Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol 2, No.8, 2012

Density and Nitrogen Effects on Forage Dry Matter Yield and Productivity Indices of Crop Residues in Rice-Cowpea Intercropping

Oroka, Frank Oke
Agricultural Science Unit, Department of Vocational Education, Delta State University, Abraka, Nigeria
E-mail of corresponding author: orkfra@yahoo.com
The research is financed by the author
Abstract
Two field experiments were conducted in 2003 and 2004 cropping seasons to ascertain the competitive behavior of rice-cowpea intercrops with regard to the forage dry matter productive capacity of the crop residues. Three treatments were used for the study. This consist of four nitrogen rates (0, 15, 30 and 45kgNha^{-1}) applied as urea {$CO(NH_2)_2$}, three cropping patterns (sole rice, sole cowpea and rice-cowpea mixture) and three cropping densities (50000, 100000 and 200000 plants ha^{-1}). Treatments were arranged in a 4x3x3 factorial with randomized complete block design. Results indicated that forage dry matter yield (DMY) of crop residues of both rice and cowpea were higher in monocropping than in the intercropping mixtures. Forage DMY had a linear relationship with mineral and residual nitrogen. Maximum density resulted in maximum forage DMY. Productivity of forage DMY of crop residues as indicated by LER and SPI values was better achieved with nitrogen rate of 30kgNha^{-1} at 200000plants ha^{-1}. Relative crowding coefficient (K) and aggressivity index (A) values showed cowpea to be dominant over rice in the intercropping system. The study suggests that residues from rice and cowpea forages are potential livestock feed for ruminant nutrition.
Keywords: plant density, system productivity index, aggressivity index, forage dry matter yield, rice, cowpea

1. Introduction

Intercropping forage legumes with cereals offers a potential for increasing forage and consequently livestock production in sub-Saharan Africa. In many countries in sub-Sahara Africa, crop residues from other crops such as groundnut, cowpea, peas, cassava, sweet potatoes, bananas, maize, rice and sorghum are important feed resources for small holder livestock farmers. Some farmers obtain up to 25% of their annual cash income from the sale of grain legume residues during this period (ICRISAT, 1991). After the grains or pods have been harvested from the stem, the residues provide good fodder for livestock. The feeding value of residues is influenced by the type of crop, fertilizer application, morphological composition and density of planting. During the wet season (May-September) animals graze mainly natural pastures but depend mostly on crop residues (over 50% of grazing time) in the dry season (October –April). Results from studies in Abet and Kurmi Birki areas of Kaduna State, Nigeria, Powell and Mohamed-Saleem (1987) indicated that crop residues grazing in Abet area accounted for 50% of the total dry season grazing time, representing some 20% of the total annual grazing time.
In other to meet up with nutritional demands of ruminant livestock, farmers have to store crop residues from previous harvest or leave crops in the field to be grazed by locally owned livestock (cattle, sheep, and goat). In southern Nigeria, agro-pastoralists graze their ruminant livestock on residues from the cropping system, particularly in the dry season.

The general experience in intercropping experiments is that the fodder yields of a given crop in the mixture are less than the yields of the same crop grown alone, but the total productivity per unit of land is usually greater than for sole crops. Fodder yield advantage of intercropping have been attributed to mainly environmental resources such as water, light and nutrients which can be utilized more efficiently in intercropping than in the respective sole cropping systems (Liu et al., 2006). As noted by Willey, (1991) and Tadesse *et al.* (2012) the underlying principle of better environmental resource use in intercropping is that if crops differ in the way they utilize resources when grown together, they can complement each other and make better combined use of resources than when they are grown separately. Potential of raising other crops such as forage legumes and non-legumes in association with major staple food crops like rice could be substantially enhanced through intercropping (Saeed *et al.*, 1999). It also helps in maintaining the soil fertility, making efficient use of nutrients and ensuring economic utilization of land, labour and capital.

