at an 0.8 IW : CPE ratio and or at crop-growth stages proved statistically identical and both these regimes recorded significantly higher N and P uptake in seed and stover and total over the rainfed control. Further, both these irrigation treatments significantly increased N and P uptake by seed and stover irrigation at 0.4 IW : CPE during 1993 and over 0.6 IW : CPE during 1994, except N uptake in stover during 1994. The maximum uptake of N and P was recorded at irrigation regime of 0.8 IW : CPE during 1993 and 1994 respectively. This was mainly because of the higher seed and

stover yields under this treatment (Table 1). Hasnabade *et al.* (1990) and Rajput *et al.* (1991) also reported increased uptake of these elements, with better moisture supply in soybean crop.

Irrigation regimes had significant effect on protein content of soybean seeds, while oil content was influenced during the first year only (Table 3). Soybean seed under irrigation regime of 0.8 IW : CPE possessed maximum mean oil content and protein content, followed by irrigation at crop-growth stages. The increase in oil and protein content under higher irrigation regimes was probably due to adequate moisture supply for growth and development of crop which induced greater metabolic activities during reproductive stage of crop. Rajput *et al.* (1991) also observed higher oil content of soybean

Table 2. Effect of irrigation regime and nitrogen on N and P uptake by soybean

Treatment	N (kg/ha)						P (kg/ha)					
	1993			1994			1993			1994		
	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total
<i>Irrigation regime</i>												
No irrigation	64.77	16.08	80.85	90.13	37.73	127.86	6.11	1.60	7.71	8.49	3.36	11.85
0.4 IW : CPE	102.32	27.48	129.80				9.79	2.41	12.20			
0.6 IW : CPE	107.66	35.08	142.74	102.79	42.70	145.49	10.12	2.87	12.99	9.51	4.20	13.71
0.8 IW : CPE	120.28	40.17	160.45	129.61	47.96	177.57	11.54	3.38	14.92	12.16	5.23	17.39
Growth stages	109.47	39.27	148.74	129.13	47.05	173.18	10.43	3.35	13.78	11.77	5.22	16.99
CD (P = 0.05)	14.09	5.43	20.50	15.11	6.94	23.02	1.303	0.444	1.946	1.342	0.717	2.26
<i>N (kg/ha)</i>												
20	82.05	27.43	109.48	97.38	38.22	135.60	7.82	2.33	10.15	9.07	3.58	12.65
40	96.23	30.91	127.14	110.63	43.07	153.70	9.06	2.66	11.72	10.37	4.35	14.72
60	112.55	34.13	146.68	122.90	47.42	170.32	10.76	2.94	13.70	11.48	5.07	16.55
80	112.77	33.99	146.76	117.75	46.83	164.58	10.75	2.96	13.71	11.01	5.01	16.02
CD (P = 0.05)	10.44	3.43	12.86	11.59	5.34	15.91	0.871	0.277	1.246	1.063	0.53	1.69

seeds under adequate soil moisture supply. The oil and protein yields obtained under irrigation regime 0.8 IW : CPE remained at par with irrigation at crop-growth stages (Table 3). However, these treatments gave significantly higher oil and protein yields than the rainfed control. The irrigation at 0.8 IW : CPE ratio gave significantly higher oil yield over irrigation at 0.4 IW : CPE during 1993 and 0.6 IW : CPE during 1994. The higher oil and protein yields could be attributed mainly to increased seed yield (Table 1) and their content at cellular level (Table 3) with increasing irrigation regimes. The present findings are also in close conformity with the findings of Hasnabade *et al.* (1990) and Rajput *et al.* (1991).

Nitrogen

Application of N had significant effect on the seed and stover yields (Table 1). The seed yield increased significantly with

increasing N level up to 60 kg/ha. The mean seed yield recorded with 60 kg N/ha was 10.54 and 20.91% higher than that recorded with 40 and 20 kg N/ha respectively. The increase in seed yield by N application was mostly owing to the beneficial effect of N nutrition in exploiting inherent potential of the crop. Similar results were also reported by Hasnabade *et al.* (1990) and Naidu and Pillai (1991).

