

Nutritional Composition of Residues Available for Ruminants from Rice + Cowpea Intercrop During the Dry Season in Nigeria

Oroka, Frank O.[1*] Omoregie A.U[2]
1.Department of Agronomy, Delta State University Asaba Campus, Delta State, Nigeria
2.Department of Crop Science, Ambrose Alli University, Ekpoma, Nigeria
*E-mail of corresponding author: orkfra@yahoo.com

Abstract
Chemical analysis to assess the mineral status of two fodder crops (rice and cowpea) was carried out. The range of P, K, Na, Ca and Mg values in the rice and cowpea plants met the minimum requirements for beef and dairy cattle and sheep/goats in this area. In rice plants, the level of crude protein (CP) met the marginal requirement, while CP values of cowpea were within the recommended requirements for ruminants in the area of study. Values of Fe and Zn were below minimum requirements while over 50% of the rice and cowpea plants had adequate Cu. Mineral supplements are suggested for correction of deficiencies in feed of ruminants in the area of study.
Keywords: crop residues, mineral supplements, macro elements, microelements, ruminants

INTRODUCTION
Livestock production systems in sub-Saharan Africa are mostly traditional and have been characterized in recent years by an increase in livestock species, especially cattle, sheep and goats, the main species. At the same time, these resources (pastures in natural fields) that form the basis of production systems has experienced severe degradation due mainly to the adverse effects of climate change but also to population pressure and other environmental effects (Kiema & Zampaligré, 2013; Muleke et al., 2013). This calls for alternative resources to feeding the ever increasing livestock.

Materials left in an agricultural field after the crop has been harvested are generally termed residues. These residues include stalks and stubble (stems), leaves, and seed pods. Crop residues are useful source of ruminant animal supplementary feed in the dry season in the sub-humid and dry tropics. In general, the feeding value of the residues is influenced by the type of crop, fertilizer application (Perry and Olson, 1975) morphological composition (Thiago and Kellaway, 1982), variations within cultivars and density of planting (Struik and Deinum, 1982).

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). The critical period in livestock production in this zone is the dry season and the major problem is poor forage quality as well as quantity. The resident cattle at this period tend to lose about 15-20% of their body weight each dry season in spite of available forage (NRC, 1976; Omoregie, 1991). Under these conditions, milk yields are low, calf mortality is high and owing to nutritional anoestrus, cow fecundity is also low (Mohamed – Saleem.,1986).

With rainfall as a limiting factor to nutritious fodder, the storage of crop residues from the previous harvest to be fed to livestock or leaving the crop residues standing in the field to be grazed by locally owned livestock (sheep, goats and cattle) are methods farmers are increasingly adopting in other to meet up with the nutritional demands of their livestock (Israel and Pearson, 2000).

In Southern Nigeria, agro pastoralists graze their ruminant livestock on residues from the cropping system, particularly in the dry season. An evaluation of the nutritional value of the residues from the system becomes important for nutritional planning for ruminants.

The aim of this study is to evaluate the feeding value of the residues from the rice-cowpea mixture, and provide information on the mineral status of these residues for feeding of sheep, goats and cattle in humid Nigeria, especially in the dry season.

MATERIALS AND METHODS
The experimental site was the Delta State Agricultural Development Programme Research Farm, Agbarho (Lat 5^{o}34'N and Long5^{o}53) in the wet humid tropical rain forest of southern Nigeria. The research was conducted in July 2003 and repeated in July 2004.

The crops studied were cowpea (*Vigna unguiculata* L. Walp Cv. Ife Brown) and rice (*Oryza sativa* cv. ITA 150). Three treatments were used, consisting of three cropping patterns (sole cowpea, sole rice and rice – cowpea mixture) nitrogen fertilizer rates applied as urea (O, 15, 30, 45KgN/ha) and planting densities (50000, 100000, 200000 plants/ha). Treatments were arranged in a 4x3x3 factorial with a randomized complete block design. Treatments were replicated three. However, the second experiment of 2004 had no applied N fertilizer. This was aimed as assessing the residual effect of applied N fertilizer.

