Groundnut in Intercropping Systems

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In the developing world, groundnuts are commonly grown in intercropping systems, especially by small farmers who use traditional combinations often involving up to 5-6 crops. Detailed statistics of farming practice are difficult to obtain, but it has been estimated that 95% of the groundnuts in Nigeria and 56% in Uganda are grown as mixtures with other crops (Okigbo and Greenland 1976). In the Northern Guinea Savanna Zone of Nigeria, Kassam (1976) reported that only about 16% of the total area under groundnut was in sole cropping while about 70% was in 2-4 crop mixtures. Underplanting tree crops such as coconut, oilpalm, and rubber trees with groundnuts in the early years of the plantation is also a common feature in S.E. Asia (Hardwood and Price 1976) and India (Aiyer 1949).

This paper considers the intercropping of groundnut only with other annual crops; it deals mainly with the cereal intercrops (millet, maize, and sorghum), which are by far the most important intercrops grown with groundnut. It also considers briefly a further important group — the long-season annuals such as pigeonpea, cotton, castor, and cassava.

Intercropping of Groundnut with Cereals

Groundnut/Pearl Millet Intercropping

The groundnut/millet combination has been chosen for special emphasis at ICRISAT because it involves two ICRISAT mandate crops and the combination is an especially important one on the lighter soils of the semi-arid tropics, notably in West Africa and India.

A series of crop physiological experiments has been carried out since 1978 in four different seasons at ICRISAT Center, to study the growth patterns and the resource use in this combination to determine how yield advantages are achieved. The first experiment, conducted during the rainy season of 1978, compared sole crops with a single intercrop treatment of 1 row millet: 3 rows groundnut. Results have been presented in detail elsewhere (Reddy and Willey 1980a) so they are only briefly summarized here.

Growth patterns are plotted in Figure 1. Sole millet showed a very rapid rate of growth, achieving 8134 kg/ha of dry matter in 85 days (Fig. 1b). Sole groundnut growth rate was somewhat slower, and this crop achieved 4938 kg/ha of dry matter in 105 days (Fig. 1a). Dry matter yield of each crop in intercropping is given in comparison with an expected yield, this being the yield that would be achieved if the crop experienced the same degree of competition in intercropping as in sole cropping. Groundnut growth very closely followed the expected dry matter yield of 75% of its sole crop yield, whilst millet produced approximately twice its expected dry matter yield of 25% of its sole crop yield. In effect, this means that groundnut produced about the same yield per plant in intercropping as in sole cropping, while the much more dominant millet approximately doubled its yield per plant in intercropping.

The combined dry matter yield in intercropping is given in comparison with the yield expected, if there was no yield advantage (or disadvantage) of intercropping, i.e.,of the LER = 1 (LER = Land Equivalent Ratio, or the relative land area required as sole crops to produce the yields achieved in intercropping). Figure 1c shows that with time there was an increasing dry matter yield advantage for intercropping; at final harvest the actual LER was 1.29, i.e., an advantage of 29% for intercropping. Grain and pod yields closely followed this pattern and actual LERs were 0.71 for groundnut and 0.55 for millet, giving a total LER of 1.26, or an overall yield advantage of 26% for intercropping.

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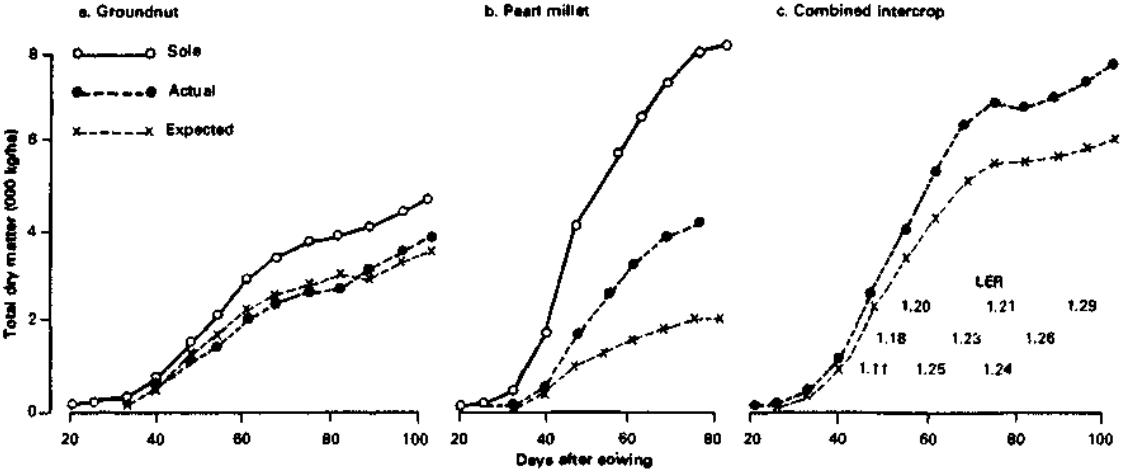

