SMIC DOCUMENT

ICRISAT

SORGHUM AND MILLETS INFORMATION CENTER
International Crops Research Institute for the Semi-Arid Tropics
ICRISAT Patancheru P.O.
Andhra Pradesh, India 502 324

Nitrogen Response Studies of Intercropped Sorghum with Pigeonpea

T. J. Rego*

Abstract

To study the N response of intercropped sorghum with pigeonpea, three experiments were conducted during 1977 and 1978 in Vertisols at ICRISAT Center. In Experiment I, sole sorghum (180 000 plants/ha), sole pigeonpea (40 000 plants/ha), and three intercrop population treatments (40:40, 80:80, and 120:120% of sole optimum) were sown as main plots with four levels of N (0, 40, 80, and 120 kg/ha) only to sorghum as subplots. In Experiment II, sole sorghum at optimum plant population (180 000 plants/ha), intercrop sorghum at 33, 67, and 100% optimum population with constant pigeonpea population (40 000 plants/ha) with the same levels of N as in Experiment I, and sole pigeonpea (40 000 plants/ha) were grown in a randomized block design. In Experiment III, a constant sorghum (150 000 plants/ha) and pigeonpea population (40 000 plants/ha) were planted as sole crops at 45 and 90 cm and as intercrops in alternate rows at 45 cm with three levels of N (0, 60, and 120 kg/ha) applied only to sorghum in a randomized block design. In all three experiments, sorghum variety CSH-6 and pigeonpea ICRISAT-1 were grown.

Based on the results of these experiments, it can be concluded that intercropped and sole sorghum responded similarly to applied N. Different sorghum populations in the intercrop performed similarly. Pigeonpea did not seem to be contributing any N to its companion sorghum. Sorghum at higher N levels had a greater effect on pigeonpea yield. Sorghum as well as pigeonpea did equally well at 45 cm and 90 cm when grown as sole crops.

Intercropping of a nonlegume with a legume crop is a common practice among the semi-arid tropics (SAT) farmers of India. In a subsistence farming situation with uncertain and erratic rainfall, which is characteristic of the SAT region, very little attention has been paid in the past to improving the soil productivity. Even though N is the most limiting plant nutrient in these soils, intercropped legumes might have been responsible for maintaining soil productivity, at least at a subsistence level. Meager data are available on the response of a nonlegume to N in the presence of a legume. Enyi (1973) reported an intercrop system where maize and other legumes were grown; crops such as bean or cowpea had a more adverse effect on maize grain yield than did pigeonpea. He attributed this to the high rates of nutrient absorption by those two legumes, which coincided with that of the maize crop, whereas pigeonpea had the greatest nutrient demand after the harvest of maize. For the experiments described here, a typical sorghum:pigeonpea intercrop system was chosen to compare the N response to intercropped and sole-crop sorghum.

Materials and Methods

Field experiments were conducted in 1977 and 1978 during the *kharif* (monsoon) season on a medium-deep Vertisol at ICRISAT Center under rainfed conditions. These soils are low in organic matter, available N, and available P, but high in exchangeable K. The dominant clay mineral is montmorillionite. The physical composition of the soils and the initial fertility status of the experimental sites are given in Table 1. The total amount of rainfall during the 1977

* Soil Chemist, ICRISAT.

Table 1. Some physical and chemical characteristics of medium-depth Vertisols at ICRISAT Center.

	Depth (cm)	Org.C. (%)	pH	CEC (m e. 100g)	Gravel	C sand	F sand	Silt	Clay
General characteristics	0–155	0.30	8.3	43	8.3	11.3	13.7	17.7	57.3

	Depth (cm)	Available N (ppm)	Available P (ppm)	Exchangeable K (ppm)
Specific characteristics				
Experimental site I	0–30	79	6.5	195
Experimental site II	0–30	62	7.0	144
Experimental site III	0–30	81	5.3	168

growing period was 571 mm, which was below normal but well distributed. However, during the 1978 growing period, the total amount of rainfall exceeded the average rainfall (715) by 373 mm. During 1978 there were many continuous rainy days, resulting in short periods of temporary waterlogging.