After harvest of grains, which coincided with the onset of the dry season in October, five plants were randomly selected from each plot, and the shoots harvested at 5cm above the ground. These were bulked based on the treatments and used for nutrient analysis. Macro and microelements contents of the rice and cowpea shoots were determined on dry mater basis using methods described by AOAC (1990), after they have been ground in a stainless hammer mill. Crude protein was calculated by multiplying nitrogen content by 6.25.

RESULTS AND DISCUSSIONS

The crude protein, macro- and micro- mineral composition of the analyzed rice and cowpea residues are presented in Tables 1 to 5.

Crude Protein (CP): The crude protein levels of cowpea in the first and second cropping ranged from 1.00 to 31.13% and 1.25 to 18.19% respectively (Table 1). CP content in rice plants ranged from 2.06 to 8.00 in the first ranged from 2.06 to 8.00 in the first cropping season and 2.88 to 5.13% in the second cropping. CP values in rice and cowpea mixtures were generally higher than their corresponding monocultures. CP values marginally increased with high planting density in mixtures, but was slightly depressed in monoculture cowpea.

In cowpea, CP levels in residue met with the recommended crude protein levels of between 6.6 to 12 and 10.8% (NRC, 1975) for sheep/goats and cattle respectively. The crude protein values for cowpea in this study are within the value of 16.19% reported by Ikhimioya and Olagunju (1996) at Abraka, Nigeria. Relwani (1970), also reported similar CP values ranging from 16.5 to 26.4% in cowpea. However, for rice residues, only 20.8% had CP value adequate for sheep and goats. Thus, ruminants to be fed with rice residues in this area should be allowed free access to diammonium phosphate (contains 18.0% nitrogen or 112.5 protein equivalent) or mono ammonium phosphate (contains 11% nitrogen or 68.7% protein equivalent) as recommended by other studies (Harris *et al.* 1994; NRC, 1989).

Phosphorus: Range of values for P content in of rice fodder are 0.27 to 0.68% and 0.18 to 0.56% of dry matter in the first and second cropping, respectively (Table 1). P content of rice fodder increased with intercropping with cowpea, but decreased with planting density. Range of P values in cowpea for the first and second cropping seasons varied from 0.15 to 0.61% and 0.20 to 0.52% respectively (Table 1). Generally P content in fodder was higher in plants of high population density in both cropping seasons.

The ranges for P requirements of beef and dairy cattle and sheep are 0.18-0.47, 0.31-0.40 and 0.16-0.37% dry matter respectively (NRC, 1975, 1978, 1984). The P content of all rice and cowpea will satisfy the requirements of beef cattle, sheep and goats. However, for the dairy cattle only 96% and 92% of the rice plants in the first and second cropping and 87.5 and 79.5% of cowpea met the critical P value for milk production. Because of its role in bone metabolism and milk production, phosphorus supplementation in form of bone meal (21% P) or dicalcium phosphate (18% P) may be given to the dairy cattle (Hale and Olson, 2001) in this locality.

Potassium (K): The potassium levels in the rice fodder ranged from 0.91 to 2.51% (first cropping) and 0.86 to 2.03 (second cropping) (Table 2). K level of the rice plants of the first cropping were averagely higher than the second cropping. Highest K value (1.16% dry matter) was obtained from the 45kgN/ha at low density of 50,000 plants/ha for the first cropping, while medium density (100,000 plants/ha) recorded highest value (0.70%) during the second cropping.

The K levels in majority of the crops were within the range of 0.86 to 2.51% and 0.39-0.82% for rice and cowpea respectively. The K requirements of beef and dairy cattle and sheep are 0.50-0.70% 0.8-1.2% and 0.50% dry matter respectively (NRC, 1975, 1978, 1984). Clearly, the rice and cowpea plants will satisfy the maintenance requirements of beef, dairy cattle, and sheep and goats to produce beef, milk and mutton respectively.

Sodium (Na): Sodium level in rice fodder ranged from 0.25 to 0.80% and 0.24 to 0.68% dry matter in the first and second cropping seasons respectively (Table 2). Relative low values of Na were obtained in cowpea fodder in both cropping seasons. Na levels ranged from 0.12 to 0.19% and 0.12 to 0.16 in the first and second cropping seasons respectively (Table 2).

