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Nodulation, nitrogen fixation and harvest index of extra-short- and short-duration cowpea varieties intercropped with maize at Otobi, Benue state, Nigeria

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1 SUMMARY

A field experiment was conducted during the rainy seasons of 2009 and 2010 at the National Root Crops Research Institute Sub-Station, Otobi to assess the nodulation and nitrogen-fixing potentials of nine newly introduced extra-short - and short - maturing cowpea genotypes. These genotypes were: IT00K-1217, IT04-221-1, IT03K-378-4, IT03K-316-1, IT99K-377-1, IT98K-692, IT04K-217-5, IT03K-324-9, and IT03K-351-1) obtained from International Institute for Tropical Agriculture (IITA), along with Ife Brown (a short – duration local check). The experiment was a split-plot laid out in randomized complete block design with three replications. The main plot treatments comprised of two cropping systems [(i) sole cropping-cowpea and maize (ii) intercropping-cowpea + maize].The sub-plot treatments were 10 cowpea genotypes. Estimation of Nitrogen (N) fixation in the cropping systems was determined by the N-difference method using maize as the non-fixing control. Significant differences in the number and biomass of nodules among cowpea varieties were observed. Total plant nitrogen varied mainly with variety of cowpea used in the intercropping systems and IT99k-377-1 produced the highest total plant nitrogen (3.18 t/ha), while IT00k-1217 gave the lowest (1.60 t/ha). N and P(Phosphorus) concentrations of all the cowpea genotypes were highest in the leaf and lowest in the roots. The nitrogen harvest index varied from 0.76-0.97 with a mean of 0.85. Nitrogen fixed by cowpea in the intercropping systems ranged from 11.40 - 51.70 kg/ha with an average of 33.90 kg/ha). IT00K-1217 had the lowest N fixation value (11.40 kg/ha) while IT99k-377-1 gave the highest (51.70 kg/ha). The mean N fixed by these extra-short - and short – duration cowpeas intercropped with maize was far below those reported for cowpea by other workers indicating that these cowpeas may not be suitable as soil ameliorants for inherent low fertility of the degraded /over-used soils in Otobi.

2 INTRODUCTION

In the West African region, more than 70 per cent of the total world cowpea (*Vigna unguiculata* (L.) Walp) production is grown. Cowpea has become an integral part of the farming systems (Ogbuinya, 1997) and is grown in mixtures with other crops in various combinations (Olufajo and Singh, 2002). In Benue State ,located in Southern Guinea Savanna of Nigeria, 272,270 metric tonnes of cowpea were produced from over 300,000 hectares of land in 2009 (BNARDA, 2009). In this region, the bulk of cowpea production is by small-scale farmers using traditional system of mixed cropping with maize, sorghum, millet, yam, cassava, pepper and other vegetable crops. Cowpea is an important source of organic fertilizer (Eaglesham *et al*., 1977), because it nodulates freely and fixes atmospheric nitrogen in the soil (Bationo *et al*., 1991). Of the sixteen essential plant nutrient elements needed for plant growth, development and reproduction, nitrogen is the most important and is the most easily limited or deficient throughout the world, particularly in the tropics (Agbede, 2009).It is also the most expensive element as a mineral fertilizer. Biological nitrogen fixation (BNF) holds great promise for smallholder farmers. Considering the contributory role of fossil fuels to global warming, the focus on BNF in the 21st century will certainly increase (Viera *et al*., 2010). Studies conducted in the moist savanna and humid forest zones of West Africa showed that by integrating cowpea into maize - based cropping systems and recycling cowpea residues, as much as 50 per cent of urea application could be saved (Vanlauwe *et al*., 2003). Balasubramanian *et al*. (1980) and Dakora *et al*. (1987) reported that cowpea fixed between 64 and 134 kg N/ha and that these amounts may supply a major part of N needed by the following cereal crop in rotation. Farmers in Southern Guinea Savanna and in most parts of Nigeria have preference for short duration genotypes of cowpea (Singh *et al*., 1997). Information on the productivity of extra-short - and short- duration cowpea varieties in sole cropping and intercropping with maize in Southern Guinea Savanna is available (Egbe *et al*.,2010). The work reported here specifically assessed the effects of extra-short- and short-duration varieties of cowpea on nitrogen economies of cropping systems by quantifying nodulation, nitrogen fixation potentials, fixed N removal in harvest, and harvest index with a view to ascertaining their soil fertility enhancing potentials.

