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Performance of sorghum (*Sorghum bicolor*) + soybean (*Glycine max*) intercropping system under varying fertility regimes in Malwa region

R. K. S. RAGHUWANSHI, RAJIV UMAT, A. K. GUPTA AND N. S. GURJAR

All-India Co-ordinated Cropping Systems Research Project, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Indore, Madhya Pradesh 452 001

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Soybean [*Glycine max* (L.) Merr.] and sorghum [*Sorghum bicolor* (L.) Moench] are of great importance in their respective groups, i.e. cereals and legumes, for food, fodder and for industrial use. Keeping this in view, an investigation was carried out to study effect of integrated nutrient-management practices on yield and economics of soybean and sorghum grown together under intercropping system, which are physiologically and morphologically different in nature.

The field experiment was conducted during the rainy (*kharif*) seasons of 1988 and 1989 at Indore. The soil was typical medium black and had clay 55.0%, sand 17.0%, silt 28.0%, $CaCO_3$ 2.6%, cation-exchange capacity 43.50 meq/100 g and 0.16 dS/m at 25°C, with pH 7.5. Available N, P and K were 232 kg, 15 kg and 718 kg/ha respectively. The experiment was laid out in the randomized block design with 4 replications. The total rainfall during 1988 at Indore was 1,043.11 mm and during 1989 it was 539 mm. A basal application of P_2O_5, K_2O and half of N was made in sorghum at sowing. The other half of N was applied at 25–30 days after sowing. Full quantity of nitrogen, phosphorus and potash were applied to soybean according to treatments requirement.

The sowing of both crops (sorghum and soybean) was done on 23 June 1988 and 19 June 1989 by hand at the depth of about 2–3 cm in proper rows and harvesting of soybean and sorghum was done on 13 October 1988 and 10 October 1989 respectively. Recommended levels of 100, 75 and 50% of N, P_2O_5 and K_2O respectively were 100, 60 and 40 kg/ha; 75, 45 and 30 kg/ha; and 50, 30 and 20 kg/ha for sorghum. The respective doses were 20, 60 and 20; 20, 45 and 20; and 20, 30 and 20 kg/ha for soybean.

The test weight of sorghum was significantly affected by the fertilizer doses applied to soybean during both the years (Table 1). Out of 3 levels of fertilizer applied to soybean, F_{100} (100% recommended level of fertilizer) produced the boldest grains of sorghum, with the test weight of 22.9 and 22.0 g during both the years and it was superior to F_{75} (75% of recommended level) and F_{50} (50% of recommended level). The test weight of sorghum was not found to be significantly affected by the fertilizer doses applied to sorghum.

Similarly, boldest seeds of soybean were produced under treatment T_2 (MC F_{100}) with a test weight of 116.2 g. This treatment was on a par with T_3 (MC F_{100} + IC F_{100}) but significantly superior to rest of the treatments. Amongst the intercropping

Table 1. Effect of different levels of fertilizers on grain yield, test weight, land-equivalent ratio (LER) and net profit (Rs/ha) in sorghum + soybean intercropping system

Treatment	Grain yield (q/ha)				Test weight (g)				LER		Net profit (Rs/ha)		Gross return (Rs/ha)		Cost of cultivation
	A		B		A		B		A	B	A	B	A	B	
	Sor-ghum	Soy-bean	Sor-ghum	Soy-bean	Sor-ghum	Soy-bean	Sor-ghum	Soy-bean							
T_1, MC F_{100}	37.62		34.25		21.3		21.4		1.00	1.00	4,414	4,581	7,714	7,881	3,300
T_2, IC F_{100}		18.80		17.32		116.2		116.2	1.00	1.00	5,748	6,163	9,233	9,648	3,485
T_3, MC F_{100} + IC F_{100}	20.50	10.60	20.00	10.00	22.0	116.0	22.00	116.0	1.10	1.16	5,421	6,603	8,813	9,995	3,392
T_4, MC F_{100} + IC F_{75}	19.80	9.50	19.87	8.50	21.8	108.0	21.50	107.2	1.04	1.04	4,856	5,734	8,204	9,082	3,348
T_5 MC F_{100} + IC F_{50}	18.42	7.92	17.55	7.00	21.2	103.0	21.50	107.0	0.92	0.94	3,870	4,421	7,175	7,726	3,305
T_6 MC F_{75} + IC F_{75}	17.30	9.02	17.20	8.50	20.8	107.0	20.70	98.0	0.96	0.96	4,330	5,076	7,628	9,004	3,298
T_7 MC F_{75} + IC F_{100}	19.37	10.23	18.25	9.00	22.9	115.0	22.00	109.2	1.10	1.07	5,992	6,599	9,334	9,841	3,342
T_8 MC F_{100} + IC F_0	17.25	5.25	19.12	6.55	20.4	95.0	21.00	95.7	0.73	0.85	3.288	4,087	6,505	7,304	3,217
CD (P = 0.05)	2.34	0.72	1.50	1.09	0.80	3.50	0.94	3.89	0.064	0.07	422	623			

A, 1988–89; B, 1989–90
MC, Main crop; IC, intercrop

treatments, T_3 recorded the maximum test weight (116.0 g), whereas the lowest test weight (95.0 and 95.7 g) was observed under treatment T_8 during both the years.

The maximum grain yield of sorghum was recorded under treatment T_1 (MC F_{100}), as it was a treatment in which 100% of area was allotted to the main crop (sorghum). Amongst intercropping treatments, highest grain yield was noted in the treatment T_3 (MC F_{100} + IC F_{100}) which was on a par with T_4 (MC F_{100} + IC F_{75}) and T_7 (MC F_{75} + IC F_{100}) during both the years, but significantly superior to rest of the intercropping treatments.