The beef and dairy cattle and sheep requirement of Na are 0.06 to 0.08%, 1.0 to 1.8% and 0.04 to 0.10% dry matter respectively (NRC, 1975, 1984). The rice and cowpea plants are rich in sodium for optimum needs of beef cattle and sheep and goat. However, none of the crops met the critical requirement for dairy cattle. This is similar to a related study with grasses in Cameroun (Njwe and Ikom, 1988). Thus, dairy cattle in this area should be allowed access to common salt (40% Na) or sodium carbonate (27% Na) (Ammerman . 1995; NRC, 1996). Cattle deficient in salt often eat dirt, manure and urine in an attempt to satisfy their appetite for salt (Hale and Olson, 2001).

Calcium (Ca): The range of Ca content of rice was 0.36 to 1.12% dry matter and 1.15 to 3.41% dry matter for cowpea (Table 3). The ranges for the requirements of beef and dairy cattle and sheep are 0.18 to 0.53%, 0.43 to 0.60% and 0.21 to 0.52% dry matter (NRC, 1975, 1978, 1984). Calcium is not a limiting mineral in the fodder obtained from this study, hence would satisfy the requirements of the three classes of livestock.

Magnesium (Mg): Mg level in rice fodder was highest in sole rice of 15kgN/ha with medium density (100,000 plants/ha) while the lowest value (0.14%) was obtained from mixture rice populations of 30kgN/ha at medium density. In the second cropping, the range of 0.19 to 0.61% Mg content in rice shoot was obtained (Table 3) Cowpea had values ranging from 0.07 to 1.94% and 0.18 to 0.98% in first and second cropping seasons respectively.

The critical level needed to satisfy the maintenance requirements of beef and dairy cattle and sheep and goats to produce some beef, milk and mutton are 0.40 to 0.10%, 0.25% and 0.04-0.08% dry matter (NRC, 1975; 1996). Rice and cowpea fodder in this study have adequate magnesium for the three classes of ruminants.

Iron (Fe): About 54.2% and 50% of rice treatments had no iron in their tissues in the first and second cropping seasons (Table 4). Range of values for both cropping seasons was 0.00 to 24.53mg/kg (first cropping) and 0.00 to 24. 82mg/kg (second cropping). Fe content in cowpea fodder was generally high. Highest Fe value (65.41mg/kg) was obtained from mixture cowpea stands of 30kgN/ha at high densities (200000 plants/ha) in the first cropping, while mixture of 45kg/ha at medium densities had the highest Fe level (50.22mg/kg) in the second cropping.

The maximum tolerable level for both beef and dairy cattle is 50mg/kg and 30-50mg/kg for goats (NRC, 1975; 1996). All iron values for rice fodder were below the requirement for cattle and sheep. However about 12.5% of the cowpea plants were above maximum tolerable level. The high iron content of some of the cowpea would be detrimental to cattle and sheep, indeed the very high levels of iron might interfere with copper metabolism (Youssef and Brathwaite, 1987). However the total absence of iron in majority of the rice fodder and residues is detrimental to ruminants in his area, since iron enables the haemoglobin in red blood cells to carry oxygen to tissues of the body (Hale and Olson, 2001). Iron supplementation with ferrous sulphate heptahydrate (20% Fe) and ferrous carbonate (38% Fe) is recommended for the ruminants using crop residues in this area.

Zinc (Zn): Zn content of rice and cowpea fodder in this study was very low. Values obtained for rice fodder ranged from 0.011 to 0.027mg/kg dry matter for the first and second cropping respectively (Table 4). The cowpea fodder had values ranging from 0.007 to 0.035mg/kg dry matter and 0.005 to 0.037mg/kg dry matter and 0.005 to 0.037mg/kg dry matter in the first and second cropping respectively.

The range of values in the cowpea and rice fodder in this study were below the minimum requirements of 20-40, 40 and 35-50mg/kg dry matter for beef dairy cattle and sheep respectively (NRC 1975, 1978, 1984). The crop residues in this study did not satisfy the zinc requirements of beef and dairy cattle and sheep. Blezinger (2002) noted that zinc is essential to all animals and plays significant roles in nucleic acid metabolism, protein synthesis and carbohydrate metabolism in grazing ruminants. Zinc supplementation with bone meal (424mg/kg Zn) or diammonium phosphate (300mg/kg Zn) is recommended.