Figure 1. Sole crop yields and actual and expected intercrop yields of groundnut and millet.

Resource use was of particular interest in this combination. Considering moisture use first, the amounts of water transpired through the sole crops and the intercrop are presented in Table 1. (The amount for the intercrop could not be apportioned between the crops.) For the combined intercrop, an expected moisture use was also estimated by calculating for each component the amount of moisture which would have been used if dry matter had been produced at the same efficiency as the respective sole crops. It can beseenthatthiscaiculated moisture use was very similar to the actual moisture use, thus there was no evidence that intercropping was able to produce more dry matter per unit of water transpired through the crop.

Light interception patterns are presented in Figure 2. Sole millet showed a particularly rapid development of light interception, but the sole groundnut was rather slower. The combined intercrop was intermediate to the two sole crops in the early stages, but by about 60 days it was similar to both the sole crops; thereafter it declined because of senescence and removal of the millet and then senescence of the groundnut. Light use by the individual components in intercropping could not be distinguished. But the estimated amount of light energy which would have been needed to produce the intercrop yields, assuming the same level of efficiency as the sole crops, was appreciably higher than the measured amount intercepted (Table 1). Calculation showed that the intercrop appeared to use light with 28% greater efficiency. This agrees very closely with the LERs given earlier, suggesting that the yield advantages of intercropping were due very largely to more efficient use of light. In fact, during the period of maximum leaf area, the intercrop supported a leaf area that was approximately 30% greater than the sole crops. Thus the greater efficiency of light use may at least partly have been because light was more evenly distributed over more leaves. It could also have been partly due to the combination of a C_4 crop in the upper canopy layers and a C_3 one in the lower canopy layers.

An important feature of this first experiment, however, was that it was conducted at a relatively high level of fertilization (80 kg N/ha and 50 kg P20s/ha) and the season turned out to be particularly wet with rainfall well above average. Thus it was considered that a major reason why the higher intercropping yields appeared to be especially associated with increased efficiency of light use could have been because nutrients and water were not limiting. A main objective of subsequent experiments was to re-examine the relative importance of this light factor in situations where the below-ground resources were more limiting. Results have been

Table 1. Efficiency of resource use in pearl millet/groundnut intercropping.

	Millet		Groundnut
		Water use	
Sole cropping			
Dry matter (kg/ha)	8134.00		4938.00
Water used (transpiration, cm)	15.86		19.63
Water-use efficiency (kg/cm)	513.00		252.00
Intercropping			
Dry matter (kg/ha)	4129.00		3821.00
Water used at sole-crop efficiencies (cm)	8.05	23.24	15.19
Expected water-use efficiency (kg/ha)		342.00	
Actual water used (cm)		22.79	
Actual water-use efficiency		349.00	
		Light-energy conversion	
Sole cropping			
Dry matter (kg/ha)	8134.00		4938.00
Total light intercepted (kcals/cm^2}	14.26		19.25
Efficiency of conversion (mg/kcal)	5.70		2.57
Intercropping			
Dry matter (kg/ha)	4129.00		3821.00
Energy required at sole crop conversion rate (kcals/cm^2)	7.24	22.14	14.90
Expected conversion efficiency (mg/kcal)		3.59	
Actual interception (kcals/cm^2)		17.25	
Actual conversion rate (mg/kcal)		4.60	

