International Journal of Agricultural Sciences ISSN: 2167-0447 Vol. 2 (5), pp. 166- 172, June, 2012. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Assessment of leaf macro nutrients turn over potential of six pigeonpea genotypes intercropped with maize in a humid savanna agro-ecology of Nigeria

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Received December 30, 2012; Accepted June 02, 2012

The macro mineral nutrients turnover potential in pigeonpea leaf comprising nitrogen (N), phosphorus (P), potassium (K) and calcium (Ca) was studied at anthesis in five improved pigeonpea genotypes from ICRISAT and one Nsukka Local genotype under intercropping with two maize genotypes and as sole crops at Nsukka, Nigeria in 2005. The experiment was a factorial laid out in a Randomized Complete Block Design (RCBD) with three replications. The result showed that the pigeonpea genotypes had high leaf production with average dry matter weight of 1455kgha^{-1} under sole cropping and 952kgha^{-1}and 1070kgha^{-1} under intercropping with hybrid maize and open pollinated maize respectively. The N turnover in the leaves on average was high at 39.6kgha^{-1} N while P, K and Ca leaf turnovers were 2.59kgha^{-1} P, 1.16kgha^{-1} K and 1.32kgha^{-1} Ca respectively. Maize intercropping significantly ($p<0.05$) depressed N, P and K turnover in the pigeonpea leaves by 38.2%, 37.3% and 39.6% respectively under hybrid maize intercropping and by 25.5%, 27.3% and 27.5% respectively under open pollinated maize intercropping. Ca turnover in the leaves was however significantly ($p<0.05$) higher in those intercropped with hybrid maize compared to those intercropped with open pollinated maize and those grown as sole crops. The pigeonpea genotypes differed significant ($p<0.05$) in their leaf dry matter weight, and the N, P and Ca turnover in the leaf. They did not differ significantly ($p<0.05$) in their leaf K turnover. The pigeonpea genotypes had high potential to improve soil fertility through leaf litter.

Key words: Pigeonpea, maize, leaf litter, macro nutrients turnover, intercropping.

INTRODUCTION

The performance of crop plants in agricultural fields depend on the supply of macro and micro mineral nutrients. The primary macro nutrients, nitrogen (N), phosphorus (P) and potassium (K) are required in large quantities but are often deficient in soils and are supplied through inorganic and or organic fertilizer sources. Kumwenda *et al.,* (1996), reported that chemical fertilizers play a major role in maintaining or increasing soil fertility in most parts of the world, but farmers in sub-saharan Africa use very little chemical fertilizer. Smailing (1993) and Stoorvogel *et al.,* (1993) estimated that annual net nutrient depletion exceeded 30 kgN and 20 kgK, per hectare of arable land in Ethiopia, Kenya, Malawi, Nigeria, Rwanda and Zimbabwe. This requires that farmers need to explore the organic sources of fertilizers to sustain the productivity of their arable lands. Organic fertilizers are in the form of animal dung, decaying animal and plant debries and nitrogen fixation in legumes. They are environmentally friendly and thus much preferred to augment nutrient deficiencies in soils.

The atmospheric nitrogen fixing ability of leguminous crop plants through their ability to interact symbiotically with the soil bacterium, genus Rhizobium (Hall 1995), and the high nutrient contribution of their leaves and

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residues to the soil organic matter (SOM) have long been recognized and exploited in agricultural systems. One of such systems is cereal/legume intercropping mostly used on marginal soils by resource poor farmers. Pigeonpea/maize intercropping is a popular legume/cereal intercropping among traditional farmers and is reportedly productive with a land equivalent ratio value greater than one (LER<1.0) (Egbe and Adeyemo 2006, Lingaraju 2008).