Copper (Cu): Copper content of rice shoot ranged from 6.25 to 18.64mg/kg dry matter and 5.09 to 15.73mg/kg dry matter for the first and second cropping seasons respectively (Table 5). Rice plants with low population density had more copper in their shoot. Intercropping with cowpea also improved the Cu content of the rice plants over their sole stands. The cowpea forage had Cu content ranging from 3.35 to 14.34mg/kg dry matter and 2.38 to 13.70mg/kg dry matter in the first and second cropping respectively.

The copper requirements for beef and dairy cattle, and sheep are 10, 10 and 5mg/kg dry matter respectively (NRC 1975; 1990). Copper was found to be adequate in both rice and cowpea for goat and sheep in this area. Copper supplementation in form of cuprous acetate (51% Cu) or cupric chloride (58% Cu) is recommended for both beef and dairy cattle. The use of soybean meal (28mg/kg Cu) is also is also recommended (Ammerman *et al*. 1995; NRC, 1998).

CONCLUSION

Crude protein and mineral content of the rice and cowpea fodder generally declined in the second cropping season with nitrogen fertilizer application. CP, Na, Fe, Zn and Cu on the basis of NRC critical requirements by ruminants were generally not adequate for some classes of livestock considered in this study. Feed supplementation will in no small measure help to correct the situation. The data showed in this study are useful in guiding livestock farmers and animal nutritionists for proper supplementation of fodder to desired and economic levels in ruminant livestock production.

REFERENCES

Ammerman, C.B.; Baker, D.H. and Lewis, A.J. (1995) Bioavailability of nutrients for animals. Academic Press, New York.

AOAC (1990) Official Methods of Analysis Association of Analytical Chemists 15th AOAC Washington D.C, USA.

Blezinger, S.B. (2002) Certain Trace Minerals Play Significant Role in Cattle http://:www.cattletoday.com/archive/202/novemberct239.shtml Last Sited 12th January 2005.

Hale, C. and Olson, K.C. (2001) Mineral Supplements for Beef Cattle http://muextension.mission.edu/explore/agguides/ansci/go208/.htm last sited 12th January 2005.

Harris, B. Jr; Adams, A.L. and Van Horn, H.H. (1994) Mineral Needs of Dairy Cattle. Florida Cooperative Extension Service. Institute of Food and Agricultural Sciences, University of Florida, Circuar 468 18pp.

Ikhimioya, I. and Olagunju, B.O. (1996) Chemical Composition of Selected Green Plants Available to Small Ruminants in the Dry season in Humid Nigeria *Tropicultura* 14 (3) 115-117.

Kiema A. & Zampaligré N. (2013) State of Ligneous Resources Of Four Pastoral Zones Of Burkina Faso: Sideradougou, Nouaho, Barani And Ceekol Nagge Int. J. Innovative Agric. & Bio. Res. 1 (2):1-19

Mohamed – Saleem, M.A. (1986) The Ecology, Vegetation and Land Use of Sub Humid Nigeria – Proc. 2nd ILCA/NAPRI Symposium, Kaduna – Nigeria, 1984, 59-84 ILCA, Addis Ababa Ethiopia Eds Kanfinann, R; Charter, S. & Blench, R.

Muleke, P. Masaazi, F ; Tamale, M B. & Nalule R. (2013) The Impact Of Commercial Agricultural Investments On The Pastoral Communities In Uganda: A Case Of Karamoja Sub-Region Int. J. Innovative Agric. & Bio. Res. 1 (2):1-11

Njwe, R.M. and Ikom, J. (1988) Survey of the Mineral Status of Pastures and Small Raminants in the West Region of Cameroun *Tropicultura* 6:150-152.

NRC (1975) Nutrients Requirements for Sheep Paper No. 5. National Research Connis National Academy of Sciences, Washington D.C.

NRC (1978) Nutrient Requirements of Dairy Cattle 5th ed. National Research Council. National Academy of Sciences Washington D.C.

NRC (1984) Nutrients Requirement of Domestic Animals, Nutrient Requirement of Beef Cattle 6th ed. National Academy of Sciences Washington D.C.

NRC (1989) Requirements of Dairy Cattle 6th Advised ed. National Research Council. National Academy of Sciences Washington D.C.

NRC (1996) Nutrient Requirement of Beef Cattle 7th Revised ed. National Research Council. National Academy Press Washington D.C.