The fodder yields of component crops vary from field to field and also depend on the crop mixture. Previous research results showed that cowpea and groundnut fodder yield varied from 120 to 1820kgha^{-1} and 144 to 1976kgha^{-1} respectively, while stover yield of sorghum and millet varied from 538 to 13015kgha^{-1} and 250 to 6995kgha^{-1} respectively (Tarawali et al., 1996). Abdul Jabbar et al. (2010) observed significant maximum fodder yield of 40.70 ton ha^{-1} when maize was intercropped in rice followed by fodder yield of sesbania (27.49 ton ha^{-1}) intercropped in rice and fodder yield of intercrop cowpea (23.69 ton ha^{-1}). The minimum fodder yield of 19.50 ton ha^{-1} was produced by intercrop of cowpea which was at par with fodder yield of intercrops pigeonpea and mungbean (20.76 & 20.60 ton ha^{-1}, respectively) (Abdul Jabbar et al. 2010).

The aim of this study was therefore to evaluate the forage dry matter yield and productivity indices of rice and cowpea residues and thus provide information for using these residues for feeding ruminants such as sheep, goat, cattle and pseudo-ruminants such as grass cutter in the dry season in humid Nigeria.

2. Materials and Methods

The study was conducted between July 2003 and October 2004 at the Delta State Agricultural Development Programme Research Farm Agbarho (Lat 5^0 34'N and Long 5^0 53'E) in the wet humid rainforest of southern Nigeria. The mean annual rainfall during period was 2116mm and 2660mm in 2003 and 2004 respectively. During the same period, temperatures and relative humidity ranged from 26^0C and 29.7^0C and 78% to 90% respectively. The experimental site was a sandy loam Arenic Paleudults ultisol (903gkg^{-1} sand; 42gkg^{-1} silt; 56gkg^{-1} clay; pH in water = 4.3; 3.2gkg^{-1} organic carbon; 0.6gkg^{-1} total nitrogen).

Cowpea (*Vigna unguiculata* L. Walp cv. Ife Brown) and upland rice (*Oryza sativa* L. cv. ITA 150) were the crops used for the study. Three treatments were used consisting of four nitrogen rates (0, 15, 30 and 45$kgNha^{-1}$) applied as urea {$CO(NH_2)_2$}, three cropping patterns (sole rice, sole cowpea and rice-cowpea mixture) and three cropping densities (5 $x10^4$, 10 $x10^4$ and 20 $x10^4$ plants ha^{-1}). Treatments were arranged in a 4x3x3 factorial. The randomized complete block design with three replicates was used on 4.8m x 2.5m plots. All plots were left fallow till the second cropping season. However the second experiment of 2004 had no applied nitrogen fertilizer. This was aimed at evaluating the residual effect of the mineral fertilizer nitrogen applied previously. In mixtures, rice and cowpea were applied to achieve a 1:1 proportion.

At maturity of crops after harvest of grains and pods of rice and cowpea respectively, all plots were sampled in a 1m x 1m quadrant by harvesting (cutting) plant herbage 5cm above the ground level. Cut materials were collected, sun dried and weighed as haulm and stover yield for cowpea and rice respectively. Forage dry matter per m^2 was converted to $kgha^{-1}$.

The forage dry matter yield of the crop residues were analyzed statistically by analysis of variance, ANOVA (Gomez and Gomez, 1984) and means were separated by the least significant difference at 5% level of probability.

Intercrop productivity advantage of forage dry matter yield (DMY) of the rice-cowpea intercrop was assessed using the following indices: land equivalent ratio (LER), system productivity index (SPI), relative crowding coefficient (K) and aggressivity index (A).

(a) Land Equivalent Ratio (LER) = $(Y_{ab}/Y_{aa}) + (Y_{ba}/Y_{bb})$, whereas Y_{aa} and Y_{bb} are corresponding forage dry matter yields (DMY) of sole crops of *a* and *b* while Y_{ab} and Y_{ba} are the corresponding forage dry matter yields of intercrops of a and *b*. Values of LER greater than 1 are considered advantageous.