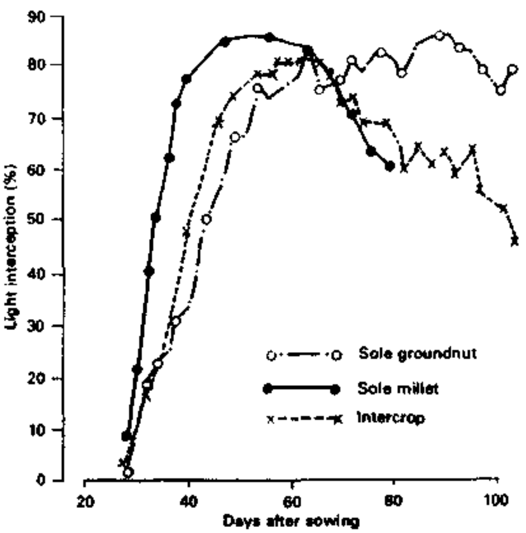

Figure 2. Light interception by sole crops and an intercrop of pearl millet and groundnut.

presented in detail elsewhere (Reddy and Willey (1980b), so again they are only briefly summarized here.

During the postrainy season of 1978, an experiment was conducted to study the effect of no-stress and stress moisture regimes (Table2). The pattern of intercrop results in no-stress was similar to that reported in the previous experiment and the reproductive yield advantage was 25%. Under stress the reproductive yield advantage was rather higher at 29%. The efficiency with which light energy was converted into dry matter was calculated as in the previous experiment; in no-stress the intercrop was 21% more efficient than expected, while in stress it was only 7% more efficient. Thus the results suggest that when moisture is more limiting, the efficiency of light use may be a less important factor in determining the yield advantage of this particular crop combination.

During the rainy season of 1979, an experiment was carried out to study the effect of two

Table 2. Grain or pod yields and land equivalent ratios in pearl millet/groundnut Intercropping under two different moisture regimes (1978 postralny season).

Treatments	Millet grain yields (kg/ha)	Millet LER	Groundnut pod yields (kg/ha)	Groundnut LER	Total LER
NO STRESS (Irrigated every 10 days)					
Sole crop	2674	-	2441	-	-
1 : 3 Intercrop	1220	0.46	1928	0.70	1.25
STRESS (Irrigated every 20 days)					
Sole crop	2114	-	2040	-	-
1 : 3 Intercrop	937	0.44	1734	0.85	1.29
LSD (0.05) within a moisture regime	109		146		0.09
LSD (0.05) across moisture regimes	133		217		0.08
CV (%) Main plots	3.26		4.95		2.57
CV (%) Split plots	3.60		4.03		4.38

different nitrogen levels on the millet (Table 3). The pattern of results was again similar to the previous experiments in that at a high level of nitrogen (Nso) the reproductive yield advantage was 21% but this increased under stress (nil N) to 32%. Dry matter yield advantages were even higher (Table 3). The efficiency of light energy conversion of the intercrop compared with the sole crops was calculated as in the earlier experiments. At Nso, the intercrop was only 14% more efficient, which was a rather smaller effect than in the previous experiments. At nil N, however, the improved light use efficiency of the intercrop was even higher, being 21%. At first, this effect at nil N is rather surprising, as it seems to contradict the earlier suggestion from the moisture regime experiment that when a factor other than light is more limiting, the efficiency of light use is less important. But the results may simply indicate some essential differences between the moisture stress and nitrogen stress situations which were created. One notable difference of course was that the moisture stress appiied to both component crops, whereas the nitrogen differences applied only to millet Current studies are examining situations where phosphate levels are also varied so that nutritional stress also applies to the groundnut.