3 MATERIALS AND METHODS

A field experiment was undertaken during the rainy seasons (April – October of 2009) and 2010 (June – October) at the National Root Crops Research Institute Sub-Station, Otobi [Latitude 07º 10′- 07º 12′ N, Longitude 08º 39′– 08º 42′E, elevation 105.1 m], located in the Southern Guinea Savanna of Nigeria. The study was to assess nodulation, nitrogen-fixing potentials, and N contribution under intercropping with maize of ten newly introduced extra-short- and short - duration cowpea genotypes [obtained from International Institute for Tropical Agriculture (IITA)]. The experimental site received a total rainfall of 1453.3 mm and 1543.6 mm, respectively, in 2009 and 2010. The sandy loam soil at the experimental site was classified as Typic Paleustalf (USDA).Table 1 shows physical and chemical properties of the soil (0-30 cm). The same site was used for the experiment in each year. The experiment was a split-plot laid out in randomized complete block design with three replications. The main plot treatments comprised of sole cropping and intercropping cowpea with maize whilst the sub-plot treatments were 10 cowpea genotypes made up of two extra-short- duration genotypes (IT00K-1217 and IT04-221-1) and eight short-duration genotypes (IT03K-378-4, IT03K-316-1, IT99K-377-1, IT98K-692, IT04K-217-5, IT03K-324-9, IT03K-351-1 and Ife Brown). The latter variety had been under cultivation in the locality (Otobi) for more than a decade, and had been shown to be early maturing (BNARDA, 1999). The maize variety used in the experiment was *Striga*-tolerant CY.TZL.comp.1 c4 obtained from IITA, Ibadan, Nigeria. The land used for the experiment was ploughed three weeks before being harrowed once and ridged. Cowpea and maize were sown as either sole crop or intercrop on ridges(which is the dominant practice used by the farmers in Otobi).The ridges spaced 100 cm apart were 50 cm wide with a 50-cm furrow spacing separating one from the other. Each sub-plot consisted of 4 ridges of 4 m length (16 m²) as gross plot.

Cowpea was planted at the crest of the ridge, while maize was planted by the side as intercrop. All sole systems were formed at the crest of the ridge. Intercropping had 1:1 row proportion (cowpea: maize), such that one row of cowpea alternated with one row of maize. Intercrop plots had 50% of the full population of each of the component crops [100,000 plants/ha-cowpea and 40,000 plants/ha-maize]. All plots received a basal application of 100 kg of NPK: 15:15:15 at the rate of 15 kg N, 6.45 kg P and 12.45 kg K per hectare by broadcasting. The sole- and inter – cropped maize were top-dressed four weeks after planting(w.a.p.) with 46 kg N per hectare by opening the soil around each plant and banding at 5-8 cm depth and covering with the dug-out soil.

Table 1: Some physical and chemical properties of the soil (0-30cm) at the experimental site at Otobi

Parameter	Value
Sand (%)	70.10

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Silt (%)	11.68
Clay (%)	18.22
pH (H_2O)	5.98
Organic carbon	0.51
Organic matter	1.27
Total N (%)	0.11
Available P (cmol kg^{-1} soil)	7.62
Ca^{2+} (cmol kg^{-1} soil)	2.62
Mg^{2+} (cmol kg^{-1} soil)	2.34
K^{+} (cmol kg^{-1} soil)	0.64
Na^{+} (cmol kg^{-1} soil)	0.34
Exch.acidity (cmol kg^{-1} soil)	0.35
ECEC (cmol kg^{-1} soil)	6.29

Two manual weeding were done at 3 w.a.p. and 6 w.a.p., respectively. Data on number of nodules per plant of cowpea and nodule biomass were collected at the peak of flowering of the cowpea component. Four core soil samples were collected from each sub-plot treatment at the depth of 0-30 cm and bulked into a composite sample for the sub-plot at the beginning and end of the experiment.

