

## 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<sub>2</sub>O<sub>5</sub>/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 Patancheru (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 Ia. Grain yield (kg/ha) of sorghum at APAU farm

N level	Spacing									Mean
	S <sub>1</sub> (45 cm × 15 cm)			S <sub>2</sub> (67.5 cm × 10 cm)			S <sub>3</sub> (90 cm × 7.5 cm)			
Cropping system										
	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	
N <sub>0</sub>	1,840	1,650	1,620	1,850	1,550	1,510	1,770	1,640	1,570	1,670
N <sub>40</sub>	2,720	2,430	2,460	2,720	2,440	2,440	2,690	2,570	2,400	2,540
N <sub>80</sub>	3,010	2,730	2,640	2,960	2,820	2,660	2,890	2,780	2,690	2,800
Mean for spacing	S <sub>1</sub> 2,340			S <sub>2</sub> 2,330			S <sub>3</sub> 2,330			
Mean for cropping system	I <sub>1</sub> (sorghum sole)			2,490;		I <sub>2</sub> (sorghum/greengram)			2,290	
						I <sub>3</sub> (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 Ib. Grain yield (kg/ha) of sorghum at ICRISAT farm

N level	Spacing									Mean
	S <sub>1</sub> (45 cm × 15 cm)			S <sub>2</sub> (67.5 cm × 10 cm)			S <sub>3</sub> (90 cm × 7.5 cm)			
Cropping system										
	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	
N <sub>0</sub>	1,390	1,300	1,250	1,560	1,300	1,300	1,320	1,260	1,280	1,330
N <sub>40</sub>	2,460	2,440	2,310	2,440	2,420	2,280	2,410	2,410	2,340	2,390
N <sub>80</sub>	2,770	2,750	2,560	2,760	2,710	2,570	2,710	2,730	2,590	2,680
Mean for spacing	S <sub>1</sub> 2,140			S <sub>2</sub> 2,150			S <sub>3</sub> 2,120			
Mean for cropping system	I <sub>1</sub> (sorghum sole)			2,200;		I <sub>2</sub> (sorghum/green gram)			2,150;	
						I <sub>3</sub> (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 level	S <sub>1</sub> (45 cm × 15 cm)			Spacing S <sub>2</sub> (67.5 cm × 10 cm)			S <sub>3</sub> (90 cm × 7.5 cm)			Mean	
	Cropping system										
	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>		
N <sub>0</sub>	2,440	2,930	4,910	2,450	3,020	4,980	2,360	3,180	5,110	3,490	
N <sub>40</sub>	3,620	3,860	6,120	3,590	4,120	6,330	3,530	4,390	6,390	4,660	
N <sub>80</sub>	4,040	4,310	6,660	3,990	4,620	6,440	3,890	4,630	6,480	5,010	
Mean for spacing	S <sub>1</sub> 4,320			S <sub>2</sub> 4,390			S <sub>3</sub> 4,440				
Mean for cropping system	I <sub>1</sub> (sorghum sole)			3,320;		I <sub>2</sub> (sorghum/greengram)		3,900		I <sub>3</sub> (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 <sup>*</sup>		
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	S <sub>1</sub> (45 cm × 15 cm)			Spacing S <sub>2</sub> (67.5 cm × 10 cm)			S <sub>3</sub> (90 cm × 7.5 cm)			Mean	
	Cropping system										
	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>		
N <sub>0</sub>	1,850	2,470	3,070	2,080	2,570	3,060	1,800	2,670	3,080	2,520	
N <sub>40</sub>	3,280	3,910	4,360	3,190	4,090	4,310	3,210	4,140	4,450	3,880	
N <sub>80</sub>	3,750	4,300	4,710	3,750	4,240	4,740	3,680	4,490	4,830	4,280	
Mean for spacing	S <sub>1</sub> 3,520;			S <sub>2</sub> 3,560;			S <sub>3</sub> 3,590;				
Mean for cropping system	I <sub>1</sub> (sorghum sole)			2,950;		I <sub>2</sub> (sorghum-greengram)		3,650;		I <sub>3</sub> (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 accommodate 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 accommodated 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
<i>N level</i>						
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
<i>Spacing</i>						
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

