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Effect of nitrogen level and spacing on sorghum intercropped with pigeonpea and greengram in semi-arid lands

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ABSTRACT

On rainfed lands at Rajendranagar and Patancheru, both in Hyderabad, Andhra Pradesh, sorghum [*Sorghum bicolor* (Linn.) Moench.] showed a marked response to applied N both under sole cropping and intercropping with pigeonpea [*Cajanus cajan* (Linn.) Millsp.] or greengram [*Vigna radiata* (Linn.) Wilczek]. but the response decreased with an increase in the N level (0, 40 and 80 kg/ha). Intercropping with pigeonpea and greengram reduced sorghum yield by 9 and 5% respectively. The 3 row spacings (45, 67.5 and 90 cm) did not affect sorghum and pigeonpea, which seemed to have greater plasticity to row width. Greengram yielded more with an increase in sorghum row width, because of an increase in the number of greengram plants when sorghum rows were spaced wider Sorghum-pigeonpea intercropping gave an extra benefit of Rs 2,620/ha at Rajendranagar and Rs 1,120/ha at Patancheru, while sorghum-greengram gave Rs 580/ha at Rajendranagar and Rs 700/ha at Patancheru over the cultivation of a sole crop of sorghum.

Intercropping is a potential agronomic practice that can increase the productivity per unit of land and water in the semi-arid tropics. To obtain a yield advantage, there must be some element of 'complementarity', either in time or space, in the way 2 crops utilise the environment (Willey, 1977). The maximum intercropping advantage occurs when the competition between the crops is reduced to a minimum. Intercropping may also offer an insurance when the weather is unfavourable.

In many semi-arid areas the growing season is too long to be effectively utilized by a single crop but too short for successful double-cropping. Sorghum–pigeonpea was found to be a potential intercropping system for the semi-arid regions (Krantz *et al.*, 1974; AICSIP, Hyderabad, 1977).

In some semi-arid areas where rainfall is relatively assured early in the season, the cropping intensity may be increased by having a short-duration intercrop like greengram along with the medium-duration base crops like sorghum or millet.

The experiment reported here was conducted to study the productivity of sorghum-pigeonpea and sorghum-greengram intercropping systems in comparison with sole sorghum under different planting patterns. The response of sorghum to applied N was also studied.

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MATERIALS AND METHODS

An experiment was conducted from July 1976 to January 1977 to study the effect of N levels, spacing and intercropping on sorghum grown on semi-arid lands at the farm of the College of Agriculture, Andhra Pradesh Agricultural University (APAU), Rajendranagar, and the research farm of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, both at Hyderabad. Both the soils are sandy loams, having a pH of 7.5 and a uniform topography. The APAU farm has 0.4% organic carbon, 300 kg/ha available N, 38.5 kg/ha available P, and 413 kg/ha exchangeable K, where as the ICRISAT Farm has 0.35% organic carbon, 250 kg/ha available N, 40 kg/ha available P, and 389 kg/ha exchangeable K.

The design was a split plot with 3 replications. The net plot size was 2.7 m×4.9 m and the gross plot size 3.6 m×8 m. The main plots accommodated 3 N levels—0, 40 and 80 kg N/ha. N was applied to sorghum through urea in 2 splits, 1/4 as basal and 3/4 band-placed 21 days after sowing. The sub-plots had 9 treatments, comprising 3 row spacings (45, 67.5 and 90 cm) under each of the 3 cropping systems (sorghum sole, sorghum-greengram and sorghum-pigeonpea). The varieties used were, sorghum 'CSH 6', greengram 'PS 16', pigeonpea 'ICRISAT 1'. Greengram and pigeonpea intercrops were added to the full sorghum population. In sorghum-pigeonpea intercropping systems the 2 crops were planted in alternate rows. The pigeonpea population of 38,000/ha and the sorghum population of 148,000/ha were constant in all the treatments. But their intra-row spacings were adjusted according to the inter-row spacings. Thus for intra-row spacings of 45, 67.5 and 90 cm, the inter-row spacings were 15, 10 and 7.5 cm in sorghum, and 60, 40 and 30 cm in pigeonpea respectively. Greengram single rows alternated with sorghum at 45-cm row width and 2 and 3 rows alternated at 67.5 cm and 90 cm widths of sorghum respectively. That resulted in 150,000, 225,000 and 250,000 greengram populations at sorghum inter-row spacings of 45, 67.5 and 90 cm respectively.