Increasing levels of N from 20 to 60 kg/ha significantly increased N and P uptake by seed, stover and total uptake (Table 2). Further increase in N level to 80 kg/ha showed inconsistency in this respect. The maximum N uptake by seed in 1993 and P uptake by stover during 1994 were recorded at 80 kg N/ha. The increased uptake of nutrients with increased N levels seems to be the resultant of higher seed and stover yields of soybean (Table 1). The results

Table 3. Effect of irrigation regime and nitrogen on oil and protein yields of soybean

Treatment	Content (%)				Yield (kg/ha)			
	Oil		Protein		Oil		Protein	
	1993	1994	1993	1994	1993	1994	1993	1994
<i>Irrigation regime</i>								
No irrigation	17.93	19.60	34.21	36.50	211.60	302.82	405.13	563.22
0.4 IW : CPE	18.93		36.18		333.90		639.42	
0.6 IW : CPE	19.32	19.80	37.29	37.55	347.64	338.78	672.41	642.16
0.8 IW : CPE	19.95	20.15	37.86	39.41	393.60	414.00	748.02	810.25
Growth stages	19.73	20.02	37.79	39.26	356.30	402.40	683.87	789.42
CD (P=0.05)	0.796	NS	1.661	1.870	49.57	54.46	77.14	84.10
<i>N (kg/ha)</i>								
20	19.65	20.43	34.16	36.12	294.35	344.34	510.22	608.40
40	19.19	20.06	36.49	37.83	317.00	367.00	601.31	691.85
60	19.05	19.71	37.59	39.01	357.50	388.40	703.80	768.43
80	18.80	19.37	38.42	39.76	345.50	358.26	704.35	735.37
CD (P=0.05)	0.660	0.825	1.354	1.606	35.00	32.98	59.84	69.08

confirm the findings of Reddy *et al* (1990).

Protein content of seeds increased significantly with the increase in N levels from 20 to 80 kg/ha, while the reverse trend was noticed for oil content (Table 3). The mean maximum oil and protein content was found at 20 and 80 kg N/ha respectively. The oil and protein yields were significantly increased with increasing N levels up to 60 kg/ha during both the years. The maximum oil and protein yields were recorded under 60 kg N/ha. Further increase in N level from 60 to 80 kg/ha had adverse effect on oil yield during both the years and protein yield during 1994. Despite inverse relationship between oil content at increasing N levels, increase in oil yield can be explained by proportionately greater increase in seed yield up to 60 kg N/ha. Increased oil yield with N application up to 60 N/ha was also reported by Kalia *et al.* (1984). Increase in protein yield was due to significant increase in protein content in seed (Table 3) and seed yield (Table 1) with increasing N levels up to 60 kg N/ha. The chlorophyll content of leaves was gradually increased with increase in N levels from 20 to 80 kg/ha; however, the difference was found significant only between 20 and 60 kg N/ha.

REFERENCES

- Hasnabade, A.R., Bharmbe, R.R., Hudge, V.S. and Cimanshette, T.G. 1990. Response of soybean to N and P and irrigation application in vertisol soils. *Annals of Plant Physiology* 4 (2) : 205-210.
- Kalia, B.D., Awasthi, O.P. and Singh, C.M. 1984. Effect of nitrogen and phosphorus fertilization with and without rhizobium culture and liming on yield, quality and economics of soybean in North-Western Himalayas. *Himachal Journal of Agricultural Research* 10 (2) : 2429.
- Martin, F.De Santa Olalla, de Juan valero, J.A. and Faberio cortes, C. 1994. Growth and yield analysis of soybean [*Glycine max* (L.) Merr.] under different irrigation schedules in castilla La Mancha, Spain. *European Journal of Agronomy* 3 (3) : 187-196.
- Naidu, M.V.S. and Pillai, R.N. 1991. Nitrogen and phosphorus fertilizer effect on yield and content of nutrients in soybean. *Journal of Oilseeds Research* 8 (2) : 244-247.
- Rajput, R.L., Kaushik, J.P. and Yadav, N.S. 1991. Effect of moisture regime, P levels and row spacing on yield and quality of soybean. *Indian Journal of Agronomy* 36 (Suppl.) : 290-291.
- Rajput, R.L., Kaushik, J.P. and Yadav, N.S. 1991. Yield and nutrient uptake in soybean as affected by irrigation, phosphorus and row spacing. *Indian Journal of Agronomy* 36 (4) : 549-552.
- Reddy, T.R., Rao, M. and Rao, K.R. 1990. Response of soybean to nitrogen and phosphorus. *Indian Journal of Agronomy* 35 (3) : 308-310.
- Tanaka, A. 1986. The physiology of soybean yield improvement. (In) *Proceedings of Symposium on Soybean in Tropical and Subtropical System*. Tsukuba, Japan, 26 September-1 October 1983, 323-331.