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Effects of phosphorus on yield of cowpea cultivars intercropped with pearl millet on Psammentic paleustalf in Niger[1]

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Abstract

Phosphorus (P) is the most limiting soil nutrient in the sandy soils of Niger and farmers rarely use chemical fertilizers in producing pearl millet and cowpea A 3-yr study was conducted in farmer s fields at two locations in South Western Niger to investigate yield response of six cowpea cultivars to applied P fertilizer (0 8 16 kg ha $^{-1}$) when intercropped with millet Significant yield differences were found between cultivars for their seed and dry fodder yield at all rates of applied P Cultivars responded differently to the application of P Millet grain was more than doubled with the addition of 8 to 16 kg P ha $^{-1}$ Cowpea cultivars did not have significant differential effect on millet yields Cowpea cultivars differed significantly in the accumulation of P in fodder with the highest yielding cultivars taking up more P than the low yielding ones The results have important implications for breeding and selection of cowpea cultivars that are adapted to a range of fertility levels

Introduction

Intercropping pearl millet (*Pennisetum glaucum* (L) R Br) and cowpea (*Vigna unguiculata* (L) Walp) is a common practice in Niger and other Sahelian countries of West Africa [3] Millet and cowpea are grown under limited moisture conditions and consequently farmers traditionally use low densities of both crops to reduce the risk of yield loss due to moisture stress The soils are low in soil fertility and P is the most limiting of all nutrients [1] but farmers rarely use chemical fertilizers because of their relatively high cost

The yield of cowpea as a sole crop can be improved with different indigenous sources of P in Niger [2] Work conducted in the Sudanian zone of Burkina Faso indicated that response to P depended on cowpea plant type [5]

A number of improved cowpea cultivars of different plant types have been developed [8] These yield very well in monoculture with high inputs of fertilizers and pesticides There is increasing interest in breeding cowpea that is suitable for intercropping with pearl millet Understanding of cowpea cultivar response to added P in intercropping may contribute to the selection of such cultivars The objective of the study was to determine the yield response to P of six cowpea cultivars intercropped with millet and to examine the implications for breeding cowpea cultivars adapted to a range of fertility conditions

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Materials and methods

The study was conducted in 1987, 1988 and 1989 in a farmer s field at Sadore, near the ICRISAT Sahelian Center (ISC) 43 km south of Niamey, and at Goberi, 120 km east of Niamey in Niger. The soils at the two sites are derived from eolian sand deposits (Siliceous, isohyperthermic Psammentic paleustalf) and are representative of soils presently used for millet/cowpea production in the Sahel. The initial soil status at Sadore was: pH (KCl 1:1) 3.0; 0.40% organic matter; 3.60 ppm Bray 1 P; and 96% sand. At Goberi, pH, organic matter, Bray 1 P, and sand were 4.20, 0.37%, 3.30 ppm, and 96%, respectively. The field at Goberi had been under bush fallow for more than 5 years while at Sadore the field had millet in the preceding year.

The treatments were arranged in a randomized split-plot design with four replications. The P rates (0, 8, and 16 kg ha^{-1}) were the main plots and six cowpea cultivars as subplots. The cowpea cultivars were: TVX 4659-03E, an erect indeterminate cultivar, TN88-63, a commercial cultivar in Niger, Dan Illa and TN5-78, recently released local cultivars in Niger; and two local land races: Sadore Local grown mainly for fodder and Tera Local grown for grain and fodder. Except for Sadore Local which is photosensitive and late maturing (>90 days from sowing), all the others are photoinsensitive and mature in 75 days after sowing. In all the trials a 110 day millet cultivar, CIVT, the most common improved variety in Niger, was used.

In 1987 and 1988, single superphosphate was broadcast on the soil surface before sowing and mixed in the upper 5 cm of the soil at the first weeding of millet (10 days after sowing) using a local hoe. Trials were carried out on the same plots in both years. In 1989, no fertilizer was added to determine the residual effect of P. Millet plots were planted in 5 rows of 6 m long with an inter- and intra-row spacing of 1.50 m and 0.75 m, respectively. Four rows of cowpea were intersown between the millet rows with a similar spatial arrangement as for the millet. Sowing of cowpea ranged from 2 to 6 weeks after millet. Each crop was thinned to three plants per hill. Nitrogen (45 kg ha^{-1}) as urea was applied to millet in two equal amounts, half at 23 days after sowing (DAS) and half at 45 DAS. In 1987 cowpea was not sprayed with insecticide to control pests following farmer's practice and this resulted in no grain production.In the following years cowpea was sprayed with Cymbush$^{(R)}$ twice during cropping to control flower and post flowering insects.

