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Soybean (*Glycine max*) growth, productivity and water use under different sowing methods and seeding rates in Punjab

HARI RAM*, GURIQBAL SINGH, NAVNEET AGGARWAL AND JAGMEET KAUR

Punjab Agricultural University, Ludhiana, Punjab 141 004

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ABSTRACT

A field experiment was conducted from 2006 to 2008 to study the effect of four sowing methods namely raised bed planting (67.5 cm wide, 2 rows per bed), raised broad bed planting (135 cm wide, 4 rows per bed), ridge-furrow sowing (60 cm spacing) and flat sowing (45 cm spacing) and three seeding rates i.e. 50, 62.5 and 75 kg/ha in soybean [Glycine max (L.) Merrill]. The highest photosynthetically active radiation interception (PARI) and net returns were recorded in raised bed planting. The highest seed yields was recorded in raised bed sowing, which was 6.70 and 5.29% higher than ridge-furrow and flat sowing methods, respectively. The highest water productivity was recorded in raised broad bed sowing which was significantly higher than flat sowing and ridge-furrow sowing methods but statistically on par with raised bed sowing. Seed rate of 50 kg/ha recorded highest crop growth rate (CGR) and pods per plant whereas the highest PARI was observed with 75 kg/ha seed rate, which was statistically on par with 62.5 kg/ha seed rate but significantly higher than 50 kg seed/ha. The soybean productivity and net returns were highest with 62.5 kg/ha seed rate.

Key words : Planting methods, Seed rate, Seed yield, Water productivity

Continuous rice-wheat cropping sequence in Punjab and the entire Indo-Gangetic Plains (IGP) has resulted in a number of ecological and other disorders like development of hardpan, low input use efficiency including water, more incidence of insects-pests, etc. besides environmental pollution through emission of gases (Prasad, 2005). Consequently, water is expected to be the most scarce ecological factor and costly input in determining agricultural production. Due to large scale cultivation of rice, the demand for water for irrigation has risen tremendously, thereby causing a serious imbalance in the availability and the consumption of water. Ground water extraction is far greater than recharge, so in 66% area of central Punjab, water table will go as deep as 70-160 feet by 2023.

Diversification of 0.5 million hectares areas under rice by other crops including soybean would result in saving of 77500 ha-m of water (Hira, 2009). Soybean [*Glycine max* (L.) Merrill] is an important crop with high protein and oil content. It is also used to make soya milk, tofu, soynuts, etc. During 2008, it was grown on an area of 9.6 m ha in India with a production of 9.0 million tonnes and productivity of 942 kg/ha (AICRPS, 2010). Furthermore, the furrow irrigated raised bed planting can save considerable amount of irrigation water and maximize water productivity (Dhindwal *et al.,* 2006). Also raised bed planting reduces seed rate and provides favourable environment for the growth and development of the soybean (Ram and Kler, 2007). The present investigation therefore planned and conducted to study the growth, yield, economics and water productivity in soybean under different planting systems and different seed rates.

MATERIALS AND METHODS

The field experiment was conducted at the Punjab Agricultural University, Ludhiana (30° 56' N, 75° 52' E; 247 m above m.s.l), Punjab during 2006-2008. The soil type was deep alluvial loamy sand, Typic Ustochrept, low in organic carbon (4.2 g C/kg at 0-15 cm), slightly alkaline (pH 8.2), medium in available Olsen P (13.8 kg/ha) and ammonium acetate extractable K (170.3). The rainfall of 482.3, 409.5 and 886.3 mm was received during year 2006, 2007 and 2008, respectively. Higher incidence of yellow mosaic virus was observed on soybean in 2007 than in 2006 and 2008. The experiment was conducted in split plot design with three replications. Four sowing methods, namely, raised bed (67.5 cm wide, 2 rows per raised bed), raised broad bed (135 cm wide, 4 rows per

***Corresponding author Email**: hr_saharan@yahoo.com

raised bed), ridge-furrow (60 cm spacing) and flat bed (45 cm spacing) were the main plots, three seeding rates of 50, 62.5 and 75 kg/ha were the sub-plots. The raised beds were formed after conventional tillage. The soybean crop (variety SL 525) was sown on 10-16 June and harvested on 25-30 October in different years of study. The recommended fertilizer dose of 30 kg N and 60 kg P_2O_5/ha was applied as urea (46% N) and single superphosphate (16% P_2O_5) before sowing soybean. Stomp 30 EC (pendimethalin) at 1.5 litres/ha was applied as pre-emergence, followed by one hand weeding at 40 days after sowing to control weeds. The crop received 3, 4 and 2 irrigations in 2006, 2007 and 2008, respectively. Irrigation water applied varied from 80 mm-ha in raised broad bed in 2008 to 300 mm-ha in flat bed in 2007 (Table 1).

