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RESPONSE OF COWPEA CULTIVARS TO PLANTING PATTERN AND DATE OF SOWING IN INTERCROPS WITH PEARL MILLET IN NIGER

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SUMMARY

A two-year study was conducted at two locations in Niger to compare the response of five cowpea cultivars to two planting patterns and two sowing dates relative to the sowing date of pearl millet. All the cowpea cultivars took less time to mature when planted three weeks after millet than when sown one week after. Early-maturing cowpea cultivars had the smallest yield, whereas the yield of the local indeterminate cultivar was nearly double that of the other cultivars at both dates of sowing. Early planting of cowpea significantly depressed millet yield, but when cowpea was planted late millet yields approached those of the sole crop. The local cultivar depressed millet yields more than the other cowpea cultivars. Planting pattern had no significant effect on the yield of either cowpea or millet. Cowpea yield was reduced by more than 50% by two weeks delay in sowing, confirming that the sowing date of cowpea relative to millet is a critical factor in the Sahelian pearl millet/cowpea intercropping system. There were marked differences in the effect of cowpea cultivar on millet yield but these differences were consistent over sowing dates.

Siembra simultanea de mijo/caupi en Nigeria

RESUMEN

En dos emplazamientos en Nigeria se llevó a cabo un estudio de dos años para comparar la respuesta de cinco variedades de cultivo de caupí respecto de dos patrones de siembra y dos fechas de siembra, en relación con la del mijo perlado. Todas las variedades de caupí tardaron menos tiempo en madurar cuando se las sembró con tres semanas de posterioridad al mijo, que cuando se las sembró con una semana de posterioridad. Las variedades de caupí con maduración temprana produjeron el menor rendimiento de cultivo, mientras que el rendimiento de la variedad indeterminada local fue casi el doble del de las demás variedades en ambas fechas de siembra. La siembra temprana del caupí redujo en forma significativa el rendimiento del mijo, pero cuando el caupí se sembró en forma tardía, el rendimiento del mijo alcanzó las cifras de un cultivo único. La variedad de cultivo local redujo el rendimiento del mijo más considerablemente que las demás variedades de caupí. El patrón de siembra no produjo un efecto significativo ni en el rendimiento e caupí ni en el del mijo. El rendimiento del caupí se redujo en más de un 50% debido a la dos semanas de retraso en la siembra, confirmando el hecho de que la fecha de siembra del caupí con relación al mijo constituye un factor crítico en el sistema de siembra simultánea de mijo perlado Sahelian/caupí. Se produjeron marcadas diferencias en el efecto de las variedades de caupí sobre el rendimiento del mijo, pero tales diferencias fueron las mismas en ambas fechas de siembra.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) plays a significant role in farming in Niger, which is Africa's second largest producer of the crop. The cropping systems in

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Niger are predominantly mixed and cereal-based, mixtures with pearl millet (*Pennisetum glaucum*(L.) R. Br.) being the most important. Cowpea grains provide nutritious food and the haulms (harvested stems and leaves) serve as fodder for livestock.

Intercropping of pearl millet and cowpeas is a common practice in the Sahelian region of West Africa (Steiner, 1982). The yield advantages of this system over the same crops grown in pure stands have been amply documented (Fussell and Serafini, 1985; Ntare *et al.*, 1989). Research on pearl millet and cowpea intercropping continues in an effort to increase the efficiency of this and similar production systems.

In Niger, local cowpeas usually flower during a period that coincides with the normal end of the rainy season. This period is characterized by a high probability of drought and rising temperatures. The two crops, pearl millet and cowpeas, compete for water, nutrients and light through most of their growth period. This limits yields, particularly when the rains end early, as is often the case.

Pearl millet is traditionally sown with the first rainfall and cowpea intercropped later at a date which depends on the progress of the rainy season. The delay may vary from 15 to 30 days after the millet has been sown. In most regions of Niger, livestock is left to roam the planted millet fields, browsing on the early weeds but apparently not on the young millet. This may be another reason why cowpea is rarely sown at the same time as millet. The delayed sowing means that millet often dominates the cowpea.