(b) System productivity index (SPI), as stated by Odo (1991), which standardizes the forage dry matter yield (DMY) of the secondary crop (cowpea), *b*, in terms of the primary crop (rice), *a*. It was computed as:

$SPI = (S_a/S_b * Y_b) + Y_a$;

where S_a and S_b are the mean forage dry matter yield (DMY) of rice and cowpea respectively in sole culture and Y_a and Y_b are the mean forage dry matter yield of rice and cowpea, respectively in mixed culture.

(c) Relative crowding coefficient (K) was calculated as: $K_{ab} = Y_{ab}/ (Y_{aa}-Y_{ab})$ and

$K_{ba}= Y_{ba}/ (Y_{bb}-Y_{ba})$ where K_{ab} and K_{ba} are relative crowding coefficients of rice and cowpea respectively. The crop component that had a higher coefficient was said to be dominant. If the coefficient of a particular crop species is less than, equal to or greater than 1, then that species has produced less yield, the same yield, or more than "expected", respectively (Willey and Rao, 1980).

(d) Aggressivity index (A): a measure of how much the relative forage dry matter yield (DMY) in species *a* is greater than that for species *b* was expressed as follows:

$$K_{ab} = \frac{Y_{ab}}{Yaa * Z_{ab}} - \frac{Y_{ba}}{Y_{bb} * Z_{ba}}$$

Where Z_{ab} and Z_{ba} are proportions of intercrop area initially allocated to rice and cowpea respectively. Thus if $A_{rice} = 0$, both crops are equally competitive, if A_{rice} is positive, then it is dominant and if A_{cowpea} is positive, then cowpea is dominant.

3. Results and Discussion

3.1 Forage dry matter yield

Forage DMY of rice was significantly ($P<0.05$) increased with increasing level of mineral nitrogen fertilizer in both sole and intercrop (Table 1) and highest value (454.83 $kgha^{-1}$) was observed when urea fertilizer was applied at 45 $kgNha-^1$. It can be seen from the Table 3 that the increasing doses of nitrogen fertilizer resulted in progressive significant ($P<0.05$) increase in dry matter yield of cowpea forage planted sole or intercropped with rice. Highest forage dry matter yield (5328.67 $kgha^{-1}$) of cowpea was observed with mineral nitrogen of 30$kgNha-^1$. Residual nitrogen of the second cropping season reduced forage yield of both crops relative to the second cropping season (Tables 2 and 4). However, a significant increase in forage DMY was still observed in rice and cowpea with highest values obtained at residual nitrogen plots of 45kgNha-^{1}. Treatments without nitrogen application recorded the least DMY in both rice and cowpea forages. The low forage DMY at low nitrogen rates showed that nitrogen greatly affected the photosynthetic activities of the plant and the subsequent storage of dry matter produced. Similar results by other researchers also noted that when total nitrogen is inadequate to meet demand, forage production will be reduced (Kiniry et al., 2001; Malagi, 2005, Hasan et al., 2010). The higher DMY observed under high nitrogen rates could be due to increase in foliage of the crops resulting in accumulation of photo-assimilate. In general, nitrogen applications tend to increase overall production, decrease in cereal portion and increase in legume portion of the mixture. The reason for the decreased rice forage DMY may be due to the increased competition brought about by the stimulated growth of the cowpea.

Progressive increase in planting density significantly ($P<0.05$) increased DMY of both rice and cowpea forages in both sole and intercrop populations under mineral and residual nitrogen regimes (Tables 1, 2, 3 & 4). Under mineral nitrogen regime, increasing plant density from 100000 plants ha^{-1} to 200000 plants^{-1} increased forage DMY of rice by 140.4% and 48.8% in sole and intercrops respectively while under the residual nitrogen regime, DMY was increased by 94.8% and 53.8% in sole rice and intercrops respectively. A similar trend was also observed with cowpea forage dry matter. Lowest dry matter yields were obtained with density of 50000 plants ha^{-1} in both cowpea and rice irrespective of nitrogen regimes. The results in this study indicate that from the point of view of plant density, maximum forage yield is achieved through maximum density. This is consistent with other related researches (White, 1976; Pinter et al., 1989).