Groundnut/Maize Intercropping

Groundnut is very commonly intercropped with maize in Southeast Asia and Africa. Mutsaers (1978) reported that in western Cameroon, the farmer grows groundnut as the main crop with maize interplanted at a fairly low density. Experiments carried out during three seasons in the Yaound'e area, Cameroon, to evaluate groundnut/maize mixtures, gaveyield advantages over pure stands ranging from 6-16%. Evans (1960) obtained yield advantages ranging from 9-54% from five different experiments conducted at two different locations in Tanzania during 1957 and 1958. In Ghana, Azab (1968) studied groundnut/maize intercropping by varying the sowing time of each crop. He observed that the mean yield of groundnuts was significantly higher when sown 4 weeks earlier than maize. The traditional practice of sowing both crops *at* the same time *gave* an intermediate yield. Koli (1975) reported that the yields of groundnuts in mixed cropping treatments were

Table 3. Grain or pod yields and land equivalent ratios in pearl millet/groundnut Intercropping under two different levels of nitrogen applied to the millet (1979 rainy season).

Treatments	Pearl millet grain yields (kg/ha)	Pearl millet LER	Groundnut pod yields (kg/ha)	Groundnut LER	Total LER
Sole groundnut	-	-	2998	-	-
Sole pearl millet (0 kg N/ha)	1968	-		-	-
Sole pearl millet (80 kg N/ha)	2872	-	-	-	-
1:3 Intercrop (0 kg N/ha)	1063	0.54	2345	0.78	1.32
1:3 Intercrop (80 kg N/ha)	1436	0.50	2131	0.71	1.21
LSD (0.05)	233		117		0.12
CV(%)	8		4		6.71

one-third to one-half the yields obtained from sole crops, but yield of maize was not reduced to the same extent. The general observation in all reports on the maize/groundnut combination is that groundnut yield is readily depressed by competition from the maize.

A groundnut/maize experiment was conducted on an Alfisol at ICRISAT in the rainy season of 1978 to study whether there was any beneficial transfer of fixed nitrogen from the legume to the cereal. Treatments consisted of maize at 0, 50, 100, and 150 kg/ha of applied nitrogen, and with and without a groundnut intercrop. With no applied nitrogen, maize growth was very poor and obviously nitrogen deficient, and there was no visual evidence of growth being any better if the groundnut intercrop were present. This observation was supported by maize grain yields which were unaffected by the groundnut at any level of nitrogen. The relative yield advantage of intercropping compared with sole cropping was 44% at zero nitrogen level but this decreased with increase in applied nitrogen and it was zero at the highest nitrogen level (Rao et al. 1979). Since there was no evidence that these differences in yield advantage could be due to differences in nitrogen transfer, it is possible that they occurred because intercropping was more efficient in using soil nitrogen, an effect that was more evident at lower levels of applied nitrogen. This finding agrees with the general trend observed in the groundnut/millet experiment referred to above (Table 3) and it has important implications in practice because it suggests that intercropping may be more advantageous in low fertility situations.

This groundnut/maize experiment was followed by a post rainy season crop of sorghum to study the residual effect of sole versus intercropped groundnut. The results showed that if no nitrogen were applied to the groundnut/maize intercrop, there was a beneficial residual effect on the following sorghum. Where nitrogen was applied to the maize, however, the groundnut growth was suppressed and the residual benefit rapidly diminished (Rao et al. 1979).

Groundnut/Sorghum Intercropping

In India and Africa, groundnut is very commonly intercropped with sorghum. Some reports have emphasized that significant yield reductions of groundnuts have been obtained when they have been intercropped with sorghum. John et al. (1943) reported that sorghum depressed the yield of groundnut by about 50% and Bodade(1964) obtained reductions of 52%. But despite reductions in groundnut yields, there are many reports of overall benefits when the yields of both crops are considered.

Bodade (1964) reported that mixed cropping of sorghum and groundnut gave higher yields than sole cropping and two rows of sorghum with eight rows of groundnut was one of the best treatments. Lingegouda et al. (1972) reported that three rows of groundnut and one row of sorghum was more profitable (Rs. 3918/- per ha) than pure sorghum (Rs. 3123/-) or pure groundnut (Rs. 2672/-). A positive benefit was shown in almost all experimental combinations of groundnuts with sorghum in East Africa (Evans 1960). Experiments conducted at ICRISAT with this combination have given yield advantages as high as 38% (Rao and Willey 1980) while Tarhalkar and Rao (1979) have reported yield advantages up to 57%.