Pigeonpea (*Cajanus cajan* (L.) Millsp) have been reported to have high leaf litter turnover and Rao *et al.,* (2002), reported that the leaves have characteristics that promote soil fertility benefits such as low lignin levels and high nitrogen content. Snapp *et al.,* (1998) reported that on-farm trials have shown that pigeonpea can produce over 2 t ha^{-1} of high quality residues without any fertilizer inputs on degraded soils and steep mountain slopes of Southern Malawi, providing one of the only cost-effective and sustainable sources of nutrients to poor farmers. Egbe *et al.,* (2009) reported pigeonpea to be superior in nodule biomass, leaf litter, total plant biomass and seed yield compared to other food legumes- cowpea (*Vigna unguiculata* (l.) Walp), soybean (*Glycine max*), groundnut (*Arachis hypogea*) and bambaranut (*Vigna subterranea*) both in sole and intercropping systems with maize in the sandy soils of moist savanna woodland of Nigeria. Tabo *et al.,* (1995) reported that farmers in Nigeria are aware of the benefit of pigeonpea on soil fertility accrueing from the accumulation of leaf litter on the soil surface and nitrogen-fixing root nodules in the soil. Despite the recognition to the pigeonpea high leaf litter turnover in the cropping systems of the traditional farmers, information on its assessed nutrient contribution to the soil fertility is lacking. This study was carried out to assess the N, P, K and Ca nutrients turnover of improved pigeonpea genotypes and a local pigeonpea genotype in the leaf under sole and intercropping systems with maize for an understanding of the contribution of the leaf litter to soil fertility in the cropping systems for sustainable crop production.

MATERIALS AND METHODS

A pigeonpea/maize intercropping field experiment was conducted under late season condition in 2005 at the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka. Nsukka is located at latitude 6°52′ within the Low-land humid tropical agro-ecology of Nigeria. The test crops for the experiment comprised of five improved pigeonpea genotypes of short- and medium-duration types (ICPL 87, ICPL 161 (short duration), ICPL 85063, ICP 7120 and ICPL 87119) (medium-duration)) obtained from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Kano Station Nigeria and a long-duration Nsukka local pigeonpea genotype which served as a check. Two maize genotypes (hybrid and open pollinated types) were also used and combined with the six pigeonpea genotyN and longitude 7°24′E and altitude 447m above sea level. It is pes to obtain pigeonpea/maize mixture treatments for two intercrop systems and the pigeonpea genotypes were equally maintained as sole crop treatments for the sole crop system to give the following treatments:

SV_1	SV_2	SV_3	SV_4	SV_5	SV_6
V_1Om	V_2Om	V_3Om	V_4Om	V_5Om	V_6Om
V_1Hm	V_2Hm	V_3Hm	V_4Hm	V_5Hm	V_6Hm

Where: SV_1 = ICPL 87 sole crop
SV_2= ICPL 161 sole crop
SV_3= ICPL 85063 sole crop
SV_4= ICP 7120 sole crop
SV_5=ICPL 87119 sole crop
SV_6= Nsukka Local sole crop
V_1Om= ICPL 87/Open pollinated maize mixture
V_2Om= ICPL 161/Open pollinated maize mixture
V_3Om= ICPL 85063/Open pollinated maize mixture
V_4Om= ICP 7120/Open pollinated maize mixture
V_5Om= ICPL 87119/Open pollinated maize mixture
V_6Om= Nsukka Local/Open pollinated maize mixture
V_1Hm= ICPL 87/Hybrid maize mixture
V_2Hm= ICPL 161/Hybrid maize mixture
V_3Hm= ICPL 85063/Hybrid maize mixture
V_4Hm= ICP 7120/Hybrid maize mixture
V_5Hm= ICPL 87119/hybrid maize mixture
V_6Hm= Nsukka Local/Hybrid maize mixture

The treatments were randomly allocated to treatment plots and laid out in Randomized Complete Block Design (RCBD) with three replications.

Soil samples to a depth of 0-30 cm were taken with soil auger at random over the experimental land area at the beginning of the experiment. The samples were bulked and mixed thoroughly. A sub-sample was taken and used for physical and chemical analyses for characterization of the site. The land was ploughed, harrowed and ridged in July, 2005 at 1.0m apart and marked out into three blocks with a spacing of 1.0m between blocks and 1.0m between plots. Each block had 18 plots each measuring 5.0m × 3.0m = 15m^2. Cross bars were erected across furrows to check erosion from running water.

Pigeonpea was planted on the two sides of the ridge at a spacing of 0.5m × 0.5m giving 6 plants on either side of a ridge and 12 plants/ridge equivalent to 40,000 plants per hectare. Maize was planted at the crest of the ridges at a spacing of 1m x 0.25m giving 12 plants/ridge representing 40,000 plants/ha. The same plant population was used under both intercrop and sole crop systems in additive series. Planting was done on the 16th July, 2005.