Intercropping of rice with cowpea significantly reduced the forage DMY of rice but had no significant effect on cowpea. This was observed with both mineral and residual nitrogen regimes. Saleem et al. (2000) observed significant reduction in rice biomass under intercropping with legumes. Similar results were observed for wheat (Tareen *et al.*1988). In a related study, Oseni (2010) observed higher stover/haulm yields of both sorghum and cowpea sole cropping than the intercropped mixtures irrespective of the planting patterns.

Interactive effects of nitrogen x density, nitrogen x system, density x system and nitrogen x density x system were all found to be highly significant ($P<0.01$) on forage dry matter of both rice and cowpea in both cropping seasons (Tables 1, 2, 3 & 4).

3.2 Forage dry matter productivity indices of rice-cowpea intercrop

Results indicated that LER was greater than unity in all of the mixtures indicating a forage dry matter yield (DMY) advantage over sole crops (Table 5 and 6). LER ranged from 1.41 to 3.47 under mineral nitrogen regime, indicating that the intercrops had 41% to 247% forage dry matter yield of their sole crops. In the residual nitrogen regime LER ranged between 1.59 and 2.67. Therefore, 59% to 167% more land was used in sole cropping in order to obtain the same yield of intercropping. On the average LER increased with progressive increase in nitrogen application. Increasing intercrop density beyond 100000 plants ha^{-1} reduced LER at all nitrogen levels in both cropping seasons. LER greater than one was due primarily to the increase in N absorption. The system productivity index (SPI) (Table 5 and 6) showed a linear relationship with nitrogen and intercropping density. Relative to the forage yield of the primary crop (rice) the standardization of the yield of the secondary crop (cowpea) was better achieved at 30 kgNha-^{1} on 200000 plants ha^{-1} with SPI value of 1873.53. The LER and SPI obtained in this study indicate the superiority of the intercrops over pure stand in terms of the use of environmental resources for plant growth. LER greater unity has been reported with other cereal-legume intercrops, maize-legume (Javarnmard et al. 2009); grass-alfalfa (Sengul, 2003).

The relative crowding coefficient values (K) of forage dry matter yield were generally below unity in both rice and cowpea during the two cropping seasons. K values for rice ranged from -32.49 to 3.32 while that of cowpea ranged from -77.48 to 13.92 in the first cropping. Ranges of values during the second cropping were within -16.95 to 12.14 for rice and -13.81 to 2.09 for cowpea. K for cowpea indicated more negative values than rice. K values averagely decreased with increase in nitrogen and increased with increasing intercropping density (Table 5 and 6). Aggressivity index (A) values ranged from -4.03 to 4.03. The dominance of cowpea with average of A values under mineral nitrogen during the first cropping increased with increasing level of nitrogen, but indicated no consistent trend in the second cropping. During the first cropping with mineral nitrogen, low intercropping density (50000 plants ha^{-1}) made rice to be more dominant than cowpea (Table 5 and 6), however beyond this density level, cowpea was the dominant crop. There was no consistent trend with density during the second cropping season. On the average, cowpea was the dominant crop, in terms of forage dry matter production during both cropping seasons. The dominance nature of the cowpea in the intercrop as indicated by the K and A values may be as a result of its better ability to capture light and soil resources. The cowpea architecture, with its horizontal trifoliate leaves may have a better ability to capture light than rice with narrow upright growth habit. In addition since the competitive ability of rice is closely associated with traits related to light capture such as large leaf weight, leaf area and tiller production, (Fischer et al. 1995), the early suppressive ability of the fast growing, high foliage cowpea may have made the rice crop to be less competitive. Reduction in biological yield of rice by associated legume has been reported by other studies (Saleem et al., 2000; Oroka and Omoregie, 2007; Abdul Jabbar et al., 2010).