Omoregie, A.U. (1991) Mineral Profile of some Fodder Crops and their residues in the Nigerian Subhumid Zone *Tropicultura* 9(1): 3-5.

Perry, L.T. and Olson, R.A. (1975) Yield and Quality of Corn and Sorghum grain and residues as influenced by N Fertilization *Agronomy Journal* 67:816-818.

Struik, P.C. and Deinum, B. (1982) Effect of Light intensity after flowering on the productivity and quality of silage maize *Neth .J. Agric. Sci*. 30. 297-316.

Thiago, L.R.L. and Kellaway, R.C. (1982) Botanical Composition and Extent of Liqnifications Affecting Digestibility of Wheat and Oat Straw and Paspalum hay *Animal Feed Science Technology* 7:11-81.

Youssef, F.G. and Brathwaite, R.a.L. (1987) The Mineral Profile of Some Tropical Grasses in Trinidad *Tropical Agriculture* 64:122-128.

Relwani, L.L. (1970) Cropping Patterns for High Milk Production *Indian Farming* 20:26-31.

Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.8, 2015

Table 1: Crude protein and phosphorus content of rice and cowpea residues

Treatment	Rice				Cowpea			
	Sole	Mixed	Sole	Mixed	Sole	Mixed	Sole	Mixed
	2003		2004		2003		2004	
	Crude protein (%)							
0kgN/ha								
50000	7.38	5.38	0.42	4.31	13.56	5.38	12.38	8.25
100000	6.00	5.31	0.51	3.94	14.19	7.94	11.88	8.75
200000	7.38	3.94	0.18	2.88	2.63	11.56	3.25	9.44
15kgN/ha								
50000	6.19	3.69	0.40	4.56	15.06	10.69	12.81	15.00
100000	6.63	4.75	0.50	3.86	18.19	10.94	14.75	12.00
200000	3.31	5.63	0.37	5.00	8.06	20.31	7.06	14.88
30kgN/ha								
50000	4.69	3.69	0.40	4.25	11.94	31.13	10.76	15.75
100000	4.63	4.75	0.30	4.56	9.81	23.88	10.00	17.38
200000	5.00	5.63	0.45	5.13	11.56	19.50	9.94	18.19
45kgN/ha								
50000	5.00	2.06	0.47	4.06	5.09	14.06	6.56	13.38
100000	4.38	4.25	0.43	4.00	8.06	15.06	7.13	12.38
200000	3.00	8.00	0.52	4.25	1.00	8.81	1.25	9.38
	Phosphorus (%)							
0kgN/ha								
50000	0.38	0.54	0.42	0.43	0.39	0.48	0.40	0.20
100000	0.63	0.68	0.51	0.48	0.50	0.50	0.42	0.22
200000	0.27	0.50	0.18	0.56	0.44	0.40	0.35	0.34
15kgN/ha								
50000	0.45	0.50	0.40	0.55	0.25	0.15	0.30	0.40
100000	0.52	0.53	0.50	0.42	0.38	0.26	0.34	0.54
200000	0.49	0.44	0.37	0.40	0.35	0.40	0.29	0.52
30kgN/ha								
50000	0.46	0.60	0.43	0.53	0.61	0.45	0.34	0.43
100000	0.38	0.51	0.30	0.51	0.51	0.60	0.45	0.50
200000	0.51	0.57	0.45	0.49	0.54	0.60	0.28	0.52
45kgN/ha								
50000	0.42	0.49	0.47	0.42	0.40	0.59	0.38	0.47
100000	0.57	0.48	0.43	0.45	0.43	0.44	0.46	0.47
200000	0.49	0.51	0.52	0.40	0.53	0.41	0.34	0.45