Groundnut Genotypes for Groundnut/Cereal Intercropping

As in sole cropping, it seems likely that groundnut performance in intercropping could be improved by identification of suitable genotypes. Indeed it can be argued that the potential for genotype improvement could be greater in intercropping because of possible interactions with the associated cereal crops. It has also been emphasized that for crops growing with a more dominant associated crop, there may be particular need for identification and selection of genotypes within the actual intercrop situation because genotype performance in intercropping may not be very closely related to genotype performance in sole cropping (Willey 1979).

At ICRISAT, studies on the identification of groundnut genotypes for intercropping with pearl millet have been carried out since 1977. To date, results are only available for a relatively few genotypes of groundnut, and these have been examined in combination with only a few pearl millet genotypes (Table 4). All studies were in simple replacement series treatments of 3 groundnut rows: 1 pearl millet row. Results have indicated that with increasing groundnut maturity, and the associated change from bunch to runner habit, the groundnut contribution in intercropping (i.e. groundnut LER) tends to increase (Table 4). This is probably because of the increasing time for compensation of the groundnut after cereal harvest.

However, this increasing groundnut con-

Table 4. The affact of groundnut ganotypa and ganaral typa of millat ganotypa on groundnut LER and total LER in groundnut /pearl millat Intarcropping.

Pearl millet genotypes		Groundnut Genotypes: 1. Chico, Spanish bunch 85 days	2. MH2, Valencia dwarf 95 days	3. TMV2, Spanish bunch 100 days	4. R33-1, Virginia semi-spreading 110 days	5. MK374, Virginia semi-spreading 125 days	6. M-13, Virginia runner 130-140 days	Means (Genotypes 3-6)
GAM73/GAM75	g nut LER		0.51*	0.63[d]	0.72[d]	0.80[c]	0.81[d]	0.74
(dwarf, late)	Total LER		1.13	1.25	1.22	1.27	1.33	1.27
BK560/WC-C75	g nut LER	0.48[s]	0.48[a]	0.61[e]	0.63[6]	0.80[c]	0.80[e]	0.71
(medium/medium)	Total LER	1.03	1.17	1.27	1.23	1.25	1.39	1.29
PHB-14/IVSAX75	g nut LER			0.67*	0.70*	0.68*	0.74*	0.70
(tall/medium)	Total LER			1.09	1.18	1.01	1.28	1.14
Ex-Bornu	g nut LER			0.90*	0.90*	0.80[a]	0.90*	0.88
(all, late)	Total LER			1.25	1.22	1.15	1.28	1.23
Means	g nut LER	0.48	0.50	0.70	0.74	0.77	0.81	
	Total LER	1.03	1.15	1.22	1.21	1.17	1.32	

a. Mean of 1 trial *b.* Maan of 2 trials *c* Mean of 3 trials *d.* Moan of 4 trials a. Mean of 5 trials tribution is not so clearly reflected in increasing yield advantages for the combined effect of both crops (i.e. total LER); although the latest maturing groundnut M-13 (130-140 days) was associated with the highest mean value for total LER, there were no real differences in total LER observable between the three genotypes TMV2 (100 days), Robut33-1 (110 days), and MK-374 (125 days). There was also little difference in groundnut or total LER for the different millet genotypes, though the range of millet genotypes was admittedly limited.

In these initial stages of identification, simultaneous screening of genotypes of both crops was carried out because there appeared to be scope for selecting more suitable genotypes of both crops. No marked interaction between genotypes of the two crops has been observed so work is now concentrating on examining a larger number of genotypes of each crop against a standard genotype of the other crop.

With the groundnuts, a more detailed study is also being carried outtodeterminethe extentto which the better intercrop performance of the longer maturing genotypes is due to greater time for compensation after cereal harvest or to some other characters which allow better growth and production in the dominated intercrop situation. In the summer season of 1980, groundnut genotypes were grown with a standard cereal (Sorghum CSH-8); the duration of cereal competition was examined by removing thesorghum at differenttimes, and the intensity of cereal competition was examined by means of a treatment in which alternate pairs of sorghum leaves were removed. First results suggest that increased groundnut contribution with reduced cereal duration was of the same order for all groundnut genotypes and both levels of competition. Differences in groundnut performance were small at a given cereal duration, though there was a tendency for the bunch types to do less well than the late runner types.