At 50% flowering, five cowpea plants were dug out from each of the sole and intercropping plots for nodule count, nodule dry weight, dry root and shoot weight. The process involved initially breaking the soils around the plants to a depth of 50 cm with a hand hoe making sure their roots were not disturbed. The plants were then pulled out gently and put in polyethylene bags. These were taken to the Crop Science Laboratory of the University of Agriculture, Makurdi and washed with water to remove soil particles on the roots. The nodules on the roots and those that broke off in the course of washing were picked and counted. These were put in envelopes and oven-dried at 70^{o}C for 72 hours after which they were weighed on a sensitive electronic balance. The roots were severed with a sharp knife from each plant, bagged separately, oven-dried at 70^{o}C for 72 hours and weighed to obtain the dry root weight and the average root weight per plant was calculated. The same procedure was used to obtain average shoot weight per plant.

The soil samples were air-dried and ground (using mortar and pestle) to pass through a 0.3 mm screen for chemical analysis. Nitrogen in soil was estimated by phenols colour formation method (Chaykin, 1969) after micro-Kjeldahl digestion. Similarly, oven-dried shoot samples of sole and intercropped cowpea and maize (non-fixing control) were separately ground to pass through a 0.6 mm screen for chemical analysis. Nitrogen yield in the leaves, stem, root, shoot and pod with seed of both sole and intercropped cowpea samples and maize shoot was determined as outlined by Chaykin (1969) after micro-Kjeldahl digestion (Black, 1965). The concentration of available phosphorus (P) was determined by the Ammonium-molybdenum blue method (Murphy and Riley, 1962; Watanabe and Olsen,1965). All the laboratory chemical analyses for N and P were done in the NICANSOL Soil laboratory of the University of Agriculture, Makurdi, Nigeria. The formula of Papastylianou (1999) for the estimation of the apparent net amount of atmospheric N_2 fixed by legumes in short- and long-term cropping systems was used to estimate N fixation.

$\mathbf{N_2}$ = (L-M) + (fi – fm)

Where N_2 = amount of nitrogen fixed by systems;

L = N harvested in a N_2-fixing legume;

M = the amount of N in a non-fixing crop grown under the same condition as the legume;

fi = soil N after the legume;

fm = soil N under the non-N_2-fixing crop.

This equation assumes that the legume crop and the non-legume crop absorbed the same amount of soil N. The soil N value (fi-fm) in the equation could be positive, zero or negative, depending on whether the legume system removed less, equal or more soil N than the non-legume grown in monoculture. The amount of total N fixed per ha by cowpea for each treatment plot was obtained by multiplying the proportion of N derived from N fixation by the dry shoot weight of cowpea in that treatment plot.

The formula of Rennie (1984) for calculating the percentage of plant N derived from the atmosphere was used to estimate the percentage N derived from the atmosphere by cowpea varieties.

%Ndfa = (N2/ShootN) x 100)

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Where %Ndfa is the percentage of plant N derived from atmosphere and shoot N is the N harvested in cowpea shoot (stem+leaves+pod with seed).
Nitrogen harvest index (NHI) of each treatment was computed by dividing the nitrogen yield of seed by the nitrogen yield of shoot
NHI = Seed N/Shoot N

Data collected were analyzed using GENSTAT Release 11.1 (PC/Windows) (2008.VSN International Ltd., London) and the least significant difference (LSD) test at 5% probability level was used to compare the treatment means. Student's t-test was used to compare N and P uptake in different plant parts and correlation analysis was carried out for N fixation, N derived from atmosphere, N harvest index and shoot N content.

