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Evaluation of Cowpea Cultivars for Intercropping with Pearl Millet in the Sahelian Zone of West Africa

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ABSTRACT

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Field trials were conducted at ICRISAT Sahelian Centre, Niger, to examine the performance of contrasting cowpea cultivars intercropped with pearl millet. Significant effects ($P \leq 0.05$) of cropping system and cultivars were observed for cowpea grain yield. Cultivar × cropping system interaction was significant only for fodder yield. Intercropping reduced cowpea yields significantly but the degree of reduction varied among cultivars. Early-maturing erect cultivars exhibited greater yield reduction than the indeterminate spreading types and had the least effect on millet yields. Indeterminate spreading cultivars produced greater grain and fodder yield than erect types and caused the greatest millet yield reduction.

The relationship between the yield of cowpea cultivars and millet when intercropped was negative. Linear correlations between yield of cowpea in sole and intercrop were positive and significant ($P < 0.01$) with r values ranging from 0.45 to 0.91. However, a small proportion of the greatest and least-yielding cowpea cultivars in intercropping would have been selected and rejected, respectively, on the basis of sole-crop grain-yield. It was concluded that selection of cowpea cultivars for intercropping with millet based on their grain yield in sole crop may have limited success. Selection based on fodder yield favoured late-maturing cultivars. Selection of cowpea cultivars for intercropping should be based on their intercropped performance, paying special attention to other agronomic factors. An appropriate cowpea cultivar for intercropping with millet would be the one that is less competitive with millet and yields both grain and fodder.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp.) is commonly grown intercropped with pearl millet (*Pennisetum glaucum* (L.) R. Br.) and sorghum (*Sorghum bicolor* L. Moench) in the Sahelian zone of West Africa (Steiner, 1982). Al-

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though there are no rigid intercropping patterns, the most common combination is the pearl-millet/cowpea system. The two crops are grown under conditions characterized by poor soils, frequent drought, high temperatures and many insect pests and diseases. Chemical fertilizers and insecticides are rarely used. Average grain yields of cowpea are around 200 kg ha^{-1}. Cowpea serves a dual purpose of providing beans for human consumption and fodder for livestock. Despite the importance of the millet/cowpea-based cropping system, research focused on understanding and improving the system is just receiving attention. Fussell and Serafini (1985) reviewed crop associations in the semi-arid west Africa and concluded that the millet/cowpea-based system generally improved and stabilized yields.

In traditional farms, a 90–110-day-cycle millet is the first of the two crops to be sown. The cowpea, generally of 120–150-day-cycle, is sown between millet rows from 2 weeks to 1 month after the millet, depending on the onset of the rainy season; in this situation, the millet becomes the dominant crop. Millet is often harvested before the cowpea, the latter maturing on residual moisture after the end of the rains. In most years, particularly in the northerly regions of the Sahel, the late-maturing cowpea may produce little grain and be useful only for fodder production.

Progress has been made at the International Institute of Tropical Agriculture (IITA) in developing improved cowpea cultivars which mature in half the time of the traditional cultivars (Singh and Ntare, 1985). These new cultivars, however, are more adapted to sole-crop systems. Experience has shown that few farmers have been prepared to change their traditional methods of intercropping cowpea with millet in order to grow sole-crops. It has not been established whether cultivars developed for sole-crop systems are also adapted to intercropping.

Varietal selection for improved intercrop performance is dependent on the objectives of the system. In the Sahel, farmers intercrop to stabilize productivity, reduce risk of crop failure due to irregularities in climate, and spread labour peaks (Norman, 1974; Matlon, 1980). They apparently seek to have a full millet grain yield with some additional cowpea grain and fodder. Research is increasingly being directed towards endeavouring to maintain the inherent stability of traditional cropping systems while increasing productivity.

Studies on evaluation of cultivars for their adaptability to intercropping have been reviewed (Galway et al., 1986; Smith and Francis, 1986). They indicate that there is a differential response of genotypes to cropping systems.

The present study was to examine the performance of contrasting cowpea cultivars intercropped with millet, to determine the relationship between performance in sole-crop and intercrop. The study also examined the effectiveness of selection for intercropped cowpea.

MATERIALS AND METHODS

Two trials were conducted from 1984 to 1986 at the ICRISAT Sahelian Center (ISC), 40 km south of Niamey in the Republic of Niger. This station (13°15′N latitude, 2°18′E longitude, 240 m elevation) is in the Sahel bioclimatic zone, an extensive semi-arid belt immediately south of the Sahara desert.

In 1984 the total rainfall was 260 mm, 59% below the average value. There was severe moisture stress during crop growth. In 1985 season, the total rainfall was 545 mm, 4% below the average and in 1986 season it was 657 mm, 15% above the average and was fairly well distributed. The sandy reddish-coloured soil is low in native fertility and organic matter, is strongly acid, and is classified as a siliceous isohyperthermic Psammentic paleustalf.

