NITROGEN FIXATION BY GROUNDNUT (*ARACHIS HYPOGAEA*) IN INTERCROPPED AND ROTATIONAL SYSTEMS

P.C.T. Nambiar, M.R. Rao, M.S. Reddy, C. Floyd, P.J. Dart, and R.W. Willey[1]

Summary

This paper examines the nodulation and nitrogen fixation of groundnut when grown in pure culture or in association with pearl millet, maize or sorghum. In all cases, association of groundnut with a cereal resulted in reduced nodulation and nitrogen fixation. This was ascribed to shading of the groundnut, leading to reduced photosynthesis. When grain millet was planted in rotation with groundnut or maize supplied 20 kg N/ha, yield following groundnut were 524 kg/ha greater than obtained in the millet/maize rotation.

INTRODUCTION

Legumes play a key role in many rotational and intercropping systems. In rotations part of the nitrogen (N_2) fixed by the legume can become available to subsequent crops; in intercropping systems, especially under small farm conditions, the ability of the legume to grow without N fertilization permits better allocation of limited resources, and lowers risk of total crop failure.

Surprisingly, there are few studies of the effects of intercropping on nodulation and N_2 fixation in legumes. Interplant competition has been shown to influence nodule function in *Phaseolus vulgaris* (Graham & Rosas, 1978a), *Trifolium subterraneum* (Phillips & Bennett, 1978) and *Vicia faba* (Sprent & Bradford, 1977). Interspecies competion between maize and beans did not affect the nodulation and N_2 fixation of a climbing cultivar of *Phaseolus vulgaris* (Graham & Rosas, 1978b), while in a soybean/sorghum intercrop, N_2 fixation by the soybean was markedly affected by association with tall, but not with dwarf, sorghum varieties (Wahua & Miller, 1978).

[1] CP No. 61, ICRISAT, Patancheru P.O., Andra Pradesh 502 324, India.

Groundnut (*Arachis hypogaea* L.) is grown in semiarid tropical regions, both as an intercrop and in rotations. In this paper we examine some effects of cropping pattern on N_2 fixation in groundnut and subsequent crop yield.

MATERIALS AND METHODS

In the three intercropping experiments reported here, we compare the nodulation and N_2 fixation of groundnut when grown in monoculture, and:

When associated with maize at four different levels of applied N;
When associated with sorghum partially defoliated to simulate different degrees of competition for light; and
When associated with pearl millet.

In each case, the cereal and groundnut were grown in separate rows, with optimum sole crop plant-to-plant spacings, using ratios of 1 row millet:3 rows groundnut; 1 row sorghum:2 rows groundnut; and 1 row maize:2 rows groundnut. Both crops were sown at the same time, and received recommended fertilization, save for N. The sorghum/groundnut experiments were conducted during the post-rainy season; the others during the rainy season.

In the experiment with maize, 0, 50, 100, 150 kg N/ha was applied to the maize at planting, while in the experiment with sorghum, a range of groundnut cultivars were tested and in half the treatments alternate leaves of the sorghum were defoliated to enhance light penetration. In all experiments nodulation and N_2 fixation were measured throughout the growing season.

Two experiments to determine the benefit from groundnut to subsequent crops were also carried out. The first compared the yield of grain millet grown after groundnut, unfertilized maize, or maize supplied 20 kg N/ha; the second, also with grain millet, compared yield after groundnut, millet, or fallow.

RESULTS AND DISCUSSION

In all three crop combinations studied, intercropping reduced nodulation and N_2 fixation by the groundnut. With millet this inhibition occurred both with and without applied fertilizer N (see Figures 1 & 2). In the maize experiment N fertilization of the maize further reduced nodulation and N_2 fixation by the groundnut (see Table 1). However, nodule formation was less affected than nodule weight or nitrogenase activity, presumably because most nodules were formed before the cereal provided any substantial competition for light. The reduction in nitrogenase activity was most closely related to the reduction in nodule weight, with an 80% reduction in activity at the highest N fertilizer level (150 kg N/ha). Final yield per plant was also decreased at the high N levels. Our results suggest that N fertilizer effects are

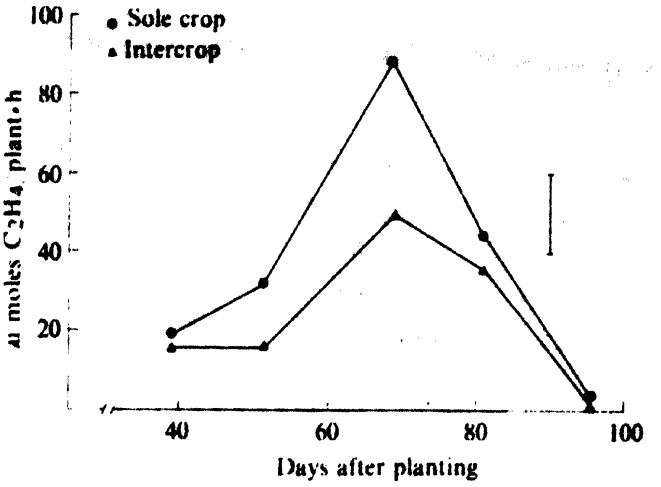

Figure 1.
Nitrogenase activity of groundnut in monoculture and intercropped with millet.