Weed control was manually done by hoeing at 21 and 45 days after planting (DAP). Fertilizer application was done manually by banding at 3 weeks after planting at the rate of 120 kg N, 60 kg P_20_5 and 80 kg K_2O per hectare. Insect pests were controlled on the pigeonpea by spraying plants with “BEST Action” (Cypermethrin plus Dimathoate) at the rate of 1.5 litres/ha using knapsack sprayer. Spraying was done at 50% flowering and at podding stages of the pigeonpea when the maize crop had been harvested in the intercrop mixture treatments.

Data Collection.

Growth and yield parameters were taken on the test crops. Five pigeonpea plants at the central three ridges of each plot were tagged to obtain data for each plot. Two representative pigeonpea plants were destructively sampled in each treatment plot at anthesis and the leaves were carefully removed and oven dried at 70^{0}C to get the dry matter weight (g) of each per plant.

Chemical Analyses.

The fifth leaf that was fully expanded was obtained from the

Table 1: Metereological records for 2005, 2006 and 2007 at Nsukka, Nigeria.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
2005 weather records	0	70.6	14.9	14.0	142.5	323.8	246.2	125.4	208.0	304.2	10.1	1.2
Total rainfall (mm)	0	2	2	10	11	18	20	17	19	16	1	1
Rain days (No.)	31.6	35.2	34.4	33.6	30.6	29.4	28.3	27.3	28.7	30.1	32.4	22.4
Max. air temp (^oC)	25.2	22.8	23.3	23.1	22.2	21.8	20.9	20.3	21.5	21.1	21.3	20.7
Min. air temp (^oC)	57.5	64.3	67.1	69.2	73.9	74.8	76.9	76.9	76.9	73.8	66.2	63.1
Relative Hum (%)												
2006 weather records	36.3	4.0	103.1	51.0	243.8	259.6	213.8	195.5	190.5	313.9	1.5	0
Total rainfall (mm)	1	2	4	5	16	16	21	19	25	19	1	0
Rain days (No.)	33.1	33.6	33.1	35.5	30.5	29.9	28.6	27.8	28.1	29.9	31.7	32.6
Max. air temp (^oC)	23.0	23.2	22.8	23.3	21.3	21.2	21.5	20.8	21.3	21.2	18.9	17.9
Min. air temp (^oC)	66.5	67.8	67.6	68.2	74.4	74.9	76.8	77.4	76.7	74.8	60.8	50.0
Relative Hum (%)												

branches of pigeonpea sample plants, oven dried and used for N P K and Ca nutrient content analyses. The leaf samples were oven dried at 70^oC to constant weight and ground with the hammer mill to pass through a 0.5mm sieve for the chemical analyses.

Total Nitrogen was determined according to micro-Kjeldahl steam distillation method as outlined by AOAC (1984). Total phosphorus was determined by the perchloric acid digestion combined with Colorimetric assessment according to AOAC (1990). Potassium (K) and calcium (Ca) were determined using Flame Photometry method according to Pearson (1976).

The nutrient element contents of the sampled pigeonpea leaf was used to calculate the nutrient turnover per hecture using the leaf fraction dry matter content of the sampled plants as follows:

Nutrient turn over (kg/ha) =

$$\frac{\%\ \text{content of nutrient}}{100} \times \text{leaf dry matter wt per hectare}$$

Data Analysis

Data collected were analysed for a Randomized Complete Block Design using Genstat (3) Discovery software. Detection of differences among treatment means for significant effect was by least significant difference (LSD) at 5% level of probability.

RESULTS

The total monthly rainfalls (mm) for 2005 and 2006 followed the characteristic bimodal pattern peaking first in the months of June or July and second in October (Table 1). Rainfall was highest in June compared with little or no rainfall in December for 2005 and 2006. Rain always fell more frequently between June and October. During the periods of January, February, November and December, rainfall was very low at 0 - 70.6mm. The minimum air temperature was always rather high all through the period of the experiments. Similarly, the maximum air temperature ranged from 28.3^oC in July to 22.4^oC in December in 2005 and from 28.6^oC in July to 32^oC in December in 2006.

The highest maximum and minimum temperatures within the year were in the months of February to April in both 2005 and 2006 seasons. The Relative Humidity (%) followed closely from the rainfall pattern, rising with high rainfalls and decreasing with decreased rainfalls, being lowest in the months of November, December, January and February. The Relative Humidity was always comparatively low in the months of December and January.