Experiment I

In 1977, a 5 × 4 split-plot design of five populations (100:0, 0:100, 40:40, 80:80, and 120:120% of sorghum and pigeonpea sole optimum plant population, considering 180 000 and 40 000 plants as optimum for sole sorghum and pigeonpea, respectively) as main plots and four levels of N (0, 40, 80, and 120 kg N/ha applied only to sorghum) as subplots were replicated four times. These varying populations were chosen because earlier evidence showed that the intercrop responded to increasing populations and there is a likelihood of interaction between populations and N levels. Before land preparation, 20 kg P/ha was uniformly broadcast and incorporated. Sorghum cultivar CSH-6 and pigeonpea ICRISAT-1 were planted manually in 45-cm rows, both in the sole as well as in the intercrop. A 2:1 sorghum/pigeonpea row-planting pattern was followed for the intercrops, and varying plant populations were achieved by changing the intrarow spacing. Both crops were sown at a higher than normal (5–6 times) seed rate and thinned to the desired plant population 14 days after germination. After final thinning (and except for zero N plots), 20 kg N/ha as ammonium sulfate was placed by the side of sorghum rows about 10 cm away and about 5 cm deep; the remaining N, as urea, was placed by the side of sorghum rows as mentioned earlier at 28 days after germination. The subplot had 12 rows of 9-m length (5.4 × 9 m). The central four rows of sorghum and two rows of pigeonpea were harvested at maturity. During the entire growing period, only two hand weedings were given, one in the second week after planting and one in the fifth week. A research level of plant protection was given against shoot fly and stemborer of sorghum and against pod borer of pigeonpea. Sorghum was harvested after 96 days and pigeonpea was harvested after 158 days.

Experiment II

In 1978, a similar trial was conducted with slight modifications based on the results of experiment I. There were 17 treatments in all, replicated three times in a randomized block design. The treatments consisted of one sole sorghum at optimum population (180 000 plants/ha) plus three sorghum/pigeonpea intercrops (at 33:100, 67:100, and 100:100% of optimum populations in a 2:1 row proportion) with four levels of N (0, 40, 80, and 120 kg/ha) applied only to sorghum, and one sole pigeonpea at optimum population (40 000 plants/ha). Land preparation, P fertilization, and other operations were similar to those of Experiment I, but planting was done by a seed drill. At the time of writing, only sorghum had been harvested (after 98 days).

Experiment III

During 1977, another sorghum/pigeonpea intercrop experiment was conducted with a constant population of 150 000 sorghum

plants/ha and 40 000 pigeonpea plants ha in a 1:1 row pattern in 45-cm rows. In addition, both crops were grown as sole crops in 45- and 90-cm rows but keeping the population constant. These planting patterns were tried with three levels of N (0, 60, and 120 kg ha) applied only to sorghum. These nine treatments were replicated four times in a randomized block design. The planting was done manually and all other operations were done as in Experiment I. Sorghum and pigeonpea were harvested 95 and 159 days after sowing, respectively.

Results and Discussion

Experiment I

There was a significant grain yield response of sorghum (Fig. 1) to N up to 80 kg N/ha, whereas

