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Production potential and energy budgeting of soybean (*Glycine max*) varieties as influenced by weed-management practices under different crop geometries

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ABSTRACT

A study was undertaken during the rainy season of 2001 and 2002 on clay loam alkaline soil at Udaipur (Rajasthan), to evaluate effect of weed control on production potential and energy budgeting of soybean [*Glycine max* (L.) Merr.] varieties grown in different crop geometris. Variety 'JS 335' recorded the maximum seed yield, additional net returns, energy gain and energy-use efficiency (EUE) compared with 'NRC 37' and 'JS 71-05'. There were no significant differences in density of grassy and broad-leaf weeds at 40, 60 days after sowing and at harvest among the varieties. Crop geometry could not affect the weed as well as crop parameters. All the weed-control treatments resulted in significant reduction in density of grassy weeds and helped in significant enhancement in soybean yield. Two hand-weedings 20 and 40 days after sowing and pre-emergence (PE) application of clomazone 1.0 kg/ha + hand-weeding at 40 days after sowing treatments registered around 88% weed-control efficiency in controlling grassy as well as brod leaf weeds. Higher seed yield, additional net returns, energy gain and EUE were recorded with 2 hand-weedings, followed by clomazone 1.0 kg/ha PE + hand-weeding at 40 days after sowing.

Key words: Clomazone, Crop geometries, Energy-use efficiency, Fenoxaprop-p-ethyl, hand-weeding, Soybean, Weed management

The soybean grown in rainy season faces severe weed competition. Weed competition in soybean at early stage of crop growth is critical, as it causes yield losses up to 35 to 50% (Tiwari and Kurchania, 1990). Hand-weeding and mechanical weeding are difficult due to continuous rainfall and lesser availability of labourers at the critical stage of crop–weed competition. Use of herbicides not only improves crop yield but also makes available significant labour for other productive activities (Kurchania et al. 1989). However, herbicides alone may fail to give satisfactory control of weeds because of their short period of persistence, late emerging and the resistant weeds cause severe reduction in crop yield. Therefore, integration of herbicdes with manual removal of weeds can be more successful. Alternation in crop geometry of varieties by way of manipulation of inter- and intra-row spacing, without chaning plant density, particularly in high plant density crops like soyban may also play important role in smothering weeds and increasing the crop productivity. The present investigation was therefore undertaken to study the production potential and energy budgeting of soybean varieties as influenced by weed management practices under different crop geometries.

MATERIALS AND METHODS

The experiment was conducted at Udaipur, Zone IV A (region, sub-humid southern plain and Aravali Hills) of Rajasthan during the rainy seasons of 2001 and 2002. The soil was fine, montmorollinitic, isohyperthermic, typic haplustert, clay loam, alkaline (pH 7.9 and 8.0), medium in available nitrogen (285.5 and 292.4 kg N/ha), phosphorus (23.4 and 24.8 kg P_2O_5/ha) and potassium (304.4 and 317.0 kg K_2O/ha). The treatments consisted of 3 soybean varieties '(NRC 37', 'JS 335' and 'JS 71-05') and 2 crop geometries (30 cm × 10 cm and 20 cm × 15 cm) in main plots and 6 weed-management practices, viz. weedy check, 2 hand-weedings (HW) 20 and 40 days after sowing, clomazone 1.0 kg/ha as pre-emergence (PE) and fenoxaprop-p-ethyl 75 g/ha as post-emergence (POE) and fenoxaprop-p-ethyl 75 g/ha as POE + HW at 40 days after sowing in sub-plots. The experiment was laid out in split-plot design with 3 replications. A uniform dose of 20 kg N and 40 kg P_2O_5/ha was applied through urea and diammonium phosphate as basal in crop rows 5 cm below the seed. Sowing was done in the second week of July and the crop was harvested in the first week of November in both the years. Total rainfall received during the