Since treatments T_3, T_4 and T_7 were statistically at par, it may be deduced that quantity of fertilizers applied to the sorghum–soybean intercropping system may be curtailed to a certain extent (up to a level of T_4 or T_7) without causing any significant reduction in the grain yield of sorghum, thereby reducing the cost of cultivation on one hand and increasing the net return/ha on the other.

The grain yield of sorghum was also significantly affected by the fertility levels applied to sorghum and soybean crops. Amongst fertility levels applied to sorghum, F_{100} (100% of recommended dose) gave the maximum yield and it was significantly superior to F_{75} (75% of recommended level). Amongst fertilizer doses applied to soybean, F_{100} gave the highest grain yield and it was significantly superior to F_{75} and F_{50}. Raghuwanshi *et al.* (1988) also reported increase in the grain yield of sorghum with increasing rates of fertilizer application.

As in sorghum the seed yield of soybean too was maximum under T_2 (IC F_{100}), as it was a sole cropping treatment. Treatment T_2 gave highest grain yield of 18.80 and 17.32 q/ha and hence it was significantly superior to rest of the treatments. Amongst the intercropping treatments, T_3 (MC F_{100} + IC F_{100}) gave the highest grain yield and it was found on a par with T_7 (MC F_{75} + IC F_{100}) but significantly superior to rest of the intercropping treatments. Here too we find that a substantial quantity of fertilizer can be saved by adopting T_7 (MC F_{75} + IC F_{100}) instead of T_3 (MC F_{100} + IC F_{100}) without any significant reduction in the seed yield of soybean.

The seed yield of soybean (Table 1) was not found to be significantly affected by the fertility levels applied to sorghum. However, it was significantly affected by the doses applied to soybean. The highest seed yield of soybean during both the years was recorded from F_{100} (100% of recommended level), which was significantly superior to F_{75} and F_{50} (Upadhyay *et al.*, 1988).

The grain yield of sorghum and of soybean were also found to be significantly influenced by the interaction of sole crop versus control versus rest.

Higher land-equivalent ratio was recorded under treatment T_3 (MC F_{100} + IC F_{100}) which was significantly superior to rest of the treatments during both the years. Increase in land-equivalent ratio as a result of intercropping of soybean with sorghum was also reported by Mohta and De (1980).

The highest net profit was obtained in treatment T_7 (MC F_{75} + IC F_{100}) during both the years, which was significantly superior to all the treatments except T_2 and T_3 (100 % fertilizer) treatments (pure stand of soybean). However, during the first year maximum net return was obtained in T_3 (MC F_{100} + IC F_{100}), which was on a par with T_2 (IC F_{100}) and T_7 (MC F_{75} + IC F_{100}) and significantly superior to rest of the treatments (Table 1). The results confirm the findings of Willey *et al.* (1982). The data of

Table 2. Soil-fertility status (kg/ha) as affected by sorghum + soybean intercropping system

Treatment	1988–89						1989–90					
	Before sowing			After harvesting			Before sowing			After harvesting		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1	259	23	647	253	22.0	641	258	21.5	644	253	20	640
T_2	260	23	647	264	21.5	645	261	24	650	263	20	646
T_3	263	22	650	263	22.0	643	264	23.5	645	261	23	643
T_4	262	22.5	644	263	22.5	651	259	22	647	258	21.5	649
T_5	260	23	647	259	22	645	261	21	639	259	21	644
T_6	262	22	643	260	23.5	642	261	23	648	257	22	647
T_7	262	24	645	264	23.5	648	260	21	649	265	22	465
T_8	260	21	647	254	21.5	645	263	22.5	648	261	21.5	641

Details of treatments are given in Table 1 soil-fertility status data show that the availability of N, P and K were in the range of medium, high and very high amounts.

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Effect of seed rate and nitrogen level on new genotypes ('PBW 154' and 'PBW 222') of wheat (*Triticum aestivum*)

J. S. SAMRA AND S. S. DHILLON

Wheat Section, Department of Plant Breeding, Punjab Agricultural University, Ludhiana 141 004

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A field experiment was conducted during the winter seasons (*rabi*) of 1988–89 and 1989–90 to study the effect of seed rate and N level on genotypes of soil (*Triticum aestivum* L. emend. Fiori & Paol.) wheat on sandy-loam at Ludhiana. The soil contained 0.3% organic carbon, 116, 17 and 146 kg/ha of available N, P and K respectively. The treatment comprised 2 genotypes ('PBW 154' and 'PBW 222') of wheat and 4 levels (0, 60 120 and 180 kg/ha) of N, allocated in man plots and 4 seed rates (75, 90, 105 and 120 kg/ha) in subplots. The experiment was laid out in split-plot design with replications. A basal dose of 60 kg P_2O_5 and 30 kg K_2O/ha was uniformly applied at the time of sowing. N as per treatments was applied, half at sowing and remaining half with first irrigation. The crop was sown on 5 and 30 November and harvested on 16 April and 2 May during 1988--89 and 1989--90 respectively.

Both the genotypes varied markedly in respect of grain yield. 'PBW 222' wheat recorded higher mean grain yield than 'PBW 154' (Table 1). However, the differences were not significant. The higher mean grain yield recorded in 'PBW 222' may be due to higher number of tillers and ears/m row length. The variety 'PBW 154' recorded