Trial 1

The cowpea cultivars used in this trial are given in Table 1. In 1984, two millet cultivars CIVT (90-day cycle) and HKP, (110-day cycle) were used. The spacing for millet was 1 m × 1 m, and cowpea was sown in alternate rows with the millet. For the erect cultivars, a density of 5 plants m^{-2} was used, and the spreading types were sown at a density of 3 plants m^{-1}. The plot size was 6 m × 6 m. These densities are much higher than in traditional systems. The treatment combinations of the six cowpea cultivars with two millet cultivars were laid out in a randomized complete-block design and replicated four times. Millet was sown on 22 June and cowpea was sown 13 days later.

In 1985 and 1986 cropping seasons, the trial included 1 millet cultivar, CIVT, and 2 additional cowpea cultivars, SUVITA 2 and 58-57; Sadore local was excluded. The treatments consisted of the 7 cowpea cultivars intercropped with

TABLE 1

Characteristics of cultivars of cowpea used in trial 1

1. IT84E 60	Determinate, erect	60	(Extra-early)
2. IT82D 716	Determinate, erect	65	
3. TVX 1999-OIF	Indeterminate bush	70	Early
4. TVX 3236	Indeterminate spreading	70	
5. SUVITA 2	Indeterminate spreading	70	
6. TN88-63	Indeterminate spreading	80	Medium-maturity
7. 58-57	Indeterminate spreading	75	
8. Local	Indeterminate spreading	>90	Late-maturing and sensitive to photoperiod

1. Cultivars 1 to 4 are improved cultivars from the cowpea breeding program at IITA; 5 to 7 are local selections in Burkina Faso, Niger and Senegal, respectively; 8 is a local land race grown mainly for fodder.

millet, and sole-crop millet was an additional treatment. These were laid out in a randomized complete-block design and replicated six times. In each year, cowpea was sown 1 week after millet; the plot size was 6×6 m.

Trial 2

In 1984, 300 advanced breeding lines from the cowpea improvement program at IITA were evaluated in sole-crop and intercropping with one millet cultivar, CIVT. The lines were divided into 15 trials, each consisting of 20 entries depending on plant type and maturity. The sole crops were sown in plots of 3 rows 4 m long, with a spacing of 1 m between rows and 30 cm within rows. Intercrop cowpea comprised of single rows 4 m long alternating with single rows of millet. Millet was sown in hills at 1 m apart and cowpea was spaced at 30 cm between plants in a row. Sole crops and intercrop plots of each trial were in adjacent blocks. The cowpea lines were arranged in a randomized complete-block design, replicated three times. Cowpea was thinned to one plant and millet to three plants per hill. In sole-crop, data were taken on the middle row. Two insecticide sprays, one at flowering and the second at pod-filling stage, were applied to the cowpea to control flowering and post-flowering pests.

In 1985 and 1986 cropping seasons, 75 lines representing 15 early (determinate, erect), 36 early (indeterminate, spreading), 17 medium-maturity (indeterminate, spreading) and 7 late-maturing (indeterminate, spreading) selected from the 1984 season were used. The 75 lines were arranged in a split-plot design with cropping systems (sole-crop and intercrop) as main plots and cowpea lines as sub-plots. Two replications were used. Each plot consisted of one row 6.0 m long. Millet was sown in hills 1.5 m apart within the row and rows were 0.75 m apart. Each cowpea line was sown in 8 hills 0.75 m apart in the same row as the millet. Both crops were thinned to three plants per hill. In the intercrop block, an additional row of sole-crop millet was included for reference. The density of cowpea in both cropping systems was similar. At harvest, six central hills of cowpea were used for yield estimation, while for millet two central hills were harvested. Both crops were sown on the same day in the last week of June in both years.

All trials received a basal application of 18 kg ha^{-1} P_2O_5 and 45 kg ha^{-1} of N as urea. The nitrogen was hill-placed adjacent to millet plants in two splits, one at 23 and the next at 45 days after planting. Analyses of variance were performed on each trial, and results are reported for each year. Linear correlations of cultivars and/or line means between cropping systems were determined for yield. Twenty and 33% selection levels of cowpea entries grown as sole-crop and intercropped were used to determine the effectiveness of selection of cowpea cultivars for intercropping, based on sole-crop performance.

RESULTS

Trial 1

Grain yield of cowpea and millet in the 1984 season are presented in Table 2. There were significant yield differences among the cultivars tested. A comparison of the cowpea yields between the two millet cultivars revealed non-significant differences among cultivars. The yield components, plants m^{-2}, seeds/pod and seed weight did not differ significantly among the millet cultivars (Table 3).