Rainfall at Sadore in 1987 was 450 mm, 20% below the long term average (560 mm) for Niamey. Sufficient rainfall for sowing was delayed until July 15. In 1988 rainfall was 699 mm, well-distributed with all the months of July to September recording above average rainfall. In 1989, June rainfall was poorly distributed and 41% below the long term average. In July it was 36% below average. There was a dry spell of 20 days during July and moisture stress was evident. At Goberi, rainfall was 403 mm in 1987, 650 mm in 1988 and 426 mm in 1989. The distribution showed similar trends as at Sadore.

Results

Cowpea yields:. In 1987, significant yield differences were found between cultivars in their dry fodder yield at all P rates (Table 1). The interaction cultivar-by P rate was also significant ($P < 0.05$). Sadore Local produced significantly more dry fodder at both rates of P than the other cultivars. However, the yield of Sadore Local was reduced at the higher P rates. The other cultivars produced low yields but responded more to added P.

In 1988 P rates and cultivar effects were significant ($P < 0.01$) for grain and dry fodder at both sites (Table 2), but there were significant cultivar-by-P level interactions. The higher P rate significantly increased yields combined over cultivars. The grain yield of Sadore Local was low at Sadore due to poor insect pest control but it produced the highest average grain yield at Goberi where insect control was better.

In 1989 yields were extremely low (Table 3). Nonetheless, residual P had a significant ($P < 0.05$) effect on grain and dry fodder yields that were somewhat higher at the P rate 16 kg ha^{-1}. Sadore Local was again the highest yielder at the two sites. At Sadore the cultivars exhibited an average 100% increase in seed yield and at Goberi 223%. For dry fodder the increase was 47% at Sadore and 100% at Goberi. Individual cultivars showed different yield responses to the application of P and the increases were markedly higher in 1989 than in the preceding year.

Table 1. Dry fodder yield (kg ha⁻¹) of six cowpea cultivars as affected by the application of P-fertilizer in 1987

Cowpea cultivars	P rate kg ha⁻¹							
	Sadore				Goberi			
	0	8	16	Mean	0	8	16	Mean
Tvx 4659-03E	65	90	120	90	120	95	130	115
TN88-63	45	110	100	85	30	70	80	60
Tera Local	160	135	190	160	110	150	170	140
Sadore Local	370	430	235	345	640	470	460	520
Dan Illa	50	60	165	90	130	95	120	115
TN5-78	220	150	210	195	205	260	260	240
Mean	150	160	170	160	210	190	200	200
SE								
P rates(P)			5.6				20.3	
Cultivars(C)			13.3				18.5	
P × C			23.0				31.9	

Millet yield:. Millet grain yield response to P was highly significant ($P < 0.01$) in the three years and yields were more than doubled with the addition of P (data not shown). Cowpea cultivar did not have significant differential effect on millet grain yield.

P uptake:. Cowpea cultivars differed significantly in the accumulation of P in the fodder with the highest yielding cultivar (Sadore Local) taking up more P than the other cultivars (Table 4). P uptake was significantly affected by P rate with a tendency for higher P at 16 kg ha⁻¹

Table 2. Effect of P rates on grain and fodder yield (kg ha⁻¹) of six cowpea cultivars at two sites in 1988

Cowpea cultivars	P rate kg ha⁻¹							
	Sadore				Goberi			
	0	8	16	Mean	0	8	16	Mean
Grain								
Tvx 4659-03E	70	100	110	90	120	130	240	165
Sadore Local	20	20	20	20	310	410	480	400
TN88-63	115	200	205	170	260	240	310	270
Tera Local	90	130	130	120	120	300	350	260
Dan Illa	120	120	150	130	150	160	250	190
TN5-78	150	160	200	170	200	215	470	300
Mean	95	120	140		185	240	330	
Se								
P rate (P)		5.3				26.6		
Cultivars (C)		8.9				21.5		
P × C		15.5				37.2		
Fodder								
Tvx 4659-03E	160	230	290	230	290	420	715	480
Sadore Local	575	485	860	640	635	920	1065	870
TN88-63	110	210.	300	210	320	270	310	300
Tera Local	220	200	320	250	270	510	670	450
Dan Illa	130	140	200	160	170	180	260	205
TN5-78	180	170	310	220	220	330	630	295
Mean	210	225	355		295	415	630	
SE								
P rates (P)		22.7				48.7		
Cultivars (C)		30.2				34.9		
P × C		52.3				6.05		

Table 3. Grain and dry fodder yield (kg ha $^{-1}$) of six cowpea cultivars at two sites as influenced by residual P in 1989