Single superphosphate was applied @ 22 kg P_2O_5/ha as a basal dose to all plots.

From the rows adjacent to the net plot, 10 plants were cut at the base, dried in an oven for 24 hr at 65°C, the weights were recorded, and the yields per hectare computed. Data collected only at APAU for all the crops and data on intercrops are only presented here. The fodder and grain yields were recorded for each net plot. A life-saving irrigation to pigeonpea was given at APAU after the harvest of sorghum.

For calculating the gross monetary returns, the following market rates were considered. Sorghum grain, Rs 120/q; pigeonpea grain, Rs 260/q; greengram grain, Rs 200/q; sorghum fodder, Rs 10/q.

RESULTS AND DISCUSSION

The results from Rajendranagar and Patancheru revealed similar trends.

Sorghum

Sorghum was highly influenced by N application at both the sites. The increase in grain yield with the application of 40 and 80 kg N/ha was 49 and 62% at Rajendranagar (APAU) and 71 and 93% at Pantancheru (ICRISAT) respectively. The increase in grain yield by the application of 80 kg N/ha over 40 kg N/ha was 9% at APAU and 13% at ICRISAT. Similar observations were made by Raheja and Krantz (1958) and Chari *et al.* (1976). The higher yields through N application were because of longer ears, and an increase in 1,000-grain weight and yield/plant, as reported by Reddi (1977). The higher grain yields with 40 and 80 kg N/ha increased the additional gross returns by Rs 1,170 and Rs 1,520/ha at APAU and by Rs 1,360 and Rs 1,760/ha at ICRISAT, respectively, over the control (Tables 2a, b). The differences between sorghum row spacings were not significant for grain yield (Tables 1a, b), gross monetary returns (Tables 2a, b) and for other yield characters like length, 1,000-

Table 1a. Grain yield (kg/ha) of sorghum at APAU farm

N level	S_1 (45 cm × 15 cm)			S_2 (67.5 cm × 10 cm)			S_3 (90 cm × 7.5 cm)			
	Cropping system									
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	Mean
N_0	1,840	1,650	1,620	1,850	1,550	1,510	1,770	1,640	1,570	1,670
N_{40}	2,720	2,430	2,460	2,720	2,440	2,440	2,690	2,570	2,400	2,540
N_{80}	3,010	2,730	2,640	2,960	2,820	2,660	2,890	2,780	2,690	2,800
Mean for spacing	S_1 2,340			S_2 2,330			S_3 2,330			

Mean for cropping system: I_1 (sorghum sole) 2,490; I_2 (sorghum/greengram) 2,290; I_3 (sorghum/pigeonpea) 2,220

Source of variation	Nitrogen (N)	Spacing (S)	Cropping system (I)	(N×S)	(N×I)	(I×S)	(S×N×I)
'F'	Sig	NS	Sig	NS	NS	NS	NS
SEm±	80	90	90	150	150	150	260
CD at 0.05	230		170				

Table 1b. Grain yield (kg/ha) of sorghum at ICRISAT farm

N level	S_1 (45 cm × 15 cm)			S_2 (67.5 cm × 10 cm)			S_3 (90 cm × 7.5 cm)			
	Cropping system									
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	Mean
N_0	1,390	1,300	1,250	1,560	1,300	1,300	1,320	1,260	1,280	1,330
N_{40}	2,460	2,440	2,310	2,440	2,420	2,280	2,410	2,410	2,340	2,390
N_{80}	2,770	2,750	2,560	2,760	2,710	2,570	2,710	2,730	2,590	2,680
Mean for spacing	S_1 2,140			S_2 2,150			S_3 2,120			