4 RESULTS

Year effects were not significant and consequently results from pooled data are presented here. The rainfalls received at the experimental site for both years (1453.3 mm and 1543.6 mm, respectively, in 2009 and 2010) were considered adequate for crop growth and development.The grand mean number of nodules per plant (NN) and the nodule biomass were 41.10 and 0.60 g, respectively. NN and NB of cowpea intercropped with maize varied significantly with the variety used; IT04K-217-5 gave the highest mean NN (62.80) while IT00K-1217 had the lowest mean value (24.40) (Table2). The highest NB was obtained by Ife Brown (0.60 g) while IT99K-377-1 produced the lowest value (0.32 g). Intercropping reduced NB in all the cowpea varieties, except, IT03K-324-7 and IT98K-692. Intercropping seemed to lower the values of NN, except in three varieties (IT99K-377-1, IT03K-351-1 and Ife Brown); overall, the mean for intercrop was lower than the sole crop.

Table 2: Number of nodules per plant (NN) and nodule biomass (NB) of extra-short- and short-duration cowpea varieties intercropped with maize at Otobi.

Variety (VAR)	**Nodules/plant**			**Nodule biomass (g)**		
	Cropping systems (CRS)			**Cropping systems**		
Extra-short duration	Sole	Intercrop	Mean	Sole	Intercrop	Mean
IT00K-1217	19.50	29.30	24.40	0.59	0.55	0.57
IT04K-221-1	24.20	40.50	26.40	0.53	0.52	0.53
Short-duration						
IT03K-378-4	49.20	30.30	39.75	0.55	0.54	0.54
IT03K-316-1	51.50	42.20	46.80	0.46	0.36	0.41
IT99K-377-1	25.70	36.30	31.00	0.35	0.30	0.32
IT03K-324-7	49.80	38.80	44.30	0.47	0.52	0.49
IT03K-351-1	44.00	58.00	51.00	0.48	0.48	0.48
IT98K-692	37.50	33.50	35.50	0.51	0.53	0.52
IT04K-217-5	80.70	45.00	62.80	0.55	0.47	0.51
Local check						
Ife Brown	28.70	58.00	49.20	0.62	0.58	0.60
Mean	42.20	40.00	41.10	0.51	0.49	0.50
FLSD (0.05)						
CRS	9.97ns			0.02*		
VAR	17.37*			0.13*		
CRS X VAR	23.73ns			0.17ns		

Figure. 1 presents the total plant nitrogen of extra-short- and short-duration cowpea varieties intercropped with maize. Intercropping generally caused nonsigninificant reduction in the total plant nitrogen of cowpea, except in IT99K- 377-1. IT99k-377-1 produced the highest total plant nitrogen (3.18 t/ha), while IT00k-1217 gave the lowest (1.60 t/ha).

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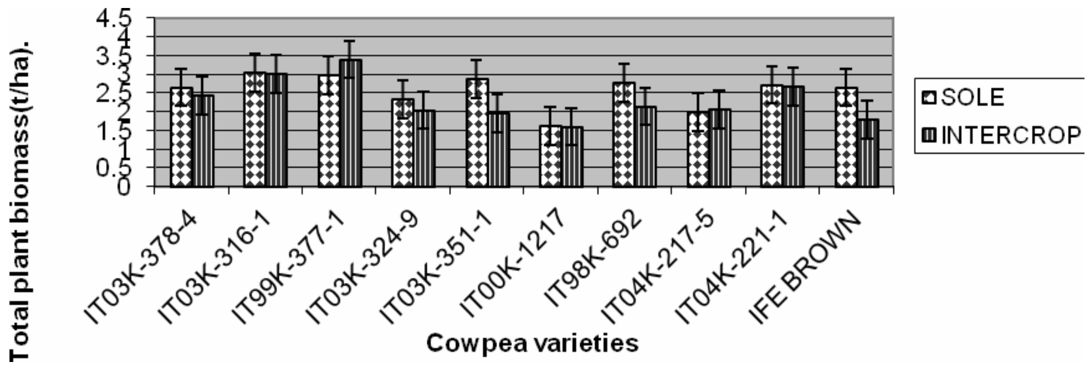

Figure .1: Total pant biomass of extra-short-and dhort-duration cowpea varieties intercropped with maize at Otobi.