4. Conclusions

Intercropping is an important practice among small holder farmers in Nigeria and other countries in Sub-Sahara Africa. Intercropping is found to increase total biomass production, provide diversity of products and reduce economic and environmental risks common in monoculture systems. With increasing pressures on land for food production, less land will be available to produce animal feed, either from pasture or fodder crops, and crop residues will assume greater importance as animal feed. The results from this study indicate cereal-legume intercropping can be used as a suitable management strategy for producing high quantity of forage from crop residues. Since intercropping legumes with cereals produces more total forage dry matter compared with sole crop, besides other forage quality and environment resource benefits, it would be worthwhile to sustain such a farming system. The study suggests use of 30kgNha-^{1} at 200000plants ha^{-1} to achieve maximum forage yield per unit area from residues of rice-cowpea intercropping.

References

Abdul Jabbar, R.A., H.B. Iftikhar, Z.A Atiqueur-Rehman1 and N.V. Shah, (2010).. Effect of different rice-based intercropping Systems on rice grain yield and residual soil fertility *Pakistan Journal of Botany*, 42(4): 2339-2348

Fischer, A.J.; Chatel, M., Ramirez, H.R., Lozano, J. & Gnimaraes, E. (1995) Components of early competition between upland rice (*Oryza sativa* L.) and *Brachiaria brizontha* (Hochst. Ex.A. Rich) Stapf *International Journal of Pest Management* 41: 100-103

Hasan, M.R., Akbar, M.A., Khandaker, Z.H & Rahman, M. M. (2010) Effect of nitrogen fertilizer on yield contributing character, biomass yield and nutritive value of cowpea forage *Bang. J. Anim. Sci*. 2010, 39(1&2): 83 – 88

ICRISAT (1991) ICRISAT West African Programs Annual Report 1990. International Crops Research Institute for the Semi-Arid Tropics, Niamey, Niger

Javanmard, A., Mohammadi Nasab, A.D., Javanshir, A., Moghaddam, M. & Janmohammadi, H (2009) Forage yield and quality in intercropping of maize with different legumes as doublecropped *Journal of Food, Agriculture & Environment* .7 (1):163-166

Kiniry, J.R., McCauley, G., Xie, Y. & Arnold, J.G (2001) Rice parameters describing crop performance of four U.S cultivars *Agronomy Journal* 93:1354-1361

Liu, J.H., Zeng, Z.H., Jiao, L.X., Hu, Y.G, Wang, Y.& Li, H. (2006). Intercropping of different silage maize cultivars and alfalfa. *Acta. Agron. Sci.* 32:125- 130.

Malagi, C.S. (2005) Response of cowpea genotypes to plant density and fertilizer levels under rainfed vertisols M.ScThesis University of Agricultural Sciences, Dharwad, India

Odo, P.E. (1991). Evaluation of short and tall sorghum varieties in mixtures with cowpea in the Sudan savanna of Nigeria: land equivalent ratio, grain yield and system productivity index. *Expl. Agric.* 27: 435–441.

Oroka, F.O. & Omoregie, A.U. (2007). Competition in rice-cowpea intercrops as affected by nitrogen fertilizer and plant population. *Scientia Agricola* (Piracicaba, Braz), 64, 621-629.

Oseni, T.O., 2010. Evaluations of sorghum-cowpea intercrop productivity in savanna agro-ecology using competition indices. *Journal of Agricultural Science* 2:229-234

Pinter, L., Schmidt, J., Jozsa, S., Szaibo, J. and Kelemen, G. (1990) Effect of plant density on the feed value of forage maize *Maydica* 35:75-79

Powell, P. and Mohamed-Saleem, M.A. (1987) Nitrogen and phosphorus transfers in a crop-livestock system in West Africa *Agricultural System* 25: 25:261-277

Saeed, M., Ullah, A., Ahmad, R. &. Jabbar, A. (1999) Bio-economic assessment of direct-seeded rice-based intercropping systems under strip plantation. *Pakistan J. Biol. Sci*., 2: 980–83.