Groundnut Intercropped with Long Season Annual Crops

No growth studies have been reported for combinations of groundnuts with any of the long season annuals. However, it is evident from the general growth patterns of the crops that considerable temporal complementarity of growth occurs. The groundnuts can give reasonably efficient use of resources during the early period when the long season annuals are slow to establish; after groundnut harvest, the long season annuals are able to make use of later resources, especially of the residual soil moisture.

Groundnut/Pigeonpea Intercropping

This combination is particularly prevalent on red soils of the southern States of India. A common practice here is that if rains commence at the normal time a groundnut/sorghum or groundnut/millet intercrop is grown, but if rains are delayed groundnut/pigeonpea is grown. Pigeonpea rows are usually wide-spaced up to 5 m apart with up to 8-10 groundnut rows in between. This traditional practice helps to obtain high yields of the groundnut cash crop but the overall advantage of intercropping may not be high because pigeonpea is too sparsely distributed to make efficient use of late season resources and produce a worthwhile yield contribution. Most studies have examined this predominantly groundnut situation.

John et al. (1943) reported from a 3-year study that groundnut/pigeonpea in 8:1 proportion was 43% more profitable than sole groundnut. Similar results were reported from studies at Tindivanam over a 7-year period during 1942-49 (Seshadri et al. 1956). Veeraswamy et al. (1974) and Appadurai et al. (1974) showed that the arrangement of 6 groundnut: 1 pigeonpea was more economical than 8:1; groundnut gave 99% of its sole crop yield and pigeonpea 37% of its sole crop yield, totaling an advantage of 36%.

At the other extreme, an alternate row arrangement at ICRISAT gave an LER of 1.53 comprising 95% pigeonpea and 58% groundnut (Rao and Willey 1980). This may not be ideal economically because of the reduced groundnut contribution, but it illustrates that higher yield advantages can be obtained with higher proportions of pigeonpea.

A good compromise situation is indicated by some studies on five Alfisol locations within ICRISAT in 1979-80. Pigeonpea was grown in 135 cm rows with five very close-spaced rows of groundnut between. The population of each crop was equivalent to its sole crop optimum. Intercrop yields averaged 82% of groundnut and 85% of pigeonpeas, i.e. 67% total advantage.

Groundnut/Cotton Intercropping

Joshi and Joshi (1965) reported that a combination of 2-3 rows of groundnut between cotton rows spaced 6 feet apart gave significantly higher monetary returns compared to either sole crop. Varma and Kanke (1969) reported that growing cotton with groundnut was much more remunerative than growing it alone; yields of groundnuts were additional to the cotton yields usually obtained. Similar intercropping of cotton and groundnut has been recommended for the northern districts of Madras by Narayan Reddy (1961). In the Sudan, Anthony and Wilmott (1957) also found higher yields from groundnut and cotton intercropped together.

Groundnut/Castor Intercropping

Reddy et al. (1965) reported that growing castor mixed with groundnut was better than raising a pure crop of castor, and monetary returns were 61.9% higher than pure castor. They also reported that the yield of castor was more when it was grown mixed with groundnut compared to castor grown mixed with greengram, cowpea, *Setaria,* millet or sorghum. In East Africa, Evans and Sreedharan (1962) showed that there was a clear increase in production when castorbean and groundnuts were planted together compared to sole cropping. Tarhalkar and Rao (1975) reported that intercropping of castor/groundnut gave monetary returns up to Rs 4394 per hectare compared with Rs 3317 per hectare obtained from a pure castor crop.

