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Productivity and economics of soybean (*Glycine max*)-based cropping sequences under irrigated conditions

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ABSTRACT

A field experiment was conducted during 1995–97 at Rahuri, to study the productivity and economics of soybean [*Glycine max* (L.) Merr.]-based cropping sequences under irrigated conditions. The total grain equivalent of soybean–chickpea (*Cicer arietinum* L.) (65.92 q/ha) was significantly higher than the rest of sequences. Next in order was soybean–wheat (*Triticum aestivum* L. emend. Fiori & Paol.) (50.60 q/ha) and lowest was in groundnut (*Arachis hypogaea* L.)–wheat (41.61 q/ha). Optimum level of irrigation (at all critical growth stages) recorded the maximum grain-equivalent yield than suboptimum (elimination of 1 irrigation from recommended CGS). The total consumptive use (CU) was maximum in soybean–wheat (55 cm), while water-use efficiency (WUE) was higher in soybean–chickpea (153 kg/ha-cm). The total CU and WUE were 24% higher and 20% lower respectively in optimum as compared to suboptimum irrigation. The soybean–chickpea sequence gave significantly higher gross (Rs 59,274/ha) and net returns (Rs 46,530/ha) than rest of sequences, followed by soybean–wheat sequence. The per day productivity (Rs 270/day/ha) and returns per unit of water used (Rs 1,398/ha-cm) were maximum in soybean–chickpea (4.65) than other sequences studied. The optimum irrigation recorded significantly higher gross and net returns than suboptimum irrigation. The returns per unit of water used were 15% lower in optimum irrigation than suboptimum irrigation (Rs 1,049/ha-cm).

Key words : Soybean-based crop sequences, Productivity, Irrigation, Economics

Among all the oilseed crops, soybean has occupied third place in the edible oil scenario of India. Maharashtra ranks second in terms of production of soybean in the country. Although. the soybean is a new crop in the state, the area under this crop is increasing day by day, as it can profitably replace the other legumes like mungbean, blackgram, pigeonpea etc. Also, it can replace rainy-season (*kharif*) sorghum in Western Maharashtra. Its cultivation is mostly confined to the rainy season with protective irrigations. After soybean, different winter crops like wheat, safflower, sunflower, chickpea and Indian mustard are grown under irrigated conditions. Grain

legumes play an important role in improving and maintaining soil fertility and increasing the growth and yield of succeeding crops (Dhama and Sinha, 1985). In view of this, an experiment was conducted to study the productivity and economics of soybean- based cropping sequences under irrigated conditions.

MATERIALS AND METHODS

The field experiment was conducted for 3 consecutive years during 1995–97 at Water Management Project, Rahuri, under irrigated conditions. The soil was clay loam, very low in available nitrogen (116.7 kg/ha), medium in available P_2O_5 (18.47 kg/ha) and very high in available K_2O (737.4 kg/ha), with pH 8.3. The treatments comprised 6 crop sequences, viz. soybean–wheat, soybean–safflower (*Carthamus tinctorius* L.), soybean–sunflower (*Helianthus annuus* L.), soybean–chickpea (*Cicer arietinum* L.), soybean–mustard [*Brassica juncea* (L.) Czernj. & Cosson] and groundnut–wheat, in main plot and 2 irrigation treatments, viz. optimum irrigations based on critical growth stages and suboptimum irrigation (elimination of 1 irrigation from recommended CGS in subplots (Table 1). The experiment was laid in split-plot design with 3 replications on fixed site for all the crops. The recommended cultural practices were followed for all the crops (Table 2). Soybean-were equivalent was calculated by converting the grain yield of winter crop into soybean grain yield on the basis of selling prices during respective years. The economics was calculated on the basis of prevailing market prices of respective crops

Table 1. Number of irrigations applied

Crop sequence	Rainy season		Winter season	
	Optimum	Suboptimum	Optimum	Suboptimum
Soybean–wheat	4	3	5	4
Soybean–safflower	4	3	3	2
Soybean–sunflower	4	3	4	3
Soybean–chickpea	4	3	3	2
Soybean–mustard	4	3	4	3
Groundnut–wheat	3	2	5	4