Saleem, F.M., Shamshad H.S., Malik, M.A & M. K. Munir, M.K. (2000) Bio-Economics of different Upland Rice-Based Intercropping Systems under Strip Plantation *International Journal of Agriculture & Biology* 2(4): 294-296

Sengul, S. (2003) Performance of some forage grasses or legumes and their mixtures under dry land conditions. *European Journal of Agronomy* 19:401-409.

Tadesse, T., Liben, M., & Asefa, A. (2012) Role of maize (*Zea mays* L.)- fababean (*Vicia faba* L.) intercropping planting pattern on productivity and nitrogen use efficiency of maize in northwestern Ethiopia highlands *International Research Journal of Agricultural Science and Soil Science* 2(3): 102-112

Tarawali, S.A., Singh, B.B., Peters, M. and Blade, S.F.(1996) Cowpea haulms as fodder In: Proceedings of the Second World Cowpea Resaecrh Conference 5-8 September, 1995 Accra, Ghana. International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria. et al., 1996

Tareen, M.A., Nazir, M.S., Ahmad, S. & Ali, N. (1988) Yield and yield components of wheat as influenced by

intercropping and planting geometry. *Pakistan J. Agri. Res*., 9: 310–15.
White, R.P. (1976) Effect of plant population on forage corn yields and maturity on Prince Edward Island *Canadian Journal of Plant Science* 56:71-77
Willey, R.W. (1991). Evaluation and presentation of intercropping advantages. *Experimental Agriculture*. 21:119-123
Willey, R.W & Rao, M.R.(1980) A competitive ratio for quantifying competition between intercrops *Experimental Agriculture* 16:117-125

Table 1 Forage dry matter yield of rice intercropped with cowpea under mineral nitrogen and varying density

	Sole rice				Intercrop rice			
				Mean				Mean
	Density (plants ha^{-1})				Density (plants ha^{-1})			
N (kgNha^{-1})	500000	100000	200000		500000	100000	200000	
0	228.50	232.11	449.12	303.51c	151.84	295.11	302.15	249.70c
15	123.74	480.12	556.24	386.70b	184.32	242.16	424.08	283.52c
30	102.25	185.30	970.11	419.22ab	114.16	235.06	552.31	300.51b
45	165.11	299.21	900.17	454.83a	238.51	415.12	487.93	388.52a
Mean	154.90c	299.19b	719.11a		172.21c	296.86b	441.62a	
Interactions								
N x D	242.09**							
N x S	1279.94**							
D x S	732.36**							
N x D x S	81.36**							

Table 2. Forage dry matter yield of rice intercropped with cowpea under residual nitrogen and varying density

	Sole rice				Intercrop rice			
				Mean				Mean
	Density (plants ha^{-1})				Density (plants ha^{-1})			
N (kgNha^{-1})	500000	100000	200000		500000	100000	200000	
0	140.51	223.19	359.81	241.17c	127.21	257.61	330.17	238.33c
15	105.49	223.11	490.61	273.17b	142.09	287.31	402.11	277.17b
30	132.18	261.89	476.20	290.09b	120.50	206.93	506.06	277.83b
45	120.40	259.10	558.06	312.52a	155.71	355.12	464.50	325.11a
Mean	124.65c	241.82b	471.17a		136.38c	276.74b	425.71a	
Interactions								
N x D	184.70**							
N x S	238.00**							
D x S	556.2**							
N x D x S	17.7**							

Table 3. Forage dry matter yield of cowpea intercropped with rice under mineral nitrogen and varying density

	Sole rice				Intercrop rice			
				Mean				Mean
	Density (plants ha^{-1})				Density (plants ha^{-1})			
N (kgNha^{-1})	500000	100000	200000		500000	100000	200000	
0	1760.50	2672.15	3877.98	2770.21b	1312.62	2493.06	3361.32	2389.00c
15	1914.15	2168.18	4567.57	2883.30b	1072.16	2545.19	5004.14	2873.83c
30	2744.12	2742.05	5297.93	3594.79ab	2780.00	5990.61	7215.40	5328.67b
45	1794.50	3500.16	4012.06	3102.24a	2744.90	4290.08	5465.01	4167.33a
Mean	2053.23c	2770.64b	4438.89a		1977.42c	3830.24b	5261.47a	
Interactions								
N x D	41.70**							
N x S	226.38**							
D x S	156.60**							
N x D x S	12.7**							