Mean for cropping system: I_1 (sorghum sole 2,200); I_2 (sorghum/green gram) 2,150; I_3 (sorghum/pigeonpea) 2,050

Source of variation	Nitrogen (N)	Spacing (S)	Cropping system (I)	(N×S)	(N×I)	(I×S)	(S×N×I)
'F'	Sig	NS	Sig	NS	NS	NS	NS
SEm±	250	40	40	70	70	70	120
CD at 0.05	690		80				

Table 2a. Gross monetary returns (Rs/ha) at APAU farm

N leve	Spacing									
	S_1 (45 cm × 15 cm)			S_2 (67.5 cm × 10 cm)			S_3 (90 cm × 7.5 cm)			
	Cropping system									
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	Mean
N_0	2,440	2,930	4,910	2,450	3,020	4,980	2,360	3,180	5,110	3,490
N_{40}	3,620	3,860	6,120	3,590	4,120	6,330	3,530	4,390	6,390	4,660
N_{80}	4,040	4,310	6,660	3,990	4,620	6,440	3,890	4,630	6,480	5,010

Mean for spacing S_1 4,320 S_2 4,390 S_3 4,440

Mean for cropping system I_1 (sorghum sole) 3,320; I_2 (sorghum/greengram) 3,900 S_3 (sorghum/pigeonpea) 5,940

Source of variation	Nitrogen (N)	Spacing (S)	Cropping system (I)	(N×S)	(N×I)	(I×S)	(S×N×I)
'F'	Sig	NS	Sig	NS	NS	NS	NS
SEm±	70	130	130	220	220	220	380
CD at 0.05	200		200				

Rates considered for working out gross monetary returns : sorghum grain Rs 120/q; sorghum fodder Rs 10/q; greengram grain Rs 200 q; pigeonpea grain Rs 260/q.

Table 2b. Gross monetary returns (Rs/ha) at ICRISAT farm

N level	Spacing									
	S_1 (45 cm × 15 cm)			S_2 (67.5 cm × 10 cm)			S_3 (90 cm × 7.5 cm)			
	Cropping system									
	I_1	I_2	I_3	I_1	I_2	I_3	I_1	I_2	I_3	Mean
N_0	1,850	2,470	3.070	2,080	2,570	3,060	1,800	2,670	3.080	2.520
N_{40}	3,280	3,910	4.360	3,190	4,090	4,310	3,210	4,140	4,450	3,880
N_{80}	3,750	4,300	4,710	3,750	4,240	4,740	3,680	4,490	4,830	4,280

Mean for spacing S_1 3,520; S_2 3,560; S_3 3,590;

Mean for cropping system I_1 (sorghum sole) 2,950; I_2 (sorghum-greengram) 3,650; I_3 (sorghum-pigeonpea) 4,070

Source of variation	Nitrogen (N)	Spacing (S)	Cropping system (I)	(N×S)	(N×I)	(I×S)	(S×N×I)
'F' test	Sig	NS	Sig	NS	NS	NS	NS
SEm±	130	100	100	170	170	170	290
CD at 0.05	350		190				

Rates considered for working out gross monetary returns : sorghum grain Rs 120/q; sorghum fodder Rs 10/q; greengram grain Rs 200/q; pigeonpea grain Rs 260/q.

grain weight and yield per plant (Reddi, 1977). This was probably because sorghum could adjust to the changes in spatial arrangement as long as the plant population was constant. This suggested that sorghum could be spaced at 90 cm × 7.5 cm to accomodate an intercrop without any detriment to sorghum grain yield.