The soil of the experimental site was texturally sand clay loam and essentially acidic in reaction (Table 2). Phosphorus, potassium, calcium and sodium were considered moderate in the site.

The pigeonpea leaf dry matter yield was considered to be generally high although depressed by the maize intercrop by about 34.6% under hybrid maize and by 25.5% under open pollinated maize (Table 3). The pigeonpea genotypes differed significantly ($P<0.05$) in their leaf dry matter yields.

Maize intercropping of pigeonpea significantly ($P<0.05$) affected the nitrogen (N) and calcium (Ca) contents of the pigeonpea leaf taken at flowering stage (Table 4). Nitrogen content was significantly highest in the leaf of the pigeonpea plants intercropped with open pollinated maize followed by the leaf of pigeonpea in sole cropping system which had a significantly higher leaf N content than pigeonpea plants intercropped with hybrid maize. Calcium content was, however, highest in pigeonpea plants intercropped with hybrid maize followed by those intercropped with open pollinated maize and least in sole cropped pigeonpea. No cropping system effect was apparent with respect to the P and K contents in pigeonpea leaf.

Pigeonpea genotypes differed significantly ($P<0.05$) in their leaf nitrogen, phosphorus, potassium and calcium

Table 2: Physical and chemical characteristics of the experimental sites before planting

Mechanical properties:	**2005**
Clay (%(	19.76
Silt (%)	9.28
Fine sand (%)	24.40
Coarse sand (%)	46.56
Textural class	Sandy clay loam
Chemical Properties	
pH in H_2O	5.2
pH in KCl	4.5
Organic matter:	
Carbon (%)	0.93
Nitrogen (%)	0.070
Exchangeable bases (meq/100g)	
Na	0.57
K	0.23
Ca	1.60
Mg	1.20
CEC	2.24
P (ppm)	44.78

Table 3: Leaf dry matter yield (kg/ha) in six pigeonpea genotypes under intercropping with two maize genotypes.

Pigeonpea Genotypes	**Cropping system**			
	P/pea + Hm	**P/pea + Opm**	**Sole P/pea**	**Mean**
Leaf (kg/ha)				
ICPL87	1140.0	1176.0	1628.0	1315.0
ICPL161	1044.0	950.0	1237.0	1077.0
ICPL85063	762.0	908.0	1413.0	1028.0
ICP7120	1089.0	1213.0	1777.0	1360.0
ICPL87119	753.0	897.0	1180.0	944.0
Nsukka Local	922.0	1277.0	1492.0	1230.0
Mean	952.0	1070.0	1455.0	1159.0

	Leaf
$Lsd_{0.05}$ for 2 crop. sys. means	173.0
$Lsd_{0.05}$ for 2 p/pea geno. Means	244.5
$Lsd_{0.05}$ for crop. sys × p/pea gen.	Ns

mineral contents. Leaf nitrogen was significantly higher in ICP 7120 and ICPL 161 compared with the other genotypes. ICPL 85063 had a significantly higher value compared with ICPL 87119, Nsukka Local and ICPL 87 genotypes which had statistically similar values. Phosphorus and potassium leaf contents were

Table 4: Mineral nutrient content (%) of six pigeonpea genotypes in intercropping system with hybrid maize and open pollonated maize at pigeonpea flowering stage.

Pigeonpea Genotypes	Cropping system				Cropping system			
	P/pea + Hm	P/pea + Opm	Sole P/pea	Mean	P/pea + Hm	P/pea + Opm	Sole P/pea	Mean
Nitrogen (N)					**Phospho**			
ICPL87	3.20	3.31	3.34	3.27	0.21	2.26	0.22	0.22
ICPL161	3.28	3.73	3.58	3.53	0.21	0.25	0.21	0.22
ICPL85063	3.17	3.42	3.60	3.40	0.24	0.24	0.22	0.24
ICP7120	3.43	3.69	3.56	3.56	0.22	0.20	0.24	0.22
ICPL87119	2.37	3.62	3.06	3.30	0.26	0.18	0.24	0.23
Nsukka Local	3.22	3.60	3.06	3.29	0.15	0.15	0.18	0.16
Mean	3.25	3.56	3.36	3.39	0.22	0.21	0.22	0.22
Potassium (k)						**Calcium (Ca)**		
ICPL87	0.11	0.10	0.10	0.10	0.18	0.15	0.05	0.13
ICPL161	0.12	0.11	0.10	0.11	0.09	0.08	0.06	0.08
ICPL85063	0.08	0.11	0.08	0.09	0.12	0.09	0.11	0.11
ICP7120	0.09	0.10	0.09	0.09	0.08	0.06	0.08	0.07
ICPL87119	0.10	0.10	0.12	0.10	0.15	0.09	0.07	0.10
Nsukka Local	0.07	0.08	0.11	0.08	0.18	0.09	0.05	0.11
Mean	0.09	0.10	0.10	0.09	0.13	0.09	0.07	0.10