Cowpea cultivars	P rate kg ha $^{-1}$							
	Sadore				Goberi			
	0	8	16	Mean	0	8	16	Mean
Grain								
Tvx 4659-03E	15	50	30	30	10	20	50	25
Sadore Local	70	160	125	120	90	180	250	175
TN88-63	20	50	75	50	30	30	90	50
Tera Local	50	60	65	60	10	30	40	30
Dan Illa	50	75	80	70	30	50	65	50
TN5-78	60	110	100	85	20	30	110	50
Mean	40	80	80		30	60	100	
Se								
P rates (P)		7 1				12 9		
Cultivars (C)		11.5				11 3		
P × C		19 9				19 5		
Fodder								
Tvx 4569-03E	90	180	155	140	70	105	210	130
Sadore Local	195	170	220	190	230	310	400	315
TN88-63	60	115	120	100	80	80	145	100
Tera Local	105	95	100	100	50	110	110	90
Dan Illa	60	110	85	85	50	70	90	70
TN5-78	90	115	150	120	60	80	170	10
Mean	95	120	140		90	120	180	
SE								
P rates (P)		16 4				18.8		
Cultivars (C)		14.1				19.6		
P × C		24 4				33 9		

Table 4. P uptake (kg ha $^{-1}$) in cowpea fodder at three P rates

Treatment	Sadore 1987	Goberi 1987	Goberi 1988
P rate			
0	0.34	0 45	0 38
18	0.45	0.46	0.43
36	0.47	0.52	0.87
SE	0.040	0 050	0 100
Cowpea Cultivars			
Tvx 4659-03E	0.25	0.30	0.30
TN88-63	0.22	0.15	0.30
Tera Local	0.42	0.33	0 77
Sadore Local	0.83	1.23	0.96
Dan Illa	0.27	0.28	0.38
TN5-78	0.52	0.55	0.36
SE	0.037	0.056	0.086

Discussion

Interaction between cultivars and P rates was observed with some cultivars declining in yield at higher P rates. This decline may have been due to millet competition. Better growth of the pearl millet (the dominant component) could have suppressed the cowpea. Some cultivars did not respond to P rate. A similar phenomenon was observed where fertilizer application significantly increased millet yields but had no effect on associated cowpea dry fodder [4]. Sadore Local, a photosensitive and a forage type cultivar produced the highest grain and fodder yield at all P rates. This superiority may partly be due to its long growth duration or its spreading and indeterminate growth habit.

The detection of cultivar differences in yield at no P application was encouraging in the context of breeding cultivars providing greater agronomic efficiency through reduced fertilizer costs. The differences in response to P could also have important implications for breeding and selection of cowpea cultivars adapted to a range of fertility conditions. Higher yield potential could itself lead to greater response to P and greater efficiency in terms of yield/unit of applied P at all levels. Further experimentation using a larger number of cultivars than in the present study should be worthwhile.

The erratic distribution of rainfall in 1987 and 1989 influenced the sowing of cowpea relative to that of millet. It has been shown that the planting date of intercrop cowpea relative to that of millet is critical with cowpea sown three weeks after millet giving extremely low yields [7]. When cowpea is sown in an already well-established millet stand the dominating effect of millet through shading and competition for nutrients may result in poor cowpea yields. Despite the low yields recorded in 1989, which was characterized by a pronounced dry spell, the percentage yield increase with the application of P was markedly higher than the preceding year which had a favourable rainfall distribution. The reason for this is not clear. However, it is possible that yield response to higher P rates is greatest under moisture stress conditions whereby plants in fertilized plots may have a much deeper root system that exploits moisture deeper in the profile than in non fertilized plots. This is an area that needs intensive study.

The results of this study show that grain and fodder yields of cowpea can be substantially increased by the application of phosphorus fertilizer and that cultivar differences in their response to applied P could have important implications in the breeding and selection of cowpea cultivars adapted to different fertility conditions.

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Tera Local	50	60	65	60	10	30	40	30
Dan Illa	50	75	80	70	30	50	65	50
TN5-78	60	110	100	85	20	30	110	50
Mean	40	80	80		30	60	100	
Se								
P rates (P)		7.1				12.9		
Cultivars (C)		11.5				11.3		
P × C		19.9				19.5		
Fodder								
Tvx 4569-03E	90	180	155	140	70	105	210	130
Sadore Local	195	170	220	190	230	310	400	315
TN88-63	60	115	120	100	80	80	145	100
Tera Local	105	95	100	100	50	110	110	90
Dan Illa	60	110	85	85	50	70	90	70
TN5-78	90	115	150	120	60	80	170	10
Mean	95	120	140		90	120	180	
SE								
P rates (P)		16.4				18.8		
Cultivars (C)		14.1				19.6		
P × C		24.4				33.9		

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