Five plants per plot were selected for plant dry matter accumulation, sun dried and then dried in an oven at 60±5°C. The data on plant dry weight at 30, 45 and 60 days after sowing (DAS) were collected to calculate crop growth rate (CGR). The data on photosynthetically active radiation interception (PARI) were recorded at the time of initiation of flowering. The data on plant height, yield attributes and yield were collected at harvest. Soil samples for moisture content were taken from various depths upto 180 cm depth for moisture content at sowing and at harvest. Water use and water productivity were calculated using standard methods. The gross returns, cost of cultivation, net returns and benefit: cost ratio (B: C ratio) were calculated by using prevailing prices of inputs and outputs. All the data were subjected to analysis of variance (ANOVA) as per the standard procedure.

RESULTS AND DISCUSSION

Growth analysis

Conventionally flat sown crop recorded the highest crop growth rate (CGR) at 30-45 days after sowing (DAS) which was statistically on par with raised bed sowing but significantly higher than raised broad bed and ridge-furrow sowing methods (Table 2). However at 45-60 DAS, CGR was found to be highest in raised bed planting method, which was significantly higher than ridge-furrow method but statistically on par with all the other planting methods. Ram and Kler (2007) also recorded better CGR of soybean in raised bed planting. The seed rate of 50 kg/ha recorded the highest CGR at both the stages of growth and was significantly higher than 75 kg/ha, but on par with 62.5 kg/ha. It could be due to the reason that more space, water and nutrient availability for the growth of the plants with lower seed rate (50-62.5 kg/ha). Planting method x seed rate interaction was not significant.

Table 1. Irrigation water applied in different sowing methods in soybean during different years

Planting methods	Total irrigation water applied (mm/ha) 2006	2007	2008
Raised bed sowing	180	240	120
Raised broad bed	120	160	80
Ridge-furrow	180	240	120
Flat	225	300	150

The highest PAR interception was recorded in raised bed planting which was 5.5% higher and significantly higher than raised broad bed planting but was on par with flat and ridge-furrow planting systems. Raised broad bed, flat and ridge-furrow planting systems were on par with each other. Ram and Kler (2007) also reported that bed planting of soybean improved light penetration in middle and bottom of crop canopy resulting in dry matter accumulation.

Seed rate also influenced the PAR interception significantly. Highest PAR interception was observed in seed rate of 75 kg/ha, which was statistically on par with 62.5 kg/ha but significantly higher than 50 kg seed/ha. It might be due to higher plant population and taller plant height in higher seed rate treatments which developed the better crop canopy. Planting method x seed rate interaction was not significant.

Tallest plants were obtained in flat bed planting, significantly taller than raised broad bed and furrow-ridge method. It might be due to better growth (CGR) and closer spacing in these treatments. The plant height recorded in 75 kg seed rate/ha was the highest, was significantly higher than 50 kg seed/ha Lone *et al.* (2010) also recorded higher soybean plant height in higher seed rate treatments. Planting methods x seed rate interaction was not significant.

Yield attributes and yield

Planting methods did not differ significantly in respect of yield attributes (pods/plant, seeds/pod, seed index) and seed and straw yield of soybean. These findings differ from those of seed rate also did not significantly affect seeds/pod, seed index and seed yield. However, pods/plant was the highest with the seed rate of 50 kg/ha and significantly decreased with each increment of 25 kg/ha in seed rate. The seed rate of 75 kg/ha produced significantly more straw than 50 kg/ha. Kaur (2003) who recorded better soybean seed yield under raised bed planting than flat planting at Ludhiana.

Water use and water productivity

Water use was maximum in flat bed sowing (Table 3), while the minimum water use was observed in raised broad bed sowing. In all the three years of study, the highest water productivity was recorded in raised broad bed

sowing, which was significantly higher than flat sowing but statistically on par with raised bed sowing and ridge-furrow sowing methods in 2006 and 2007, whereas in 2008 the differences were not significant. Water use efficiency was reported to be the highest with fresh raised bed system, followed by renovated raised bed and conventional tillage, respectively (Aggarwal *et al.,* 2002). Khatri *et al.* (2001) observed that raised bed planting gave similar grain yield of wheat under raised bed and flat bed planting but with sizeable saving in irrigation water. In 2006, the highest water productivity was recorded in 50 kg/ha seed rate, which was statistically on par with 62.5 kg seed rate/ha but significantly higher than 75 kg/ha seed rate. However, in 2007, 2008 and on pooled basis, differences in water productivity due to seed rate are not significant.