Table 3 presents leaf, stem, root and shoot N of extra-short-and short-duration cowpea varieties intercropped with maize at Otobi. There were no significant differences among the varieties; however, N concentration in leaf (2.36 g/ 100g) of cowpea was significantly higher than that in the stem (1.99g/100 g), which in turn was significantly higher than root (1.57 g/100g). Also, the N content of the shoot (2.18 g/100 g) was higher than those of the stem and root. Interactions between cropping systems and variety as well as the main effects of variety on the phosphorus (P) content of extra-short- and short-duration cowpeas were significant ($P \leq 0.05$), but the main effects of cropping systems was not (Table 4). The P content of the cowpea varied with the plant parts. Cropping systems effects on P content was erratic, although the sole systems generally had higher P content than the intercropping. The overall mean P concentration of leaf (0.064 g/100 g) was higher than that of the stem (0.052 g/100 g), which in turn was higher than the root (0.040 g/100 g) in all the cowpea varieties tested (Table 4).

Table 3: Nitrogen (N) concentrations (g/100g) in the leaves, stems and roots and shoot N of extra-short and short – duration cowpea varieties intercropped with maize at Otobi.

Variety	Leaf N	Stem N	Root N	Shoot N
Extra-short duration				
IT00K-1217	2.53	2.06	1.76	2.29
IT04K-221-1	2.36	2.01	1.69	2.19
Short duration				
IT03K-378-4	2.47	2.14	1.78	2.30
IT03K-316-1	1.93	1.64	1.09	1.79
IT99K-377-1	2.49	2.12	1.66	2.31
IT03K-324-7	2.21	1.94	1.59	2.08
IT03K-351-1	2.20	1.80	1.38	2.00
IT98K-692	2.54	2.11	1.69	2.32
IT04K-217-5	2.25	1.88	1.25	2.07
Local check				
Ife Brown	2.59	2.27	1.82	2.43
Mean	2.36	1.99	1.57	2.18
FLSD (0.05)	0.41ns	0.27ns	0.61ns	0.46ns

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Paired t-test (0.05)				
Leaf vs stem	18.41*			
Leaf vs shoot	16.74*			
Leaf vs root	22.83*			
Stem vs root	13.04*			
Shoot vs root	18.66*			
Shoot vs Stem	20.11*			

Table 4: Phosphorus (P) concentrations (g/100g) in the leaves, stems and roots of extra-short and short – duration cowpea varieties intercropped with maize at Otobi.

Variety	**Leaf**			**Stem**			**Root**		
Extra-short duration	Sole	Intercrop	Mean	Sole	Intercrop	Mean	Sole	Intercrop	Mean
IT00K-1217	0.074	0.071	0.073	0.063	0.057	0.060	0.040	0.031	0.036
IT04K-221-1	0.062	0.080	0.071	0.045	0.064	0.055	0.032	0.059	0.045
Short duration									
IT03K-378-4	0.077	0.068	0.073	0.065	0.062	0.064	0.057	0.039	0.048
IT03K-316-1	0.055	0.055	0.055	0.040	0.043	0.041	0.028	0.036	0.032
IT99K-377-1	0.067	0.056	0.061	0.057	0.043	0.049	0.052	0.031	0.041
IT03K-324-7	0.069	0.043	0.056	0.060	0.033	0.047	0.050	0.028	0.039
IT03K-351-1	0.065	0.05	0.058	0.057	0.038	0.048	0.044	0.024	0.034
IT98K-692	0.065	0.069	0.067	0.057	0.058	0.057	0.043	0.049	0.046
IT04K-217-5	0.054	0.049	0.052	0.045	0.044	0.044	0.035	0.030	0.033
Local check									
Ife Brown (check)	0.073	0.072	0.072	0.060	0.057	0.058	0.049	0.042	0.046
Mean	0.066	0.062	0.064	0.055	0.050	0.052	0.043	0.037	0.040
FLSD (0.05)									
CRS	0.034 ns			0.036ns			0.034ns		
VAR	0.011 *			0.010*			0.010*		
CS X VAR	0.026 *			0.027*			0.026*		
Paired t-test (0.05)									
Leaf vs stem	15.05 *								
Leaf vs root	14.99 *								
Stem vs root	8.88*								