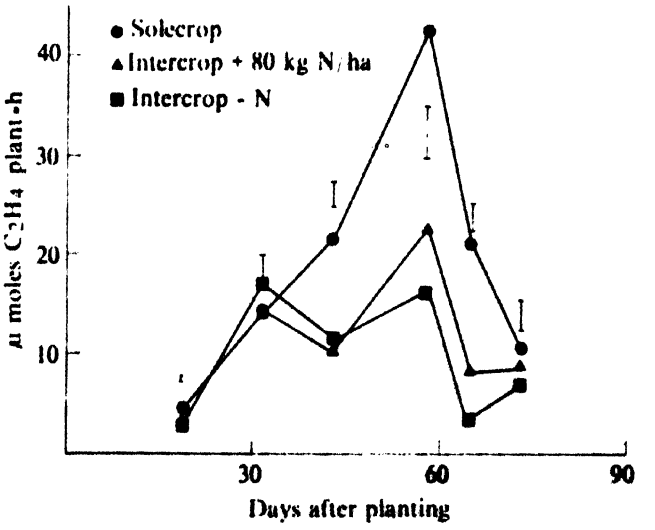

Figure 2.
Effect of intercropping with millet on nitrogenase activity of groundnut.

not directly on legume fixation, but rather due to the decrease in available light resulting from more vigorous growth of the cereal.

Decreasing the competition for light by the sorghum by removing alternate leaves increased the N_2 fixation by the intercropped groundnut (see Table 2). There was little difference between groundnut cultivars in this response. Even the sorghum with 50% of its leaves removed provided a substantial competition for the groundnut, and nodule number and nitrogenase activity per plant were both substantially less than for the sole crop. Top weight per plant was also decreased in the intercropped groundnut.

In the rotation experiments, grain millet grown in the irrigated post-rainy season yielded 45% more following the groundnut cultivar Robut 33-1 than when maize was the preceding crop (see Table 3). However, in a second experiment, where grain millet was grown following groundnut, millet, or fallow, there was no apparent yield benefit.

One of the earliest recognized advantages of a legume crop was the residual benefit for a subsequent crop. It has been suggested that some legumes excrete

TABLE 1: Nodulation and N_2 fixation of groundnut in sole culture and intercropped with maize.

Treatment	Nodule number/ plant	Nodule weight (mg/ plant)	Nitrogenase activity (μmoles C_2H_4/plant per h)	Light reaching groundnut canopy (%)
Sole groundnut	171	124	21.3	100
Intercropped groundnut				
N added to maize (kg/h)				
0	165	117	20.1	67
50	160	94	9.4	54
100	150	78	7.0	43
150	134	65	3.5	46
SEM ±	6.3	11.0	1.92	

some of the N_2 fixed into the soil during the growth of the crop, but present evidence suggests that the amounts involved under field conditions are small, and likely to be of little benefit to an intercrop (Henzell & Vallis, 1977). The main residual effect of a legume will depend on the proportion of N retained in nonharvested residues and their rate of mineralization. Clearly, the planting of groundnuts in association with cereals could limit the rate of N_2 fixation by the legume, and thus the benefits for subsequent crops. In an attempt to alleviate this, we are examining different groundnut and cereal genotypes for compatability and hope to find both groundnut cultivars more tolerant of low light intensities, and so able to maintain high levels of N_2 fixation in the intercropping situation, and cereal lines whose plant architecture permits light penetration. Adjusting season durations and sowing times of the two crops, relative to each other, also offers some scope for increasing fixation by the groundnut, since it changes the pattern of competion of the cereal in relation to the maximum period of nitrogenase activity of the groundnut.

TABLE 2: Nodulation and nitrogenase activity of five groundnut cultivars in sole culture and intercropped with sorghum.

Cultivar	Nodule number/plant			N_2ase activity (µ moles C_2H_4/plant·h)		
	Sole crop	Intercrop (partial sorghum canopy[1])	Intercrop (normal sorghum canopy)	Sole crop	Intercrop (partial sorghum canopy[1])	Intercrop (normal sorghum canopy)
Chico-17200	104	75	64	15.2	11.8	6.8
TMV-2	108	81	64	18.1	12.6	8.3
MK-374	190	137	100	25.8	23.6	12.2
Robut 33-1	118	86	75	21.5	15.9	12.2
MH 2	151	66	68	15.4	7.9	9.1
Gangapuri	137	84	62	15.7	10.6	6.5
SEM ±		11.38			1.36	

[1]70 days after planting, groundnut with a partial sorghum canopy received 57% of the light, and that with a normal sorghum canopy received 42% of the light intercepted by the sole crop.

TABLE 3: Residual effect of groundnut and maize on millet grain yield in an Alfisol.[1]

Preceding crop	Yield (kg/ha)
Groundnut	1980
Maize, unfertilized	1325
Maize, fertilized with 20 kg N/ha	1456
LSD (0.01)	360

[1]Groundnut and maize grown in rainy season 1977 at ICRISAT, followed by irrigated millet, in dry winter season 1977-78.

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