Groundnut/Cassava Intercropping

Introducing an additional crop like groundnut between the traditionally wide-spaced cassava plantings would increase the production efficiency of cassava-planted land as well as conserving soil moisture and fertility. An experiment conducted at Khon Kaen University, Thailand in 1977, produced higher yields of cassava (26 756 kg/ha) when intercropped with groundnuts compared to sole crop of cassava (24 538 kg/ha). The experiment indicated that presumably intercropped groundnut increased the yield of cassava by supplying additional nitrogen from nitrogen fixation. This groundnut/cassava combination gave around double the net income compared with the sole cassava planting. Contrary to this, the Department of Agriculture, Tanganyika (1959) reported that when early sown groundnuts were intercropped with late-planted cassava, the yield of groundnuts was not seriously affected, but the yields of cassava were reduced to less than one-fifth of the sole crop. Potti and Thomas (1978) reported that trials conducted in the farmers' fields in Kerala, India gave an average of 1263 kg/ha of groundnut in addition to the cassava yield.

Conclusions

There is good evidence that groundnut/cereal intercropping can give worthwhile yield advantages over sole cropping. The ICRISAT studies suggest that these advantages can be due partly to more efficient use of light, but further research is needed to determine the importance of this light factor when below-ground resources are limiting. The more rapid early growth of the cereals, and the later maturity of groundnut compared with the early cereals, may also be an important factor giving some complementarity between the crops and allowing better use of resources.

Other ICRISAT studies have shown that the later maturing, semi-spreading or runner types of groundnut have given the highest groundnut yields in intercropping, but this has not always resulted in improved yield benefits from the whole system.

Although there has been little detailed work on the intercropping of groundnuts with the long season annuals, pigeonpea, cotton, castor, and cassava, there is good agronomic evidence that these systems can give very substantial yield advantages. The general growth patterns of these crops suggest that the main factor responsible for these advantages is that the use of early resources by the groundnut complements the use of late resources by the longer season crops.

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Session 5 — Crop Nutrition and Agronomy

Discussion

Microbiology

J. S. Saini

In a trial in the Punjab we found that when winter wheat was planted either after groundnuts, hybrid maize, or local maize we got better wheat yields after the local maize. This was surprising. What explanation can be offered?

P. T. C. Nambiar

It is difficult to generalize on this. One likely explanation is that in this instance, nitrogen was not limiting. At ICRISAT we have obtained a 30% yield increase in pearl millet when it followed groundnuts.

N. D. Desai

When do nodules form and when does fixation commence?

P. T. C. Nambiar

Initiation varies from season to season. In the rainy season they form as soon as 11 days after planting. In the postrainy season, they may not form until 18 days after planting. Nitrogenase activity commences 20 days after planting in the rainy season.

P. J. Dart

There are large nitrogen reserves in the seed and therefore a shorter dose of *nitrogen* may not be needed. Water also limits nodulation and the uptake of nitrate.

D. J. Nevill

We heard a lot about host and *Rhizobium* strain interactions. What about higher order interactions such as strain x host x environment interactions? In other words, does a successful combination of strain and host behave the same way in North Carolina as it does in India?

P. T. C. Nambiar

We are doing such trials but we have no results yet.

J. C. Wynne

We are cooperating in these trials with ICRISAT. We do not have results yet, but I would suspect that the combinations would be specific to sites. A lot would depend on the variety and the photosynthetic activity of the variety in the different environments.

S. N. Nigam

In one of the slides that showed analysis of several characters, there was no significance for nodule number for the host cultivars. I would have expected that there was a large amount of variability for nodule number, unless very few genotypes were in the study. Secondly, regarding the use of plant color in evaluating fixation by different strains of *Rhizobium,* the different botanical types of groundnuts themselves vary in leaf color. Could we say in general that the Virginia types have better nodulation than Valencia and Spanish types?

J. C. Wynne

The nodule varies with genotype, and if enough genotypes are used then significant differences are recorded. The results shown were limited and were not for all the experiments we have conducted. We would not use leaf color for selection purposes. When we evaluate strains we use nitrogen-free soils and we remove the cotyledons also. Color is then a useful parameter for comparison of strains on a single cultivar. Generally in North Carolina, we find that Virginia cultivars are the best nodulators followed by Spanish and then Valencia botanical types.

R. 0. Hammons

Nonnodulating lines were found by Dr. G or bet