A goal of many resource-poor farmers in Niger is to achieve full production of the millet plus any additional yields associated with seed and fodder from the cowpea. Cowpea is rarely grown in pure stands and the competitive effects of cowpea on millet dictate a rather low cowpea density (1000 to 5000 plants ha^{-1}) for the local cultivars. In a millet/cowpea intercrop, light availability during critical stages of cowpea development could theoretically be manipulated by modifying the planting patterns and planting dates of the cowpea relative to the pearl millet. In this way it might be possible to allow maximum growth and yield of the cowpea while avoiding large reductions in pearl millet yields.

Research has already been conducted on several of the factors that affect millet/cowpea intercrop performance. These include choice of cowpea cultivars (Ntare, 1989), the effect of fertilizer (Fussell and Serafini, 1985), and the interaction of cowpea sowing date with millet and cowpea density (Ntare, 1990). In the sowing date and plant density study it was shown that cowpea in the intercrop needs to be sown not later than two weeks after the millet in order to obtain reasonable yields of cowpea. The potential for increased production in intercrop combinations through modification of sowing dates and spatial arrangements may not have been fully exploited, and a better understanding of the interaction between these factors for different cowpea cultivars may contribute to further improvements in the production system.

The objectives of this investigation were therefore to determine the effect of row arrangement and the relative date of sowing of cowpea and millet on the yield of

both crops. In addition, the effect of sowing date and cultivar on competition between millet and cowpea was investigated.

MATERIALS AND METHODS

Experiments involving a factorial combination of 24 treatments arranged in a randomized block design with four replications were conducted at the ICRISAT Sahelian Center (ISC) research farm, at Sadore, 45 km south of Niamey town, and in a farmer's field at Goberi, 120 km east of Niamey, in 1988 and 1989. The soil at both sites is derived from eolian sand deposits and is representative of the soils used for millet/cowpea production. It is classified as a sandy, siliceous, isohyperthermic psammentic Paleustalf.

Rainfall received at Sadore from June to September was 699 mm in 1988 and 623 mm in 1989. This was 25 and 11% above the long term average (560 mm) for Niamey, respectively. In 1988 the rainfall was well distributed, permitting timely sowing of intercrop cowpeas. In 1989, the rainfall was poorly distributed during the growing season. June rainfall was 41% below the long term average and July rainfall 36% below. There was a long dry spell of 15 days during July when plant moisture stress was evident, but moisture availability was relatively good during August and September. The rainfall received at Goberi was 749 mm in 1988 and 426 mm in 1989.

The treatments were five cowpea cultivars, two planting patterns, and two sowing dates for the cowpea in relation to the pearl millet sowing date. The cowpea cultivars were: TVX 3236 (a semi-erect cultivar with profuse flowering habit that matures in about 70 days), B111-2 (a spreading type maturing in 65 days), Suvita 2 (a spreading type maturing in 75 days, and selected from the local landraces in the Sahel zone of Burkina Faso), TN5-78 (a spreading type maturing in 75 days) and Sadore Local (a highly vegetative photoperiod-sensitive prostrate variety maturing in more than 90 days). The cultivars represented the maturity range of cultivars introduced and adapted to the area and included both determinate and indeterminate growth habits. Planting patterns were: single rows of millet alternating with single rows of cowpea, and double rows of millet alternating with double rows of cowpea. The planned sowing dates for the cowpea were one week and three weeks after the millet. The widely grown millet cultivar, CIVT, which matures in 110 days, was used at both locations.

Millet was sown in hills spaced 1.5 m between rows and 0.75 m within rows for the single row system. The distance between and within rows in the double row arrangement was 0.75 m. The distance between pairs of rows was 2.25 m. The sowing dates for both crops are shown in Table 1. The sowing dates of cowpea were influenced by the rainfall situation after the millet was sown.