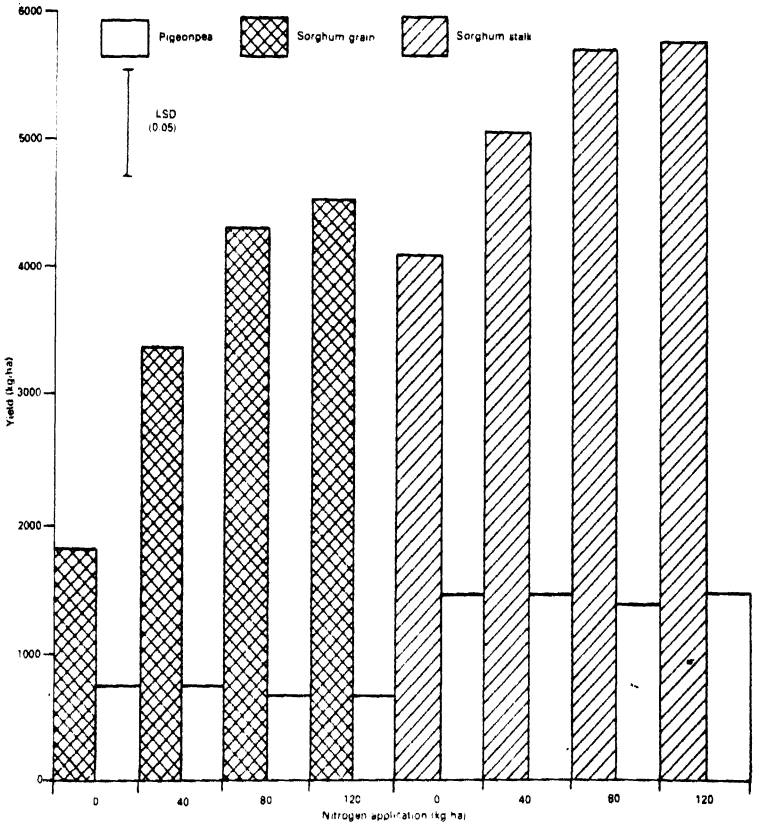

Figure 1. Effect of nitrogen on grain and stalk yields of intercropped sorghum and pigeonpea on Vertisols at ICRISAT Center, 1977.

yields at 80 kg and 120 kg N/ha were similar. Interestingly, in the intercrop situation, all three populations performed equally well and their grain yields did not significantly differ from each other. However, sole sorghum yielded more grain yield than intercrop sorghum at any level of N and more so at higher levels of N. On an average, the intercrop yield was nearly 20% less than the sole. The interaction between population and N levels was not significant. The increase in grain yield with increasing N levels was mainly due to an increase in grain weight/ear and an increase in 1000-grain weight, whereas, as the population increased, grain weight/ear decreased, especially from 80 to 120% population. This character might have been responsible for compensation of yields of different sorghum populations.

The response of sorghum populations at different levels of N (Fig. 2) reveals that near-optimum sorghum populations (80 or 120% of optimum) behave more or less as sole optimum population, although at a lower grain yield level; but low population (40% of optimum) at higher N (120 kg/ha) still responds to N. The sorghum fodder yield also more or less followed the same trend, except that the fodder yields at different populations did not differ significantly.

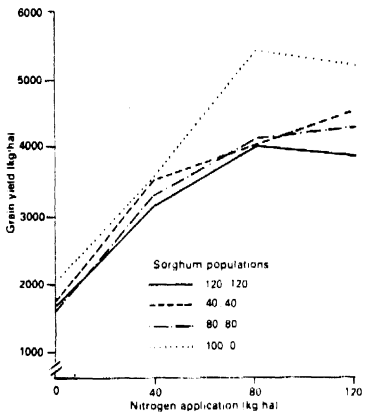

Figure 2. Nitrogen response of sole sorghum and different populations of sorghum intercropped with pigeonpea on Vertisols at ICRISAT Center, 1977.

The pigeonpea grain as well as stalk yields in the intercrop were not influenced by either the N applied to its companion sorghum or by varying populations. Even though a reduction in the pigeonpea yield might be expected especially at higher levels of N and at higher sorghum population, these effects might have been countered by simultaneous increase in pigeonpea population. The Cropping Systems group at ICRISAT, on similar soil and during the same period working in 2:1 sorghum/pigeonpea intercrop system, found a positive response to pigeonpea population whereas sorghum populations at 90 000 and 360 000 plants/ha performed equally well (ICRISAT 1978). On an average, pigeonpea yields were about 65% of the sole pigeonpea grain yields and about 60% of stalk yields.

The total N uptake (Fig. 3) in sorghum increased with increasing levels of applied N. On an average, sole and all intercrop populations were similar in N uptake. The different levels of N applied to sorghum in intercrop did not influence the N uptake by pigeonpea. The total P uptake by sorghum was similar for the 40, 80 and 120 kg N/ha treatments, but this was higher than zero N treatment. As in the case of N uptake, the total P uptake by pigeonpea was not influenced by different N levels.

Experiment II

Only the sorghum crop in this experiment has been harvested, and the data are presented in Table 2. Unlike the previous year, both the sole and the intercrop sorghum responded up to 120 kg N/ha. This may be mainly because of excess rain resulting in more N loss compared to the previous year. The sorghum in intercrop was as good as sole in 0 and 40 kg N/ha, but at 80 and 120 kg N/ha it yielded about 90% of sole sorghum. During the previous year, a similar trend had also been observed.