	N	P	K	Ca
$Lsd_{0.05}$ for 2 crop.sys means	0.067	Ns	Ns	0.019
$Lsd_{0.05}$ for 2 p/pea geno.	0.095	0.031	0.009	0.027
$Lsd_{0.05}$ for 2 crop sys. p/pea	0.165	Ns	0.015	0.047

significantly lower in Nsukka Local genotype compared with the ICRISAT genotypes. The ICRISAT genotypes however, differed significantly in their potassium content. Calcium leaf content was significantly higher in ICPL 87 compared with the other genotypes. This was followed by ICPL 85063 and Nsukka Local with statistically similar values but significantly higher than the values for ICPL 87119, ICPL 161 and ICP 7120 which were also statistically different.

Combining cropping system with pigeonpea genotype showed that irrespective of the cropping system, ICP 7120 had greater leaf N content than the other genotypes except ICPL 161. Hybrid maize intercropping of pigeonpea depressed leaf N-content in all the pigeonpea genotypes compared with the situation for open pollinated maize. Open pollinated maize intercropping with pigeonpea enhanced N-content in ICPL 161, ICP 7120, ICPL 87119 and Nsukka Local genotypes compared with sole cropping. Pigeonpea intercropping with hybrid maize depressed K-content in most of the pigeonpeas compared with open pollinated maize and sole cropping. Maize intercropping of pigeonpea enhanced the Ca leaf content of most of the pigeonpea genotypes.

The nitrogen turnover was high compared with the other macro nutrients under both intercrop and sole crop systems (Table 5). The nitrogen turnover in pigeonpea leaf was significantly ($p<0.05$) depressed by maize intercropping by about 38.2% under hybrid maize and by 25.5% under open pollinated maize compared with sole cropped pigeonpea. The pigeonpea genotypes differed significantlt ($p<0.05$) in their nitrogen turnover with ICP 7120 yielding significantly ($P<0.05$) higher nitrogen turnover compared with ICPL 85063 and ICPL 87119 genotypes. ICPL 87119 had the least value compared with those of other genotypes. Phosphorus leaf turnover was significantly ($P<0.05$) depressed in pigeonpea intercropped with hybrid maize by 37.3% and by 27.3% in

Table 5 : Mineral nutrient turnover (kg/ha) in pigeonpea leaf at flowering stage under intercropping with two maize genotypes.

Pigeonpea Genotypes	Cropping system				Cropping system			
	P/pea + Hm	P/pea + Opm	Sole P/pea	Mean	P/pea + Hm	P/pea + Opm	Sole P/pea	Mean
	Nitrogen (N)				Phosph			
ICPL87	33.0	38.7	53.6	41.8	2.23	3.28	3.60	3.04
ICPL161	39.9	37.4	44.3	40.6	2.44	2.61	2.65	2.57
ICPL85063	24.4	31.0	51.1	35.5	2.04	2.49	3.20	2.58
ICP7120	37.4	46.2	63.7	49.1	2.45	2.40	4.35	3.07
ICPL87119	24.5	27.3	33.8	28.5	2.03	2.50	2.76	2.10
Nsukka Local	25.6	48.2	52.1	42.0	1.25	2.09	3.23	2.19
Mean	30.8	37.1	49.8	39.6	2.07	2.40	3.30	2.59
	Potassium (k)				Calcium (Ca)			
ICPL87	1.12	1.17	1.65	1.32	2.13	1.84	0.80	1.59
ICPL161	1.28	1.13	1.23	1.21	1.02	0.81	0.79	0.87
ICPL85063	0.63	0.99	1.21	0.94	0.93	0.82	1.60	1.12
ICP7120	1.02	1.23	1.66	1.30	0.85	0.74	1.33	0.97
ICPL87119	0.75	0.79	1.33	0.96	1.14	0.79	0.85	0.92
Nsukka Local	0.60	1.16	1.84	1.20	1.73	1.14	0.83	1.23
Mean	0.90	1.08	1.49	1.16	1.30	1.02	1.03	1.12