Before sowing, 100 kg P_2O_5 ha^{-1} as single superphosphate was surface broadcast in the farmer's field and incorporated at the first weeding of the millet. At the research farm the superphosphate was incorporated before the millet was sown. Nitrogen as urea was applied to the millet at 45 kg ha^{-1} in split applications

Table 1. *Sowing dates of cowpea relative to millet at Sadore and Goberi, 1988 and 1989*

	Sadore			Goberi		
		Cowpea			Cowpea	
	Millet	Date 1	Date 2	Millet	Date 1	Date 2
1988	14 June	20 June	18 July	15 June	25 June	18 July
1989	29 June	9 July	1 August	27 June	8 July	29 July

(23 and 45 days after planting, DAP). The urea was placed in a hill 10 cm from the millet hills. A sole millet treatment was added for reference. Cowpea sole crop treatments were not included because cowpea is not usually cropped alone in this part of Niger. The cowpea was sprayed twice to control insect pests, once at flowering and again at the podding stage. No supplementary irrigation was given.

Four rows 6 m long of cowpea and three rows of millet were harvested for yield estimation. Samples were dried to constant weight in the sun. The competitive effect of cowpea cultivars on the millet was assessed as a compensation ratio (T), defined as the ratio of the cowpea yield in a treatment to the loss of millet yield as a result of competition from the cowpea, thus:

$$T = C_i/(M_s - M_i)$$

where C_i is the yield of cowpea in the i^{th} treatment, M_s is the yield of sole crop millet and M_i is the yield of millet in the i^{th} treatment. Thus a large result indicates that the competitive effects of cowpea on the millet were balanced by substantial gains in cowpea, while a value of unity indicates mere substitution of cowpea for millet.

RESULTS

As expected, Sadore Local was the latest cowpea cultivar to mature, averaging more than 90 days from sowing (Table 2). The time to maturity was shorter from the second sowing date, with significant differences between cultivars.

Sowing date had a significant effect on seed and fodder yields of cowpea, which differed significantly between cultivars (Table 3). Except for grain yield at Sadore in 1988, Sadore Local yielded nearly twice as much grain and fodder as the other cultivars from both sowing dates. The low grain yield of Sadore Local at Sadore in 1988 was attributed to untimely insect pest control. A delay of two weeks in the sowing of cowpea resulted in a reduction of more than 50% in the grain and fodder yield of all cowpea cultivars. The early maturing cultivars (TVX3236 and B111-2) produced the smallest grain and fodder yield from both sowing dates. Planting pattern had no significant effect on the average yields of either the cowpea or the millet.

Table 2. *Effect of cowpea cultivar and delay in the sowing date of cowpea relative to millet on time to maturity (days) of cowpea at Sadore and Goberi, 1988 and 1989*

	Sadore				Goberi			
	1988		1989		1988		1989	
Cowpea cultivar	1 week	3 weeks	1 week	3 weeks	1 week	3 weeks	1 week	3 weeks
TVX3236	65	62	78	60	73	63	73	71
B111-2	68	62	75	66	67	55	74	72
SUVITA 2	73	65	70	64	71	60	74	73
TN5-78	78	74	66	63	71	61	74	73
Sadore Local	100	92	90	76	105	80	106	88
SE ±	2.2		3.4		1.5		0.6	

Cowpea cultivars and sowing dates had a significant effect on millet grain yield. Sowing cowpea one week after millet reduced millet yields more than the later sowing. Cowpea cultivars also had a substantial effect on the compensation ratios for grain, fodder and total biomass (Table 4), with an interaction for T between date and cultivars in the distribution of benefit between fodder and grain. Throughout, TVX 3236 decreased millet yield by more than its own yield, while at the second sowing date TN5-78 had no effect on millet grain yield but was close to being a substitute competitor for fodder. SUVITA 2 and Sadore Local both had high compensation ratios but with considerable sowing date interaction between grain and fodder. Thus, although there were considerable differences in absolute yields between the genotypes, the benefits were offset by the larger decreases in millet yields.