The yields of CIVT and HKP differed significantly ($P < 0.05$) in both sole

TABLE 2

Grain yield (kg ha^{-1}) of six cowpea cultivars intercropped with two constrasting millet cultivars in trial 1, 1984

Cowpea cultivar	Cowpea with CIVT	Cowpea with HKP	Millet	
			CIVT	HKP
IT82E 60	160	160	230	75
IT82D 716	320	200	190	280
TVX 1999-OIF	90	120	305	160
TVX 3236	180	150	270	45
TN88-63	158	130	285	70
Local[1]	—	—	228	100
Sole-crop millet			670	380
SED 27 d.f.	27.8			
(30 d.f. millet)			72	

[1] The local cultivar produced no grain and is not included in the analysis.

TABLE 3

Yield components of five cowpea cultivars intercropped with two millet cultivars in trial 1, 1984 season

Cowpea cultivar	Pods m^{-2}		Seed/Pod		100-seed weight (g)	
	with CIVT	with HKP	with CIVT	with HKP	with CIVT	with HKP
IT82E-60	26.2	24.5	4.5	4.5	14.3	13.6
IT82D-716	41.5	27.5	5.8	5.8	10.8	12.3
TVX 1999-01F	20.0	25.8	6.0	7.0	12.9	12.1
TVX 3236	23.5	21.5	6.0	6.5	10.0	9.5
TN88-63	31.8	28.5	6.0	5.8	9.4	10.3
SED, 27 d.f.	1.26		0.29		0.30	

TABLE 4

Cowpea and millet yield (kg ha^{-1}) in trial 1, 1985 and 1986 seasons

Treatment	1985			1986		
	Cowpea grain	Cowpea dry fodder	Millet	Cowpea grain	Cowpea dry fodder	Millet
Intercrop						
IT82E 60	100	320	2040	90	110	1230
IT82D 716	120	400	2170	100	180	1330
TVX 1999-OIF	320	600	2010	110	145	1200
TVX 3236	400	830	1790	200	230	1100
SUVITA 2	620	1340	1550	430	500	1125
TN88-63	420	1060	1600	180	460	1300
58-57	600	1300	1860	380	770	1165
Sole-crop millet			2240			1140
SED, 30 d.f. cowpea	80.5	77		56	60.0	
(36 d.f. millet)			124			212

and intercropping, with HKP producing the lowest yield (Table 2). Cowpea had a significant effect on millet yields. Both crops were seriously affected by drought during August and September. Fodder yield of cowpea was not measured in this year owing to leaf senescence resulting from drought stress.

In the 1985 and 1986 cropping season the rainfall distribution was favourable, and the crops did not suffer from moisture stress. The cowpea yield of grain and fodder differed significantly among cultivars, with the early-maturing cultivars producing the lowest yields (Table 4). The spreading cultivars maintained their rank in yield in both years and appeared to be more tolerant to millet competition. However, they significantly reduced millet yields in 1985. No cultivars significantly reduced the millet yield in 1986. The correlation between cowpea and millet yield was -0.80 ($P < 0.05$) (d.f. = 5) in 1985 and -0.62 (not significant) in 1986.

Trial 2

In 1984 cowpea intercrop yields were extremely low, owing to drought. Nonetheless an attempt was made to relate intercrop with sole-crop yields. Non-significant r values ranged from 0.16 to 0.33. Pooled over trials, a significant

TABLE 5

Cowpea and millet yield reduction (%) for different cowpea plant types in trial 2, 1985 and 1986 season

Cowpea plant type	n	1985			1986		
		Cowpea grain	Cowpea fodder	Millet	Cowpea grain	Cowpea fodder	Millet
Early erect determinate	15	37	36	24	51	46	34
Early semi-erect indeterminate	36	33	33	42	47	34	47
Early spreading	17	31	34	32	49	42	34
Late spreading	7	21	23	54	32	22	50

TABLE 6

Linear correlation (r values between yield of intercropped cowpea and millet in trial 2, 1985 and 1986 seasons

Plant type	1985		1986	
	Cowpea grain	Cowpea fodder	Cowpea grain	Cowpea fodder
Early erect determinate (d.f. = 13)	−0.05 n.s.	−0.27	−0.14 n.s.	−0.32
Early semi-erect indeterminate (d.f. = 34)	−0.10 n,s,	−0.48**	−0.29 n.s.	−0.65**
Early spreading (d.f. = 15)	−0.22 n.s.	−0.72**	−0.25 n.s.	−0.52*
Late spreading (d.f. = 5)	−0.66 n.s.	−0.80*	−0.36 n.s.	−0.76*

Significant at *$P < 0.05$, ** $P < 0.01$, or not significant, n.s.