	Nitrogen	Phosphor	Potas.	Calc.
$Lsd_{0.05}$ for 2 crop. sys. means	6.85	0.52	0.24	0.23
$Lsd_{0.05}$ for 2 p/pea gen. means	9.69	0.73	Ns	0.33
$Lsd_{0.05}$ for 2 crop. sys. x p/pea	Ns	Ns	Ns	0.57

those intercrop with open pollinated maize compared to where they were grown as sole crops. ICP 7120 and ICPL 87 gave significantly (p<0.05) higher P values compared with those of Nsukka Local and ICPL 87119 genotypes. ICPL 85063 and ICPL 161 genotypes followed with statistically similar values which were also significantly higher than those of Nsukka Local and ICPL 87119 genotypes. Potassium turnover in the pigeonpea leaf was significantly (P<0.05) depressed by maize intercropping by 39.6% under hybrid maize and by 27.5% under open pollinated maize compared to the sole cropped pigeonpea. The pigeonpea genotypes did not differ in their leaf potassium turnover. Calcium turnover in pigeonpea leaf was significantly higher in those intercropped with hybrid maize by 22.0% compared with those grown as sole crop and least in the leaves of those intercropped with open pollinated maize where it was lower by 9.5%. The pigeonpea genotypes differed significantly in their calcium turnover with ICPL 87 having a significantly (p<0.05) higher turnover compared to all the other genotypes. ICPL 85063 and Nsukka Local genotypes had statistically similar values but were significantly higher than those for ICP 7120, ICPL 87119 and ICPL 161 genotypes. Interaction of cropping systems with pigeonpea genotypes did not significantly affect nitrogen, phosphorus and potassium turnover in pigeonpea leaf. However, calcium turnover increased with intercropped pigeonpea in ICPL 87 and Nsukka Local genotypes but decreased with ICPL 87119 and ICP 7120.

DISCUSSION

Pigeonpea is usually adaptable, flourishing across broad ranges of environment (Versteeg and Koudokpon, 1993, Degrande, 2001) and maize can grow across a broad range of agroecological zones (IITA, 2007). The high rainfall in the months of July to October and the minimum and maximum temperature ranges from 20.3 – 21.5^{o}C and 27.4 – 30.1^{o}C in this study were within the requirements for both the maize and pigeonpea crops as reported by Purseglove (1972) and van der Maesen (1989). The drop in rainfall and relative humidity in the months of November and December coincided with flowering and maturity periods for pigeonpea and was good for dry pod harvest. The slightly acidic sandy clay loam nature of the soil was within the tolerable limits for both the maize (IITA, 2007) and pigeonpea crops (Bogdan, 1977, and van der Maesen 1989).

The high pigeonpea leaf dry matter obtained in this study agrees with report by Ladd (1990) who reported that pigeonpea can produce over 2t ha^{-1}of high quality residues without any fertilizer input on degraded soils. The depression in leaf dry matter fraction weights of intercropped pigeonpea was attributed to maize intercropping effect. The fast development in maize and its shorter duration compared to pigeonpea placed it in an advantaged position in competing for scarce resources over the pigeonpea. It consequently shaded the pigeonpea thereby depressing its leaf dry matter fraction yield as similarly reported by Egbe (2007) and Lingaraju *et al*; (2008). The greater depressing effect of hybrid maize compared with open pollinated maize on the leaf dry matter fractions of pigeonpea butresses the hybrid maize′s greater intercropping effect on the pigeonpea. The differences among the pigeonpea genotypes in the leaf dry matter fraction was attributed to their genotypic and duration differences. The significantly lower N turnover of ICPL 87119 under both sole and intercrop conditions implied its low attributes for N-turnover.