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crop-growth period was 362.7 and 253.2 mm in 2001 and 2002 respectively. Due to long dry spell at critical growth stages 2 life-saving irrigations were applied at flowering and pod-initiation stages in 2001 and 2002. Due to late onset of monsoon, dry sowing was done and 1 irrigation was applied immediately after the sowing for coming up of crop and second irrigation was applied at pod-initiation stage. Clomazone was applied on the next day of sowing, while fenoxaprop-p-ethyl was applied 20 days after sowing. The data on category-wise weed density were recorded at 40, 60 days after sowing and at harvest. Weed-dry matter category-wise was recorded at harvest only. The seed yield, oil and protein content were recorded at harvest. Mean weed density from 2 places were used for square-root transformation ($\sqrt{x+0.5}$) to normalize their distribution. Weed-control efficiency was calculated. Energy inputs and outputs were calculated using the equivalents as described by Mittal and Dhawan (1988).

RESULTS AND DISCUSSION

Effect on weeds

Major weed species infesting soybean crop included *Trianthema portulacastrum* L., *Commelina benghalensis* L., *Parthenium hysterophorus* L., *Amaranthus spinosus* L. and *Digera arvensis* L. among broad-leaf weeds; and Echinochloa colonum (L.), *Cynodon dactylon* (L.) Pers. and *Cyperus rotundus* among grassy weeds. Echinochloa colonum and Trianthema portulacastrum were the most dominant ones. Population of *T. portulacastrum* at the harvesting stage was missing on account of shorter life span (Shrma *et al.,* 1988) than that of soybean crop.

Varieties had no significant effect on density and dry matter of grassy and broad-leaf weeds (Table 1). Crop geometries too did not show any significant effect on density and dry matter of both grassy and broad-leaf weeds.

At all the 3 stages, maximum density of grassy and broad-leaf weeds was recorded in weedy check. The weed-control treatments significantly reduced the density of grassy weeds. The lowest weed density of broad-leaf weeds was recorded with 2 hand-weedings compared to rest of the treatments at 40 days after sowing, because this treatment resulted in broad-spectrum weed control. Clomazone alone and integration with hand-weeding, both treatments were at par and significantly reduced the density of grassy and broad-leaf weeds compared to fenoxaprop-p-ethyl alone, fenoxaprop-p-ethyl + HW and weedy check. Clomazone 1.0 kg /ha PE controlled the grassy weeds and some broad-leaf weeds (Kurchania *et al.,* 1996). Fenoxaprop-p-ethyl alone and integration with hand-weeding, both treatments, significantly reduced the density of grassy weeds compared to weedy check. Fenoxaprop-p-ethyl 75 g/ha POE controlled only grassy weeds and did not control broad-leaf weeds (Sharma, 2000).

At 60 days, all the 3 treatments, having hand-weeding at 40 days after sowing recorded significantly lower density of broad-leaf weeds compared to rest of the treatments. At harvest, 2 hand-weedings and clomazone + HW significantly reduced the density and dry matter of broad-leaf weeds, whereas former 2 treatments and clomazone alone were at par and significantly reduced the density and dry matter of grassy weeds compared to rest of the treatments. Higher weed-control efficiency of grassy and broad-leaf weeds was recorded with 2 hand-weedings (88.64 and 88.40%), followed by clomazone + hand-weeding (88.56 and 88.69%).

Effect on crop

'JS 71-05' soybean recorded significantly higher oil content and 'NRC 37' soybean recorded the highest protein content compared to other tested varieties (Table 1). 'JS 335' soybean exhibited its superiority in seed yield (16.09 q/ha) and additional net returns (Rs 5,507/ha) to 'NRC 37' and 'JS 71-05'. Highest incremental benefit : cost ratio (1.32) was recorded with variety 'NRC 37'. These results confirm the findings of Singh *et al.* (2000).