Table 2. Recommonded cultural practices followed in different crops

Crop	Variety	Seed rate (kg/ha)	Spacing (cm × cm)	Fertilizer applied (kg/ha)		
				N	P_2O_5	K_2O
Soybean	'MACS 124	75	30 × 10	50	100	00
Wheat	'HD 2189	100	22.5	120	60	60
Safflower	'Bhima'	10	45 × 20	50	25	00
Sunflower	'Morden'	10	60 × 30	60	30	30
Chickpea	'Vijay'	75	30 × 10	25	50	00
Mustard	'Seeta'	5	45 × 15	50	25	00
Groundnut	'SB XI'	100	30 × 10	25	50	00

Table 3. Soybean grain-equivalent yield (q/ha) as affected by crop sequence and irrigation

Treatment	1995			1996			1997			Pooled mean		
	Rainy season	Winter season	Total	Rainy season	Winter season	Total	Rainy season	Winter season	Total	Rainy season	Winter season	Total
Crop sequence												
Soybean–wheat	24.56	22.93	47.48	28.01	27.87	55.83	27.78	20.73	48.51	26.78	23.84	50.61
Soybean–safflower	25.46	23.06	49.02	28.88	19.26	48.09	25.29	12.55	37.84	26.71	18.29	45.02
Soybean–sunflower	25.40	19.69	45.08	32.74	12.90	45.64	27.89	14.28	42.17	28.68	15.62	44.30
Soybean chickpea	27.30	33.55	60.85	27.81	42.94	70.74	25.40	38.28	63.68	26.84	38.25	65.92
Soybean–mustard	26.55	13.55	40.16	32.44	17.49	49.30	24.60	16.16	40.76	27.86	15.73	43.62
Groundnut–wheat	16.34	22.20	38.74	15.62	27.50	43.13	22.65	20.32	42.97	18.27	23.34	41.61
CD (P = 0.05)		6.08	7.40	3.86	10.10	10.89	NS	2.00	4.65	5.04	6.65	5.98
Irrigation												
Optimum	24.09	22.49	46.59	27.88	26.18	54.06	25.47	21.47	46.94	25.81	23.38	49.20
Suboptimum	24.68	22.50	47.18	27.28	23.14	50.42	25.44	19.30	45.04	25.90	21.62	47.55
CD (P = 0.05)			NS		2.08	3.12		1.03	NS	NS	NS	NS

on pooled basis.

RESULTS AND DISCUSSION

Soybean grain-equivalent yield

The total productivity measured in terms of soybean-grain equivalent yield was significantly affected by crop sequences (Table 3). The grain-equivalent yield of soybean was significantly higher in soybean-based crop sequences than ruling groundnut–wheat cropping sequence. The highest soybean grain–equivalent yield was recorded in soybean–chickpea sequence, which was significantly higher than the rest of sequences. Soybean–wheat sequence proved to be next best crop sequence, which also recorded significantly higher soybean grain equivalent yield than remaining sequences except soybean–safflower. Soybean–chickpea sequence was most productive, followed by soybean–wheat sequence (Singh *et al.* 1993). The good potential yield and reasonable market price of chickpea were major factors responsible for higher production of soybean grain equivalent yield under soybean-based crop sequence. The lowest soybean grain-equivalent yield was found in groundnut–wheat being 24.31 q/ha lower than soybean–chickpea sequence. All the crop sequences recorded the maximum soybean grain-equivalent yield under optimum irrigation than suboptimum irrigation on pooled basis. Similar results were obtained during individual years except 1995, where yield was slightly increased at suboptimum irrigation treatment.

Moisture

In soybean-based cropping sequence (Table 4) the mean consumptive use was maximum in soybean–wheat sequence and minimum in groundnut–wheat sequence and soybean–chickpea sequence, but reverse trend was observed in water-use efficiency (WUE). The WUE was highest in soybean–chickpea sequence (153.62 kg/ha-cm) and lowest in soybean–wheat sequence (90.56 kg/ha-cm). The mean consumptive use in optimum irrigation treatment was 24% higher (51.48 cm) than

Table 4. Water used by different soybean-based crop sequences (mean) during 1995–97