The high nitrogen content of the pigeonpea leaves in this study was in agreement with the findings of Rao *et al.,* (2002). Sakala *et al.,* (2000) also reported that senesced pigeonpea leaves that fall on the ground add 28-40kgN ha^{-1} from long-duration varieties. This is charcteristic of leguminous crop plants due to their nitrogen fixing ability through sysmbiotic association with the Rhizobium spp. Anantawiroon *et al.,* (2006) reported that pigeonpea produced the highest crude protein content, especially in the leaf fraction when compared with *Crotolaria juncea*, *Leucaena leucocephala* and *Sesbania luteola*. The higher nitrogen content in sole cropped pigeonpea leaves was attributed to lack of competition from any intercrop. Egbe *et al.,* (2007) reported that intercropping lowered the total nitrogen yield of most pigeonpea compared to sole cropping in a pigeonpea/maize intercropping system. Katayama *et al.,* (1996) reported more accumulation of N in sole pigeonpea than intercropped pigeonpea. The higher mean N leaf content of the open pollinated maize intercropped pigeonpea compared with sole cropped pigeonpea and those intercropped with hybrid maize implied high compartibility between the pigeonpea genotypes and the open pollinated maize genotype.in this study. The high N leaf content of ICP 7120, ICPL 161 and ICPL 85063 under both intercrop and sole crop conditions implied their potential for high N turnover in cropping systems compared with the other genotypes in this study. The enhanced N content in maize intercropped Nsukka Local genotype leaf could be attributed to its high adaptability to intercropping conditions and the environment compared with the newly introduced ICRISAT genotypes.

The phosphorus leaf content in this study was similar to that reported by Snapp *et al.,* (2003) in pigeonpea residues surveyed in Malawi. The non significant effect of cropping system on the phosphorus leaf content of the pigeonpea agreed with report by Anantawiroon *et al.,* (2006) where there was no effect of grass : legume ratio on phosphorus content. The slightly higher phosphorus leaf content in open pollinated maize intercropped pigeonpea was attributed to the lower nutrient requirement of the open pollinated maize compared to hybrid maize thus making P available for the pigeonpea to absorb. The significantly higher P and K leaf contents of the ICRISAT pigeonpea genotypes compared to Nsukka Local genotype was attributed to genotypic differences. Maize intercropping tended to enhance K leaf content in ICPL 87, ICPL 161, ICPL 85063 and ICP 7120, and lower it in ICPL 87119 and Nsukka Local. Maize intercropping also tended to enhance Ca leaf content in ICPL 87, ICPL 161, ICPL 87119 and Nsukka Local. The higher content of calcium in pigeonpea leaves where intercropping was high was attributed to reduced leaching of the nutrient due to greater leaf cover thereby making the nutrient more available for absorption.

The higher nitrogen turn over (kgha^{-1}) in sole cropped pigeonpea leaves compared to those intercropped with maize was attributed to the lack of competition effect of maize. Snapp *et al.,* (1998) reported that N contribution from leaaf abscission over the growing season on farmlands has been estimated to be 10 – 40 kgNha^{-1}. A 3 years study at 40 farm sites in Malawi found pigeonpea residues providing 30 – 70kg/ha N and were particularly suited to the resource base of small holders (Kanyama – Phiri *et al;* (1998).

The higher phosphorus turn over in open pollinated maize intercropped pigeonpea leaves was attributed to the lower demand for the nutrient element by the open pollinated maize compared to its hybrid maize counterpart thereby making the element available for the component pigeonpea crop plant for absorption. The differences among the pigeonpea genotypes in their Nitrogen and calcium leaf nutrient turn over were attributed to genotypic differences. The higher turn over of calcium in pigeonpea leaves where intercropping was high was attributed to reduced leaching of the nutrient due to greater leaf cover thereby making the nutrient element more available for absorption. The turnover of nutrients into the soil through the decomposition of plant residues is important as it determines the balance of nutrients that need to be added through fertilizers.

CONCLUSION

The high leaf dry matter yield of the pigeonpea genotypes under both intercrop and sole crop systems are indicative of their potential to improve the soil organic matter in production systems. The high N turnover and the moderate P, K and Ca turnover in the pigeonpea genotypes leaves implied their potential to improve the soil fertility of their production systems through its leaf litter. Adopting these pigeonpea genotypes in the cropping systems of the resource poor farmers of the tropical regions will greatly improve the productivity of their depleted farmlands requiring less chemical fertilizer supplemental need for maximum output.

ACKNOWLEDGEMENT.

The release of the improved pigeonpea genotype seeds by International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) through its Kano station, Nigeria for this study is highly appreciated.

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