Experiment III

There was no significant difference in sorghum grain yield between 45- and 90-cm row spacing as a sole crop at all levels of N (Table 3). The sorghum grain yields both in sole as well as in

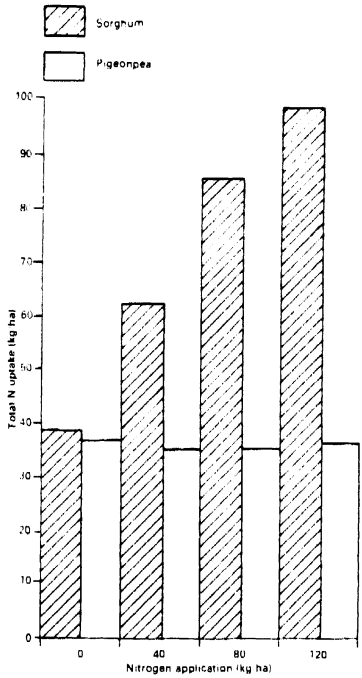

Figure 3. Effect of nitrogen on the total N uptake of intercropped sorghum and pigeonpea grown on Vertisols at ICRISAT Center, 1977.

intercrop responded up to 120 kg N/ha. The intercropped sorghum yielded significantly lower grain when compared to sole cropping at 60 and 120 kg N/ha, but they were not significantly different at zero N treatment. The increase in grain yield of sorghum with increase in N level is mainly due to increase in grain weight/ear and increase in 1000-grain weight. The reduction in intercrop sorghum grain yield compared to sole at the same level of N is mainly due to reduction in grain weight/ear.

Pigeonpea grain yields from 45- and 90-cm row spacings were similar. The pigeonpea yields were significantly lower in intercropping than in sole cropping. The different levels of N applied to companion sorghum did not influence the intercrop pigeonpea, since pigeonpea yields were similar at different N levels. The advantages of intercropping were 68, 39, and 47% for the 0, 60, and 120 N treatments, respectively. This may be in agreement with the work of Liboon and Harwood (1975), but in the 2 : 1 system of Experiment I, the LER was more or less the same at all levels of N—1.46, 1.58, 1.34, and 1.41 at 0, 40, 80, and 120 kg N/ha, respectively. Although the LERs for the 60 and 120 N treatments were lower than the zero N treatment, the total absolute yield or total value was far greater in the 60 and 120 N treatments.

The data for fodder yields of sorghum and stalk yields of pigeonpea show a pattern similar to that of their grain yields. The total N uptake by sorghum (Fig. 4) shows that at 0 and 60 kg N/ha, the sole and intercrop sorghum were similar, but at 120 kg N/ha, the intercrop sorghum had a lower uptake than the sole. As expected, with increasing levels of N, the N uptake of sorghum also increased. In contrast, pigeonpea at all three levels of N to sorghum had more or less the same amount of N uptake. This emphasizes that whether its companion sorghum is fertilized with N or not, the uptake remains more or less constant. Dalal (1974) had clearly shown that in a maize/pigeonpea alternate-row arrangement, at the end of maize harvest (16 weeks), the intercrop pigeonpea had taken only 5.7 kg N, whereas the sole pigeonpea had taken 17.1 kg N/ha. At pigeonpea harvest, however, sole and intercrop pigeonpea had taken 119.4 and 126.8 kg N/ha, respectively, which was similar. In Dalal's trial, sole and intercropped pigeonpea yielded similarly, but intercropped maize yielded only 80% of sole maize. From the data of sorghum-N uptake at the zero N level, it can be concluded that there was no current transfer of N from intercrop pigeonpea to sorghum as sole, and intercrop sorghum had almost the same quantity of N uptake. There was also no evidence of transfer at a low fertility level of 60 kg N. Henzell and Vallis (1977), in an extensive review on transfer of N in grass/legume forages, found no evidence of current transfer of N from legume to its companion nonlegume. Dalal and Quilt (1977), in a study of response of pigeonpea to N, clearly showed that pigeonpea did not respond to applied N. This response holds here also, because even though pigeonpea did not receive directly any

Table 2. Effects of nitrogen and population on grain yield (kg/ha) of sorghum (Experiment II 1978).