Treatment	Profile depletion (cm)	Effective rainfall (cm)	Irrigation applied (cm)	Total water (cm)	Consumptive use (cm)	Soybean grain equiavalent (q/ha)	WUE (kg/ha-cm)
Crop sequence							
Soybean–wheat	48.63	7.25	56.10	63.35	55.88	50.606	90.56
Soybean–safflower	42.71	6.05	41.48	47.63	48.76	45.016	92.32
Soybean–sunflower	41.55	6.25	49.86	56.11	47.80	44.298	92.67
Soybean–chickpea	35.01	7.36	42.83	50.19	42.37	65.092	153.62
Soybean–mustard	39.73	7.36	48.05	55.41	47.09	43.617	92.62
Groundnut–wheat	33.00	7.25	46.35	53.06	40.25	41.608	103.00
Irrigation							
Optimum	44.56	6.92	53.09	60.01	51.48	49.197	95.56
Suboptimum	34.41	6.92	41.83	48.75	41.33	47.548	115.04

Table 5. Economics of soybean-based crop sequences and irrigation levels (1995–97)

Treatment	Gross returns (Rs/ha)				Net monetary returns (Rs/ha)				Benefit : cost ratio	Productivity (Rs/day ha)	Returns/ unit of water (Rs/ha/cm)
	1995	1996	1997	Pooled	1995	1996	1997	Pooled			
Crop sequence											
Soybean–wheat	44,930	52,819	46,659	48,136	31,520	39,461	33,249	34,743	3.59	216	861
Soybean–safflower	42,722	45,605	39,843	41,056	31,767	34,862	23,888	30,172	3.77	178	842
Soybean–sunflower	31,741	42,578	39,300	37,872	25,439	31,614	28,890	28,647	4.10	187	792
Soybean–chickpea	53,304	65,667	58,853	59,274	40,894	52,602	46,443	46,530	4.65	270	1,398
Soybean–mustard	35,273	46,563	37,762	39,866	24,318	35,675	26,807	28,933	3.64	197	846
Groundut–wheat	39,786	42,602	41,449	41,279	24,286	27,106	26,039	25,810	2.66	185	1,025
CD (P = 0.05)	7,803	8,789	4,460	5,695	5,327	8,782	44,60	5,336			
Irrigation											
Optimum	42,105	51,243	44,057	45,801	31,141	38,494	31,723	33,747	3.79	210	889
Suboptimum	40,479	47,369	42,232	43,360	28,268	35,279	30,048	31,198	4.26	199	1,049
CD (P = 0.05)	NS	2803	NS	1,398	NS	2,822	NS	1,572			

sub-optimum irrigation treatment (41.33 cm), and WUE was 20% (115.04 cm) in suboptimum irrigation compared to optimum irrigation compared to optimum irrigation (95.56 kg/ha-cm).

Economics

The pooled data on economics of different crop sequences indicated that the soybean-chickpea sequence gave significantly higher gross (Rs 59,274/ha) and net returns (Rs 46, 530/ha) than rest of sequences, followed by soybean-wheat sequence (Table 5). Similar results were reported by Tomar *et al.* (1996), Dwivedi *et al.* (1995). Based on net returns and B:C ratio, the soybean-wheat sequence was found optimum under Pantnagar conditions (Singh and Lal, 1994). The lowest gross returns were obtained from groundnut-wheat sequence. The per day productivity based on gross returns was maximum in soybean-chickpea (Rs 270/day/ha) followed by soybean-wheat sequence (Rs 216/day/ha). The soybean-chickpea sequence recorded the maximum returns per unit of water (Rs 1,398ha-cm); next in order were groundnut-wheat (Rs 1,025/ha-cm) and soybean-wheat (Rs 861/ha-cm). The benefit cost ratio was also the highest in soybean-chickpea (4.65) and lowest in groundnut wheat sequence. The optimum irrigation applied as per critical growth stages of the crop under sequences recorded significantly higher net monetary returns (Rs 33, 347/ha) over sub-optimum irrigation by eliminating one irrigation at CGS in which net returns were lower (Rs 31,198/ha). Khot *et al.* (1998) also reported the maximum grain yield under optimum irrigation levels in chickpea based crop sequences. The per day productivity was 6 per cent higher in optimum irrigation than sub-optimum irrigation (Rs 199/ha-cm). The returns per unit of water use was 15 per cent lower in optimum irrigation than sub-optimum irrigation (Rs 1049/ha-cm).

Hence soybean–chickpea was found to be the most remunerative and profitable crop sequence in scarcity tract of Maharashtra, whereas soybean–wheat proved to be the next best crop sequence with optimum irrigations to both the crops in the crops sequences.

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