Economics

The highest net returns and B:C ratio recorded in raised bed sowing which were significantly higher than flat bed and ridge furrow methods of planting (Table 4). As compared to this Jain and Dubey (1998) reported higher net return with ridge sowing of soybean. As regards seed rates, net return and B.C ratio, 50 and 62.5 kg/ha were at par and significantly superior to 75 kg/ha. Lone *et al.* (2010) also reported higher net reruns with 60 kg/ha of seed rate.

It is concluded that raised bed, raised broad bed and ridge furrow sowing of soybean should be advocated over flat bed sowing mainly due to their ability to save irrigation water. The seed rate for soybean recommended is 62.5 kg/ha.

Table 2. Effect of planting methods and seed rate on mean crop growth rate (2 years mean), photosynthetically active radiation interception (PARI), plant height, pods/plant, seeds/pod, seed index, straw yield, seed yield and harvest index of soybean (pooled mean of 3 years)

Treatment	Mean crop growth rate ($g/m^2/day$)		PARI (%) at pod initiation	Plant height (cm)	Pods/ plant	Seeds/ pod	Seed index (g)	Straw yield (t/ha)	Seed yield (t/ha)	Harvest Index (%)
	A	B								
Planting method										
Raised bed	36.0	36.2	81.1	72.6	53.9	2.47	10.45	4.79	2.39	33.69
Raised broad bed	34.6	32.2	75.6	70.5	52.5	2.52	10.72	4.58	2.32	34.45
Ridge-furrow	33.7	31.6	79.9	71.3	53.8	2.38	10.43	4.52	2.24	33.23
Flat	36.2	36.1	79.0	74.0	53.1	2.38	10.32	4.76	2.27	32.48
SEm±	0.5	1.8	2.2	1.0	0.5	0.05	0.16	0.10	0.06	0.79
CD (P=0.05)	1.2	4.0	4.5	2.1	NS	NS	NS	NS	NS	NS
Seed rate (kg/ha)										
50	36.6	35.4	75.9	69.7	56.6	2.41	10.50	4.56	2.30	34.23
62.5	35.2	33.5	79.8	72.1	53.9	2.46	10.54	4.67	2.33	33.59
75	32.6	32.1	81.0	74.3	49.4	2.46	10.41	4.72	2.29	32.58
SEm±	1.2	0.9	2.0	1.8	2.9	0.02	0.05	0.07	0.02	0.65
CD (P=0.05)	3.5	2.9	4.5	2.1	2.5	NS	NS	0.15	NS	NS

A: 30-45 days after sowing; B:45-60 days after sowing

Table 3. Water expense, water productivity, gross returns, cost of cultivation, net returns and B:C ratio (pooled mean of 3 years) in soybean as influenced by planting methods and seed rate

Treatment	Water use (mm)				Water productivity (g seed yield/litre of water)				Gross returns	Net returns	B:C ratio
	2006	2007	2008	Mean	2006	2007	2008	Mean	($\times 10^3$ ₹/ha)	($\times 10^3$ ₹/ha)	
Planting method											
Raised bed	722	709	1,066	832	0.38	0.24	0.26	0.29	29.2	14.4	2.12
Raised broad bed	662	629	1,026	772	0.41	0.26	0.26	0.31	28.4	14.9	2.10
Ridge-furrow	722	709	1,066	832	0.36	0.22	0.24	0.27	27.4	13.7	1.99
Flat	767	769	1,096	877	0.35	0.19	0.24	0.26	27.8	13.9	2.00
SEm±	-	-	-	-	0.02	0.02	0.01	0.02	0.3	0.5	0.05
CD (P=0.05)	-	-	-	-	0.05	0.04	NS	0.03	0.7	0.8	0.10
Seed rate (kg/ha)											
50	718	704	1,064	828	0.39	0.22	0.23	0.28	28.1	14.9	2.14
62.5	718	704	1,064	828	0.38	0.22	0.25	0.28	28.5	15.1	2.13
75	718	704	1,064	828	0.35	0.23	0.26	0.28	28.0	14.2	2.04
SEm±	-	-	-	-	0.01	0.01	0.01	0.01	0.2	0.3	0.04
CD (P=0.05)	-	-	-	-	0.03	NS	NS	NS	0.4	0.6	0.07

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