Crop geometries did not affect significantly seed yield, quality and economical parameters. Oil content in seed was not significantly influenced by any of the weed-control treatments, whereas higher protein content was recorded over weedy check for adopting various weed-control treatments, except fenoxaprop-p-ethyl 75 g/ha POE. All the treatments applied to control weeds resulted in significant enhancement in soybean seed yield. Among different weed-control practices, 2 hand-weedings and clomazone+ hand-weeding resulted in significantly higher seed yield than rest of the treatments, though variation between these two was statistically non-significant. The increase in yield under clomazone + hand-weeding and 2 hand-weedings may be attributed to the significant reduction in weed density and dry matter, thereby reduction in crop–weed competition. Results corroborate the findings of Pandya *et al.* (2005). Highest additional net returns was found due to 2 hand-weedings (Rs 7,538/ha), followed by clomazone + hand-weeding (Rs 6,643/ha). Maximum IBCR (1.72) was recorded with clomazone alone, followed by 2 hand-weedings (1.59).

Energy budget

Maximum gross and net energy gain, energy-use efficieny were recorded in soybean 'JS 335' followed 'NRC 37' and 'JS 7105'. Both the crop geometries recorded equivalent gross and net energy gain and energy-use efficiency.

Table 1. Effect of varieties, crop geometries and weed management practices on category-wise weed density, weed dry matter and weed-control efficiency (WCE) in soybean (pooled data of 2001 and 2002)

Treatment	Grassy weed density (No./m^2)			Broad-leaf weed density (No./m^2)			Weed dry matter at harvest (q/ha)		Weed-control efficiency at harvest (%)	
	40 DAS	60 DAS	at harvest	40 DAS	60 DAS	at harvest	Grassy weeds	Braod-leaf weeds	Grassy weeds	Broad-leaf weeds
Variety										
'NRC 37'	5.35	5.51	6.74	8.54	7.76	7.64	4.23	8.12	79.51	66.53
	(28.22)	(29.95)	(45.10)	(72.60)	(59.90)	(58.01)				
'JS 335'	5.20	5.35	6.56	8.34	7.55	7.44	4.08	7.78	81.06	67.11
	(26.64)	(28.17)	(42.63)	(69.16)	(56.58)	(54.94)				
'JS 71-05'	5.28	5.40	6.66	8.40	7.68	7.57	4.14	7.96	79.95	66.95
	(27.46)	(28.77)	(43.90)	(70.19)	(58.59)	(56.83)				
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS		
Crop geometry										
30 cm × 10 cm	5.21	5.38	6.60	8.37	7.60	7.47	4.10	7.82	80.33	67.00
	(26.76)	(28.51)	(43.15)	(69.76)	(57.36)	(55.48)				
20 cm × 15 cm	5.34	5.46	6.71	8.48	7.73	7.62	4.20	8.09	80.02	66.74
	(28.11)	(29.41)	(44.60)	(71.52)	(59.34)	(57.71)				
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS		
Weed management										
Weedy check	9.77	10.41	11.23	11.55	12.90	11.37	12.47	17.98		
	(95.10)	(108.16)	(125.66)	(133.47)	(166.30)	(128.85)				
2 HW at 20 and 40 DAS	3.87	3.88	4.63	4.84	4.65	4.92	1.42	2.09	88.64	88.40
	(14.52)	(14.56)	(21.03)	(23.04)	(21.21)	23.78)				
Clomazone 1.0 kg/ha PE	3.79	4.15	4.70	5.80	6.22	6.36	1.43	4.18	88.54	76.76
	(13.93)	(16.74)	(21.72)	(33.21)	(38.26)	(40.07)				
Clomazone 1.0 kg/ha PE+ HW at 40 DAS	3.85	3.93	4.68	5.82	4.70	5.15	1.42	2.03	88.56	88.69
	(14.39)	(15.02)	(21.47)	(33.55)	(21.71)	(26.08)				
Fenoxapropp-ethyl 75g/ha POE	5.20	6.17	8.45	11.30	12.58	11.08	5.53	17.44	56.14	2.96
	(26.66)	(37.76)	(70.93)	(127.60)	(157.92)	(122.49)				
Fenoxaprop-p-ethyl 75 g/ha POE+HW at 40 DAS	5.18	3.98	6.23	11.24	4.93	6.42	2.61	7.03	79.01	77.56
	(26.46)	(15.40)	(38.50)	(126.68)	(23.87)	(40.77)				
CD (P=0.05)	0.22	0.24	0.27	0.29	0.31	0.24	0.21	0.43		