The nitrogen harvest index (NHI) of extra-short- and short- duration cowpea varieties intercropped with maize at Otobi varied from 0.76-0.97 with a mean of 0.83. IT99k-377-1 had the highest NHI (0.97),but this was only comparable to the NHI of IT03K-316-1,IT04K-221-1 and IT03K-351-1 (Table 5).

Percentage N derived from air by extra-short- and short- duration cowpea varieties intercropped with maize at Otobi varied from 35.00 (IT00K-1217) to 78.00 (Ife Brown) with a mean of 65.80. Nitrogen fixed by cowpea in the intercropping systems ranged from 11.40 - 51.70 kg/ha with an average of 33.90

kg/ha) (Table 5). IT00K-1217 had the lowest N fixation value (11.40 kg/ha) while IT99k-377-1 gave the highest (51.70 kg/ha).

Table 5: Nitrogen harvest index (NHI), % N derived from air (% Nder) and N fixed by extra-short- and short-duration cowpea varieties intercropped with maize at Otobi**.**

Variety	NHI	%Nder	N fixed (kg/ha)
Extra-short duration			
IT00K-1217	0.79	35.00	11.40
IT04K-221-1	0.91	75.40	45.70
Short duration			
IT03K-378-4	0.76	69.00	42.10
IT03K-316-1	0.96	64.70	35.60
IT99K-377-1	0.97	66.10	51.70
IT03K-324-7	0.82	63.80	28.00
IT03K-351-1	0.88	71.00	29.10
IT98K-692	0.78	63.50	32.10
IT04K-217-5	0.83	71.00	29.70
Local check			
Ife Brown	0.76	78.00	33.50
Mean	0.85	65.80	33.90
FLSD (0.05)	0.14	13.63	11.70

Nitrogen fixed showed positive correlation with NHI, % Nder and shoot N, but it was only significant with % Nder.

Table 6: Correlation (Pearson) coefficients of nitrogen fixation (Nfix),nitrogen harvest index (NHI), %nitrogen derived from air (%Nder) and shoot nitrogen (ShootN) concentrations of extra-short- and short-duration cowpea varieties intercropped with maize at Otobi.

	NHI	%Nder	Nfix	ShootN
NHI		r = 0.283 p < 0.428	r = 0.546 p < 0.103	r = -0.576 p < 0.081
%Nder	r = 0.283 p = 0.428		r = 0.675* p < 0.032	r = -0.050 p < 0.891
Nfix	r = 0.546 p < 0.103	r = 0.675* p < 0.032		r = 0.096 p < 0.792
ShootN	r = -0.576 p < 0.081	r = -0.050ns p < 0.891	r = 0.096 p < 0.792	

*. Correlation is significant at the 0.05 level (2-tailed).

5 DISCUSSION.

Nodulation is important in nitrogen fixation by legumes. However, Sinclair and Vadez (2002) have noted that greater nodulation does not necessarily lead to greater nitrogen fixation. The significant main effect of variety on nodulation and the non-significant effect of interaction show that number of nodules in extra-short - and short-duration cowpeas may be a varietal characteristic as a result of genetic composition. Significant differences in the number and biomass of nodules among crop varieties of the same species have been reported (Kaleem, 2000; Egbe, 2007). The differences in the number and biomass of nodules observed among cowpea genotypes used in this study agreed with results of earlier studies (Ayisi *et al*., 2004; Njoku and Muoneke, 2008). The reduction in nodule biomass of cowpea varieties under intercropping with maize might be ascribed to effects of shading from the taller maize