Table 2: Potassium and sodium content of rice and cowpea residues

Treatment	Rice				Cowpea			
	Sole	Mixed	Sole	Mixed	Sole	Mixed	Sole	Mixed
	2003		2003		2003		2004	
	Potassium (%)							
0kgN/ha								
50000	1.20	1.20	0.95	1.15	0.54	0.58	0.50	0.50
100000	2.51	1.31	0.65	1.20	0.39	0.75	0.48	0.58
200000	0.91	2.26	0.30	1.97	0.58	0.66	0.50	0.60
15kgN/ha								
50000	2.04	1.57	0.57	1.62	0.47	0.56	0.43	0.52
100000	1.20	1.82	0.60	1.70	0.58	0.58	0.47	0.60
200000	2.26	1.49	0.60	1.51	0.62	0.62	0.50	0.61
30kgN/ha								
50000	0.91	2.11	0.30	1.83	0.56	0.81	0.53	0.61
100000	1.31	1.78	0.40	1.58	0.49	0.62	0.54	0.59
200000	2.44	2.00	0.40	1.97	0.54	0.79	0.53	0.63
45kgN/ha								
50000	1.64	2.11	0.51	1.88	0.54	1.16	0.49	0.65
100000	2.00	1.82	0.49	1.90	0.45	0.82	0.50	0.70
200000	1.42	1.86	0.40	1.80	0.64	0.71	0.48	0.66
	Sodium (%)							
0kgN/ha								
50000	0.29	0.29	0.95	0.35	0.13	0.13	0.12	0.12
100000	0.80	0.40	0.68	0.40	0.14	0.14	0.13	0.13
200000	0.25	0.66	0.30	0.35	0.15	0.14	0.13	0.13
15kgN/ha								
50000	0.66	0.44	0.57	0.48	0.13	0.14	0.14	0.13
100000	0.29	0.51	0.60	0.50	0.14	0.13	0.13	0.14
200000	0.69	0.44	0.60	0.33	0.14	0.13	0.14	0.16
30kgN/ha								
50000	0.25	0.69	0.30	0.60	0.13	0.18	0.12	0.12
100000	0.36	0.55	0.40	0.58	0.13	0.18	0.12	0.12
200000	0.80	0.69	0.40	0.61	0.14	0.13	0.12	0.12
45kgN/ha								
50000	0.51	0.73	0.51	0.67	0.12	0.19	0.12	0.14
100000	0.62	0.62	0.49	0.60	0.13	0.15	0.12	0.14
200000	0.44	0.62	0.40	0.54	0.13	0.15	0.12	0.13

Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.8, 2015

Table 3. Calcium and magnesium content of rice and cowpea residues

Treatment	Rice				Cowpea			
	Sole	Mixed	Sole	Mixed	Sole	Mixed	Sole	Mixed
	2003		2004		2003		2004	
Calcium (%)								
0kgN/ha								
50000	0.46	0.61	0.51	0.42	1.96	1.92	1.58	1.52
100000	0.46	0.79	0.36	0.50	1.96	1.48	1.63	1.35
200000	0.55	0.96	0.50	0.62	2.61	1.24	1.80	1.40
15kgN/ha								
50000	0.77	0.96	0.68	0.75	2.32	1.32	2.05	1.35
100000	0.55	1.12	0.60	0.80	3.41	1.32	1.93	1.33
200000	0.83	0.64	0.68	0.51	1.64	2.08	1.15	1.87
30kgN/ha								
50000	0.72	0.66	0.65	0.73	2.00	2.16	1.80	1.62
100000	0.72	0.90	0.48	0.68	1.24	1.23	1.80	1.62
200000	0.53	0.45	0.50	0.78	2.08	1.72	1.94	1.45
45kgN/ha								
50000	0.59	0.46	0.56	0.55	1.72	1.88	1.65	1.66
100000	0.55	0.43	0.68	0.43	1.76	1.60	1.67	1.53
200000	0.58	0.48	0.53	0.55	1.76	1.06	1.80	1.20
Magnesium (%)								
0kgN/ha								
50000	0.35	0.67	0.20	0.61	0.58	0.39	0.51	0.40
100000	0.25	0.52	0.19	0.54	0.41	0.34	0.36	0.30
200000	0.57	0.27	0.38	0.30	0.07	0.39	0.18	0.38
15kgN/ha								
50000	0.48	0.16	0.41	0.21	0.56	0.63	0.45	0.52
100000	0.93	0.26	0.39	0.30	0.75	1.05	0.63	0.98
200000	0.27	0.43	0.21	0.35	1.89	0.88	0.98	0.98
30kgN/ha								
50000	0.36	0.46	0.30	0.15	1.31	0.78	0.75	0.70
100000	0.43	0.14	0.38	0.38	0.85	0.88	0.63	0.82
200000	0.54	0.51	0.19	0.26	0.46	2.24	0.69	0.93
45kgN/ha								
50000	0.45	0.52	0.40	0.45	0.85	0.54	0.70	0.45
100000	0.57	0.55	0.43	0.50	0.34	0.88	0.50	0.73
200000	0.58	0.53	0.50	0.42	0.56	1.94	0.86	0.75