Values in parentheses are transformed; DAS, days after sowing

Table 2. Effect of varieties, crop geometries and weed management practices on quality parameters, seed yield, economics and energy budgeting of soybean (pooled data of 2001 and 2002)

Treatment	Oil content (%)	Protein content (%)	Seed yield (q/ha)	Additional net returns (Rs)	IBCR	Energy input (MJ/ha)	Gross energy output (MJ/ha)	Net energy output (MJ/ha)	EUE
Variety									
'NRC 37'	16.69	39.05	12.29	4,880	1.32	8,953	18,070	9,118	2.00
'JS 335'	17.66	38.11	16.09	5,507	1.27	9,247	23,660	14,414	2.55
'JS 71-05'	18.26	37.30	12.92	5,146	1.13	9,541	18,971	9,430	1.98
CD (P=0.05)	0.30	0.42	0.61						
Crop geometry									
30 cm × 10 cm	17.56	38.18	14.02	4,968	1.19	9,247	20,610	11,364	2.22
20 cm × 15 cm	17.51	38.13	13.51	5,387	1.29	9,247	19,858	10,611	2.14
CD (P=0.05)	NS	NS	NS						
Weed management									
Weedy check	17.51	37.37	8.48			9,142	12,469	3,327	1.36
2 HW at 20 and 40 DAS	17.54	38.74	17.18	7,538	1.59	9,370	25,254	15,884	2.69
Clomazone 1.0 kg/ha PE	17.49	38.37	15.20	6,177	1.72	9,270	22,314	13,044	2.40
Clomazone 1.0 kg/ha PE+ HW at 40 DAS	17.61	38.51	16.90	6,643	1.37	9,325	24,838	15,513	2.66
Fenoxapropp-ethyl 75g/ha POE	17.52	37.74	10.91	1,700	0.63	9,159	16,042	6,883	1.75
Fenoxaprop-p-ethyl 75 g/ha POE+HW at 40 DAS	17.55	38.19	13.93	3,830	0.88	9,214	20,487	11,273	2.22
CD (P=0.05)	NS	0.43	0.66						

IBCR, Incremental benefit:cost ratio; EUE, energy-use efficiency

Application of clomazone + hand-weeding consumed maximum energy inputs, like 2 hand-weedings. The higher energy inputs in both the treatments may be due to the manual power for weeding. A perceptible variation was observed in energy gain, net energy and energy-use efficiency (Table 2). The highest gross and net energy gain came from 2 hand-weedings, followed by clomazone + hand-weeding. The higher energy gains in aforesaid treatments may be on account of reduced weed load in providing congenial atmosphere for growth and development of crop leading to higher yield and subsequently higher energy gains.

Two hand-weedings recorded the maximum energy-use efficiency, followed by clomazone + hand-weeding. The results are in conformity with the findings of Billore *et al.* (1992). The differences in energy-use efficiency may be due to the differences in their energy inputs and outputs of respective treatments.

Thus soybean crop should be sown in either 30 cm × 10 cm or 20 cm × 15 cm crop geometry, using varity 'JS 335' to obtain higher production and profitability. Weed management by 2 hand-weedings or clomazone + hand-weeding gave similar yield and additional net returns. However, total reliance on hand-weeding does not appear practical due to non-availablility of labour at peak time of demand on large scale. Therefore, an approach of intergrated weed control by pre-emergence application of clomazone, followed by hand-weeding at 40 days after sowing is recommended.

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