component, particularly as this parameter was evaluated at 50%flowering (33-50 days after planting) when maize was at peak vegetative growth. Nodule growth and function require light- dependent photosynthates. The non-significant effect of cropping systems on the total plant nitrogen of cowpea in this work indicated that competition between the taller maize component was not intensive enough to adversely affect this yield parameter more so that the maize plant population in the intercrop (40,000 plants/ha) was low and biomass was evaluated at harvest.
It is absolutely clear that both N and P are essential elements in their structural, biochemical and physiological roles contributing to crop growth (Sinclair and Vadez, 2002). N accumulation of cowpea in this work was not significantly affected by the variety, but P concentration of extra–short – and short – duration cowpeas was significantly influenced by cropping systems x variety interactions. These results indicated that some genotypes of cowpea used in this work were differentially endowed to access and utilize P in the two cropping systems tested. N and P concentrations of all the cowpea genotypes used in this study were highest in the leaf and lowest in the roots. This was to be expected as absorbed plant nutrients are first translocated to the leaves through the stem, the root usually has the least reserve. Ahiabor *et al.* (2004) had made similar observations with P being most concentrated in the leaf portion and least in the roots of cowpea in Ghana. Indeed, much of the variation in leaf photosynthetic capacity for different cultivars, age of leaves and growth conditions can be attributed directly to differences in leaf N content (Sinclair and Horie, 1989).The success in providing the accumulated N and P to the seed is indicated by the harvest index for each of the elements. The NHI in this study seemed to be high, and this finding was consistent with the observations of Sinclair and Vadez (2002) that modern crops have high NHI values. Percentage Nder (mean = 65.80%) was high suggesting that the cowpea varieties depended more on symbiotic fixation for their N requirement, possibly because of the low available N (0.11%) present at planting. Mean N fixed (33.90 kg/ha) by the extra-short - and short – duration cowpeas intercropped with maize was far below values reported by other workers, Balasubramanian *et al.* (1980) and Dakora *et al.* (1987). Kumar Rao *et al.* (1987) had reported that short duration varieties of pigeon pea fixed lower quantities of N compared to the medium and the long duration genotypes. This implies that these extra-short - and short – duration cowpeas may not be suitable as soil ameliorants for inherent low fertility of the degraded /over-used soils in Otobi. The high NHI values of these varieties compound the problem since cowpea is principally cultivated for grain production in the study area. Thus, little or no N will be left in the stover to benefit subsequent crops in the rotation. The results obtained are consistent with the observations of Sinclair and Vadez (2002), that plant residues from grain legumes are sometimes considered poor sources of N because large amounts of the N is exported to grain. They therefore suggested that it might be important to consider low harvest index and high N fixing ability in legumes. Also, rotations that include a legume as a green manure crop would be especially beneficial in increasing soil N fertility. One of the challenges in cowpea research in the study area and indeed wherever high preferences exist for short duration genotypes would be to incorporate high nitrogen – fixing abilities into short duration lines to meet both human nutritional demands and soil health.
The significant positive correlation of N fixed with %Nder indicated a strong evidence that N fixed by the cowpea varieties and N derived from air were highly associated with one another: cowpea with high N fixation ability also have high capacity to derive their N requirement from N fixation. Such varieties as IT99K-377-1, IT03K-378-4 and IT04K-221-1 fixed above 40 kg N/ha and may be considered for further investigation under intercropping with maize for their soil ameliorating properties.

6 CONCLUSION

Intercropping only significantly affected the total plant nitrogen of cowpea but the number of nodules per plant, nodule biomass, total plant nitrogen concentration, nitrogen harvest index, percentage N derived from air and nitrogen fixation varied with variety of extra-short - and short – duration cowpeas in this study. The mean N fixed (33.90 kg/ha) by these extra-short - and short – duration cowpeas intercropped with maize was far below those reported for cowpea by other workers. This implies that these cowpeas may not be suitable as soil ameliorants for inherent low fertility of the degraded /over-used soils in Otobi. This is further compounded by high NHI values of these varieties, since cowpea is principally cultivated for their grains in the study area.

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