Table 4: Iron and zinc content of rice and cowpea residues

Treatment	Rice				Cowpea			
	Sole	Mixed	Sole	Mixed	Sole	Mixed	Sole	Mixed
	2003		2004		2003		2004	
	Iron (mg/kg)							
0kgN/ha								
50000	0.00	16.94	0.00	0.00	22.19	0.00	1.05	0.00
100000	7.01	24.53	0.00	15.36	2.39	0.00	2.14	0.08
200000	3.54	22.19	6.52	24.82	0.54	21.02	0.60	15.02
15kgN/ha								
50000	6.47	1.17	1.86	21.15	0.58	10.51	0.18	18.62
100000	0.00	0.00	7.50	1.82	38.54	35.04	16.72	18.14
200000	0.00	0.00	1.13	0.00	22.19	25.26	15.31	25.36
30kgN/ha								
50000	0.00	0.00	0.00	0.00	37.81	0.00	28.62	0.04
100000	0.00	0.00	0.00	0.00	1.75	65.41	16.11	38.71
200000	0.00	0.00	0.00	0.00	5.71	21.61	4.71	20.70
45kgN/ha								
50000	4.09	0.00	0.00	0.00	7.01	58.77	8.03	48.37
100000	1.17	0.00	15.60	1.81	21.61	61.32	0.32	50.22
200000	21.61	2.92	3.90	1.15	15.18	44.38	0.45	42.18
	Zinc (mg/kg)							
0kgN/ha								
50000	0.076	0.013	0.030	0.010	0.008	0.033	0.005	0.030
100000	0.020	0.016	0.015	0.016	0.007	0.035	0.007	0.030
200000	0.018	0.015	0.012	0.020	0.006	0.027	0.005	0.031
15kgN/ha								
50000	0.021	0.018	0.022	0.023	0.028	0.026	0.018	0.014
100000	0.021	0.027	0.019	0.025	0.031	0.014	0.020	0.008
200000	0.017	0.027	0.015	0.018	0.025	0.014	0.017	0.015
30kgN/ha								
50000	0.016	0.024	0.019	0.020	0.044	0.019	0.033	0.017
100000	0.012	0.017	0.015	0.021	0.036	0.018	0.037	0.016
200000	0.013	0.022	0.013	0.020	0.036	0.018	0.035	0.017
45kgN/ha								
50000	0.011	0.020	0.013	0.020	0.041	0.014	0.025	0.015
100000	0.012	0.018	0.011	0.019	0.034	0.014	0.025	0.015
200000	0.012	0.020	0.110	0.019	0.042	0.017	0.036	0.015

Table 5 : Copper content of rice and cowpea residues

Treatment	Rice				Cowpea			
	Sole	Mixed	Sole	Mixed	Sole	Mixed	Sole	Mixed
	2003		2004		2003		2004	
	Copper (mg/kg)							
0kgN/ha								
50000	7.17	16.25	8.05	15.73	8.61	13.38	8.60	12.82
100000	10.04	18.64	9.83	12.82	11.96	13.38	10.15	13.35
200000	8.60	10.99	8.00	11.54	9.56	14.34	8.75	13.70
15kgN/ha								
50000	11.95	17.21	10.63	12.01	6.21	12.91	6.05	11.90
100000	7.17	13.38	6.18	15.08	3.35	10.91	2.38	9.86
200000	9.56	18.16	10.11	14.92	3.82	12.43	4.05	10.15
30kgN/ha								
50000	10.80	9.56	10.33	12.01	14.34	6.21	13.35	8.36
100000	9.08	13.86	9.79	15.68	12.43	14.34	13.40	10.75
200000	10.99	18.16	10.61	10.61	9.56	14.34	10.38	13.52
45kgN/ha								
50000	11.95	9.56	9.87	10.01	10.99	8.60	11.31	10.05
100000	6.25	13.86	5.09	14.01	9.08	14.34	8.04	10.75
200000	16.75	14.34	5.05	12.82	11.95	3.35	8.04	2.70