Sorghum-greengram

Sorghum–greengram system gave Rs 580 and Rs 700/ha more gross returns than the sole crop of sorghum at APAU and ICRISAT respectively (Tables 2a, b). Krantz *et al.* (1976) and Bhalerao *et al.* (1976) also reported similar advantages from this crop combination. Willey and Osiru (1972) attributed the yield advantage of maize and bean mixtures to more efficient utilization of light by the combination of tall maize and short bean. Baldy (1963) suggested the possibility of more efficient extraction of soil water, resulting from the complementarity of rooting depth in the crop mixture. With an increase in the level of N applied to sorghum, there was a significant increase in the yield of greengram dry matter, indicating that the N applied to the main sorghum crop was shared by the intercrop. But the grain yield statistically remained unaffected (Table 3) in greengram, which, like other legumes, did not respond to applied N.

The yield of intercropped sorghum increased at N levels of 40 and 80 kg/ha. But when compared with the sole crop of sorghum the increase was less at all the N levels, the differences being higher at no nitrogen than at 40 and 80 kg N/ha (Table 1b). This trend suggested that, if adequate N fertilizer is provided, intercropping will be helpful in realizing the potential yield of the component crops. This trend was not seen at APAU (Table 1a), where the soil was inherently fertile. Further study, however, is needed to draw firm conclusions.

Spacing had no influence on the grain yield of sorghum (Tables 1a, b) but it did influence the greengram yield significantly (Table 3). More plants of greengram were accomodated when sorghum rows were spaced wider, resulting in more grain yield of greengram. But the gross monetary returns were not statistically influenced (Tables 2a, b).

Table 3. Dry matter and grain yield (kg/ha) of greengram and pigeonpea

Treatment	APAU				ICRISAT	
	Greengram		Pigeonpea		Greengram	Pigeonpea
	Dry matter	Grain yield	Dry matter	Grain yield	Grain yield	Grain yield
N level						
Control	1,090	420	6,820	1,120	420	510
40 kg N/ha	1,230	430	7,540	1,160	415	500
80 kg N/ha	1,310	380	8,120	1,110	360	480
CD at 0.05	120	NS	330	NS	NS	NS
N×S	NS	NS	NS	NS	NS	NS
Spacing						
45 cm × 15 cm	1,110	340	7,510	1,110	330	490
67.5 cm × 10 cm	1,230	410	7,500	1,130	390	480
90 cm × 7.5 cm	1,280	470	7,480	1,160	450	510
CD at 0.05	140	100	NS	NS	30	NS

Sorghum-pigeonpea

Sorghum-pigeonpea system gave a higher gross return than sole sorghum (Tables 2a, b). Mane and Ramshe (1976) also reported similar results. The gross return was Rs 2,620/ha more at APAU and Rs 1,120/ha more at ICRISAT than the gross return obtained with the sole crop of sorghum. The higher return at APAU could be attributed to the irrigation given to the field. The intercropping advantage might have resulted partly through better soil exploration by the different root-systems of the mixture, and partly by complementarity in time.

Application of 40 and 80 kg N/ha to sorghum did not influence the grain yield of the intercropped pigeonpea but it influenced the dry-matter yield significantly (Table 3). Narayanan and Sheldrake (1976) reported that 120 kg N/ha produced more dry matter than 22 kg N/ha in pigeonpea.

With 40 and 80 kg N/ha the yield of sorghum increased as much when it was intercropped as when it was grown as a sole crop. But, when compared with the sole crop of sorghum, intercropped sorghum yielded statistically less (though the magnitude of difference is small) under all N levels and spacings (Tables 1a, b). Bhalerao *et al.* (1976) also reported a yield reduction in sorghum when it was intercropped with pigeonpea.

Intercropping systems gave higher gross returns than the sole system. Application of 80 kg N/ha increased the sorghum yield. Spacing did not influence the yield of either sorghum or pigeonpea (Tables 1a, b and 3). However, population, a result of spacing, has influenced greengram yield (Table 3).

Sorghum-pigeonpea gave higher returns than sorghum-greengram. But the choice depends on the soil, rainfall, and cropping period. For example, with late-season rain and more profile moisture, sorghum-pigeonpea system may be advantageous. In shallow soils, and shorter season with assured early rains, sorghum-greengram system may prove profitable.

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