DISCUSSION

A significant cowpea yield decline occurred when cowpea was sown three weeks after millet, probably as a result of competition from the millet. This is consistent with the results from an earlier study (Ntare, 1990) which showed that very low cowpea yields were obtained when it was sown more than two weeks after millet. In both years, cowpea matured earlier from the second sowing than from the first. Local cowpeas normally start flowering in early October, when decreasing daylength and rising temperature combine to promote floral development in accordance with the known effects of temperature and daylength on time to maturity of cowpeas (Summerfield *et al.*, 1985). Individual cultivars varied in their response to sowing date. Sadore Local, the latest maturing cultivar, yielded more than the earlier maturing cultivars from both sowing dates, and TVX 3236 and B111-2 were particularly sensitive to delayed planting. The superior yields of Sadore Local may be a result of its adaptation to the environment of the study and the effects of its prostrate nature and strong vegetative growth on soil temperature. Sadore Local tended to depress millet yields more than the other

Table 3. *Effect of cowpea cultivar and delay in the sowing date of cowpea on the yields of cowpea and millet (kg ha^{-1}) at Sadore and Goberi, 1988 and 1989*

	1988			1989		
	Cowpea grain	Cowpea fodder	Millet grain	Cowpea grain	Cowpea fodder	Millet grain
			Sadore			
One week's delay						
TVX 3236	60	260	670	70	90	230
B 111-2	220	650	630	250	210	250
Suvita 2	420	790	660	460	350	340
TN5-78	440	870	525	400	340	240
Sadore Local	30	2340	610	650	1880	190
Three weeks' delay						
TVX 3236	0	120	580	20	40	315
B 111-2	40	330	810	80	110	230
Suvita 2	70	300	770	120	140	290
TN5-78	80	355	675	100	170	260
Sadore Local	50	540	681	270	270	250
Sole millet	—	—	750	—	—	380
SE	36	77	50	32	47	32
			Goberi			
One week's delay						
TVX 3236	60	120	320	70	80	170
B 111-2	160	320	500	140	290	160
Suvita 2	260	360	515	250	360	110
TN5-76	270	400	420	210	350	130
Sadore Local	650	1060	370	590	1600	160
Three weeks' delay						
TVX 3236	30	60	590	35	75	290
B 111-2	100	130	515	50	110	210
Suvita 2	130	160	550	50	100	230
TN5-76	150	170	445	70	120	250
Sadore Local	350	385	650	230	580	215
Sole millet	—	—	540	—	—	355
SE	21	44	60	23	66	29

cultivars. These differences in the competitive effects of cowpea cultivars on millet are consistent with previous results (Ntare, 1989) and probably resulted from differences in crop cover (as suggested by differences in the fodder yields), creating varying levels of competition for nutrients and water.

The choice of cowpea cultivar and sowing date is further confounded by the different market values of the four components of the pearl millet/cowpea intercrop system (livestock grazing, millet and cowpea grain, and cowpea

Table 4. *Effect of delay in the sowing date of cowpea relative to millet on cowpea : millet compensation ratios for grain, fodder and total biomass of five cowpea cultivars intercropped with millet*

Cowpea cultivar	Grain		Fodder		Total biomass	
	1 week	3 weeks	1 week	3 weeks	1 week	3 weeks
TVX 3236	0.44	0.33	0.65	0.85	0.64	0.76
B 111-2	1.58	1.00	1.57	1.89	1.68	1.75
Suvita 2	3.50	2.40	3.32	8.75	3.85	4.21
TN5-78	1.83	†	1.41	1.37	1.81	2.46
Sadore Local	2.67	3.83	6.37	2.47	5.24	3.15

†No competition from cowpea was detected.

fodder). TVX 3236 is unsuitable for intercropping because of its negative impact on millet yield and its own poor yield in the intercrop. If the strategy is to ensure maximum productivity of millet grain, then TN5-78 sown at a later date would be the logical choice since it has no significant negative affect on millet grain. On the other hand, if total productivity is the objective, early sown Sadore Local would be preferable. However, these trials were conducted during a period of above average rainfall and it is possible that the late maturity of Sadore local might lead to relatively unstable performance because of the high probability of end-of-season droughts. SUVITA 2, a medium maturing cultivar would provide a compromise with the least decrease in millet yield and a very good compensation ratio.