Table 4. Forage dry matter yield of cowpea intercropped with rice under residual nitrogen and varying density

	Sole rice				Intercrop rice			
				Mean				Mean
	Density (plants ha^{-1})				Density (plants ha^{-1})			
N (kgNha^{-1})	500000	100000	200000		500000	100000	200000	
0	2225.74	1940.15	3456.12	2540.67b	1505.11	2951.17	4199.71	2885.33c
15	2108.35	2788.42	3180.56	2692.51b	2566.72	3449.08	3428.89	3148.23bc
30	1657.92	2497.36	4246.22	2800.50b	2098.52	3203.19	5234.78	3513.83ab
45	2410.82	4173.51	4774.18	3786.17a	2837.33	3552.70	5580.96	3990.33a
Mean	2100.71c	2849.91b	3914.27a		2251.92c	3289.04b	4611.09a	
Interactions								
N x D	41.5**							
N x S	313.50**							
D x S	213.60**							
N x D x S	12.70**							

Table 5. Productivity indices of rice-cowpea intercrop under fertilizer nitrogen and varying density

		LER	SPI	K		A	
				Rice	cowpea	rice	cowpea
Nitrogen	Density (plants ha-1)						
0 kgNha^{-1}							
	50000	1.41	322.21	1.98	2.93	0.51	-0.51
	100000	2.20	511.92	-4.68	13.92	0.67	-0.67
	200000	1.54	692.13	2.04	6.51	-0.39	0.39
15 kgNha^{-1}							
	50000	2.15	253.63	-3.04	1.27	1.86	-1.86
	100000	1.73	805.76	1.02	-6.75	-1.42	1.42
	200000	1.86	609.41	3.21	-5.42	-0.67	0.67
30 kgNha^{-1}							
	50000	2.68	217.75	-7.86	-2.89	-0.77	0.77
	100000	2.50	639.89	-4.72	-5.42	0.09	-0.09
	200000	1.93	1873.53	1.32	-3.76	-1.58	1.58
45 kgNha^{-1}							
	50000	2.45	491.07	-32.49	-77.48	0.86	-0.86
	100000	3.57	782.03	-3.58	-1.84	-1.60	1.60
	200000	1.90	1714.09	1.18	-3.76	-1.64	1.64

Table 6. Productivity indices of rice-cowpea intercrop under residual nitrogen and varying density

		LER	SPI	K		A	
				Rice	cowpea	rice	cowpea
Nitrogen	Density (plants ha-1)						
0 kgNha^{-1}							
	50000	1.59	231.97	9.56	2.09	0.46	-0.46
	100000	2.67	465.85	-7.48	-5.39	-0.73	0.73
	200000	2.14	642.04	12.14	-2.92	-0.59	0.59
15kgNha^{-1}							
	50000	2.51	201.18	-3.58	-5.65	0.26	-0.26
	100000	2.53	549.22	-4.54	-5.60	0.11	-0.11
	200000	1.90	939.61	4.54	-5.22	2.37	-2.37
30kgNha^{-1}							
	50000	2.18	254.41	10.32	-13.81	-0.71	0.71
	100000	2.07	779.09	3.77	-4.76	-0.99	0.97
	200000	2.29	1154.61	-16.95	-5.30	-0.43	4.03
45kgNha^{-1}							
	50000	2.47	339.88	-4.41	-6.65	0.24	-0.24
	100000	2.22	672.84	-3.70	5.72	1.04	-1.04
	200000	2.00	1224.66	4.96	-6.92	-0.68	0.68

Oroka, Frank Oke is currently a Senior Lecturer at the Delta State University, Abraka, Nigeria. He obtained his PhD in Crop Science with specialization in farming systems from the Ambrose Alli University, Ekpoma, Nigeria in 2006.