TABLE 7

Linear correlations (r values) between performance of cowpea in solecrop and intercrop with millet in trial 2

Year	d.f.	Grain	Fodder
1984	292	0.45**	
1985	73	0.75**	0.87**
1986	62	0.91**	0.83**

**Significant at 1% level.

TABLE 8

Selection levels (20 and 33%) of cowpea cultivars grown as sole crop and intercropped with millet in trial 2

Year	No. cultivars tested	No. of cultivars			
		20% selected	Common	33% selected	Common
1984	300	60	17(29%)	99	51(52%)
1985	75	15	10(67%)	25	17(68%)
1986	75	15	11(73%)	25	20(80%)
Totals		90	38(42%)	149	88(59%)

Numbers in brackets are the percentage selected in common by the two cropping systems.

($P < 0.01$) correlation ($r = 0.45$) was obtained but too low to permit prediction of the best cowpea cultivars for intercropping on the basis of their sole-crop yields.

In 1985 and 1986, the analysis of variance showed significant effects ($P < 0.05$) of cropping systems, and cultivars. Cultivar × cropping system interaction for cowpea grain was not significant in either year but was significant for fodder yield. Intercropping reduced cowpea yields significantly but the degree of reduction varied among genotypes (Table 5).

The reduction in millet yield tended to be related to cowpea plant types. The late-maturing spreading cowpea caused the greatest reduction in millet yields (Table 5); the relationship between cowpea and millet yields indicated a similar trend (Table 6). Absolute cowpea yields in sole and intercropping were significantly correlated (Table 7).

Using grain yield as a selection criterion, 29–73% of the top 20% high-yielding cultivars in both cropping systems ranked in common by the two systems (Table 8). At 33% selection level, 52–80% of the cultivars ranked in common. Based on the results of 1985 and 1986, with 33% selection level, only 32% of the highest-yielding lines in the intercrop would have been selected from sole-crop in both years. On the other hand, only 16% of the lowest-yielding lines (at 33% rejection level) would have been eliminated based on their sole-crop performance (data not presented). Selection based on fodder yield favoured late-maturing cultivars.

DISCUSSION

In the trials, millet density was maintained at 10 000 hills ha^{-1}, the recommended density in the area. Cowpea density was greater than the farmers' common practice. The aim was to improve the performance of cowpea without adversely affecting the dominant cereal.

Although there were differences among cowpea cultivars in their competitive effect on millet, there was no significant cultivars × cropping system interaction for cowpea grain yield. A significant cultivar × cropping-system interaction for fodder yield was found, which seemed to be due to differences in competitive ability among the cultivars. Some cultivars had less effect on millet yields than the others. The erect determinate cultivars were intolerant of millet competition and were low-yielding. The medium-maturing spreading cultivars produced greater grain and fodder yield than the early erect and spreading types. On the other hand, the late-maturing types produced the greatest fodder yields but least grain and caused the greatest millet-yield reduction. The influence of plant type on competitiveness has been reported in maize/cowpea (Wien and Nangju, 1976) and maize/bean (Francis et al., 1982) intercropping.

The negative relationship between cowpea yields in intercropping and associated millet yield suggests that the lesser millet yield with certain genotypes could have been due to greater cowpea competition.

In the Sahel, the average length of the rainy season is from June to mid-September. The traditional cultivars which are sensitive to photoperiod do not flower until the end of September and, if rains terminate early as has been the trend in recent years, yield of grain is extremely low. The cowpea cultivars selected for intercropping with millet will therefore represent a compromise. Since drought-stress is a major concern particularly at the end of the season, early-maturing cultivars to escape drought would minimize the probability of all components being equally affected. They should not be erect and extra-early, and not too leafy to be too competitive with the millet. An appropriate cowpea cultivar for intercropping with millet would be the one that is less competitive and yields both grain and fodder. To achieve this will require considerable adjustment and manipulation of other agronomic factors.

The relationships between cowpea yields in sole and intercropping were positive and significant, indicating that evaluation in sole-crop gave a reasonable prediction of cowpea performance in intercropping. This is in agreement with Francis et al. (1978a,b) who evaluated different genotypes of bean (*Phaseolus vulgaris* L.) intercropped with maize. However, the ranking of cultivars in the two cropping systems revealed that a small proportion of the highest-yielding cultivars in intercrop would have been selected from sole-crop. Similarly, a small proportion of the lowest-yielding cultivars in intercrop would have been rejected based on their sole-crop performance. These results suggest that selection of cowpea cultivars for intercropping with millet based on their grain yield in sole-cropping may have limited success. Since sole and intercropped performance were reasonably related, selection for simply inherited traits such as resistance to diseases and insects, plant type, and maturity could be done in segregating populations in sole-crop. The final selection for intercropping should be based on intercropped performance of advanced breeding lines.

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