The results of this study have implications for the design of appropriate strategies for the development of cowpea cultivars suitable for intercropping with millet in the variable environments of the Sahel. Analysis of long term rainfall data for 58 locations in Niger and Burkina Faso suggests that prediction of the rainy season potential may be possible (Sivakumar, 1988). This analysis indicates that for Niger, an early onset of the rains offers the probability of a longer growing season (about 120 days) while a delayed onset results in a considerably shorter growing season (90 days). Therefore, in breeding cowpea cultivars suitable for intercropping, emphasis should be given to those that can offer alternatives to the farmer. The main concern is the impact of inter-seasonal or even intra-seasonal anomalies in the rainfall patterns.

One difficulty in the selection of cowpea cultivars for intercropping is their competition with the companion crop. In this context, we believe that the use of a compensation ratio can provide a valuable selection guide to the breeder and a treatment evaluation index for the agronomist. The analysis using compensation ratios showed a consistent behaviour of all cultivars for biomass, particularly across the sowing dates. This suggests that for these environments, relative sowing date may not be important in cultivar choice. To maximize yields, early sowing of cowpea relative to millet is necessary. However, this would involve major changes in livestock management practices, and increased crop producti-

vity will have to be balanced against the cost of finding alternative feed for livestock prevented from grazing the fields.

Earlier maturing cultivars offer an opportunity to manipulate competition gaps. In practice, however, the number of options is fairly limited. New cultivars will need to be screened to determine their consistency of performance in the existing cropping systems.

REFERENCES

Fussell, L. K. & Serafini, P. G. (1985). Association de cultures dans les zones tropicale semi-arides d'Afrique de l'Ouest: stratégies de recherches antérieueres et future. In *Technologies Appropriées pour les Paysans de Zones Semi-arides de l'Afrique de l'Ouest*, 254–278 (Eds W. Ohm and J. G. Nagy). West Lafayette, Indiana, USA; Purdue University.

Ntare, B. R., Serafini, P. G. & Fussell, L. K. (1989). Recent developments in pearl millet/cowpea cropping systems for low-rainfall areas of Sudano-Sahelian Zone of West Africa. In *Soil, Crop, and Water Management Systems for Rainfed Agriculture in the Sudano-Sahelian Zone: Proceedings of an International Workshop, 7–11 January 1987, ICRISAT Sahelian Center, Niamey, Niger*, 277–289. Patancheru, India: ICRISAT.

Ntare, B. R. (1989). Evaluation of cowpea cultivars for intercropping with pearl millet in the Sahelian Zone of West Africa. *Field Crops Research* 20:31–40.

Ntare, B. R. (1990). Intercropping morphologically different cowpea with pearl millet in a short season environment of the Sahel. *Experimental Agriculture* 26:41–47.

Sivakumar, M. V. K. (1988). Predicting rainy season potential from the onset of rains in southern Sahelian and Sudanian climatic zones of west Africa. *Agriculture and Forestry Meteorology* 42:295–305.

Steiner, K. G. (1982). *Intercropping in Tropical Smallholder Agriculture with Special Reference to West Africa.* Eschborn, Germany: Deutsche Gesellschaft für Technische Zusammenarbeit.

Summerfield, R. J., Patel, J. S., Roberts, E. H. & Wien, H. C. (1985). The physiology of cowpeas. In *Cowpea Research, Production and Utilisation*, 65–101 (Eds S. R. Singh and K. O. Rachie). Chichester, UK: John Wiley and Sons.