	Population (% of sole optimum)				
	Sole crop	Intercrop			
Applied N	100 : 0	33 : 100	67 : 100	100 : 100	Mean
0	1293	1621	1394	2082	1598
40	3192	3542	3288	2986	3252
80	4293	4261	3920	3944	4104
120	4967	4593	4656	4448	4666
Mean	3436	3504	3314	3365	
			Population	N	Population × N
LSD (0.05)			NS	298	NS
CV (%) 10.5					

Table 3. Effects of row spacing and nitrogen application upon grain and straw/stalk yields of sole and intercropped sorghum and pigeonpea (Experiment III).

		0 N on sorghum		60 N on sorghum		120 N on sorghum	
Crop	Row spacing (cm)	Yield (kg/ha)	LER	Yield (kg/ha)	LER	Yield (kg/ha)	LER
Grain yield							
Sole sorghum	45	930		2890		4590	
Sole sorghum	90	1330		3140		4240	
Sole pigeonpea	45	1390					
Sole pigeonpea	90	1370					
Intercropped sorghum	a	1240	1.10	2410	0.80	3710	0.84
Intercropped pigeonpea	a	800	0.58	820	0.59	870	0.63
Total LER			1.68		1.39		1.47
LSD (0.05): Sorghum 571	Pigeonpea 401	CV (%) Sorghum 14.3		Pigeonpea 22.9			
Straw stalk yield							
Sole sorghum	45	4110		5640		6750	
Sole sorghum	90	4110		4390		5360	
Sole pigeonpea	45	2740					
Sole pigeonpea	90	2440					
Intercropped sorghum	a	3420	0.83	4250	0.85	4690	0.77
Intercropped pigeonpea	a	1760	0.68	1440	0.56	1900	0.74
Total LER			1.51		1.41		1.51
LSD (0.05) Sorghum 770	Pigeonpea 111	CV(%) Sorghum 11.1		Pigeonpea 33.6			

a Alternate row, 45 cm.

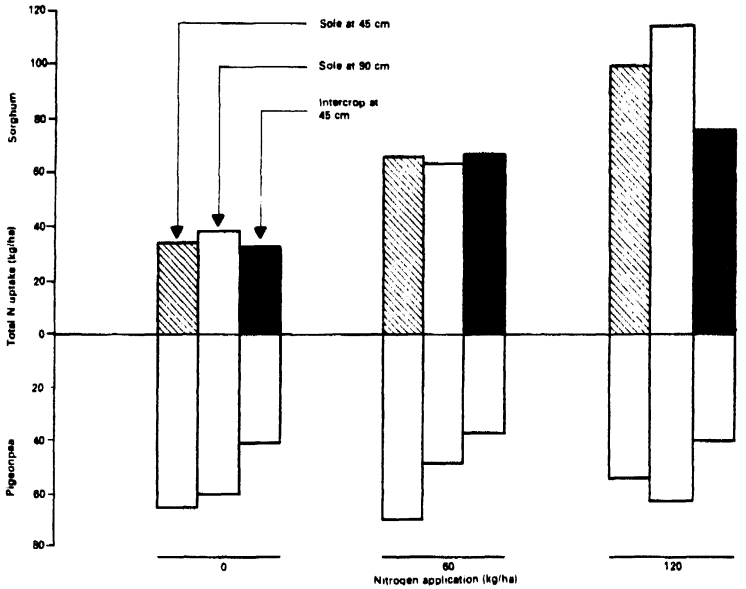

Figure 4. Effect of nitrogen on total N uptake of sole and intercropped sorghum and pigeonpea grown on Vertisols at ICRISAT Center, 1977.

applied N, its companion sorghum received up to 120 kg N/ha. The total P uptake more or less followed the same pattern as N uptake but at a very low magnitude.

Conclusions

Based on the results of these experiments, the following conclusions can be drawn.

In a sorghum/pigeonpea intercrop system, the sorghum response to applied N is more or less similar to sole-sorghum response. The sorghum crop seems to be very plastic with regard to population response. At high levels of N (80 or 120 kg/ha), there is a slight reduction in sorghum LER, which causes a small reduction in total LER.

Indirect evidence reveals that pigeonpea in a 2:1 sorghum/pigeonpea system may suffer a little at higher levels of N applied to its companion sorghum, and in such a situation, a response to pigeonpea population might be expected.

At low levels of N fertility, sorghum planted in rows at 45 and 90 cm performs equally well.

Acknowledgments

I thank Drs. B. A. Krantz and R. W. Willey for their continuous support and advice during the study.