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EFFECTS OF MUCUNA (*MUCUNA UTILIS* L.) RESIDUE INCORPORATION AND NITROGEN LEVELS ON THE PERFORMANCE OF UPLAND RICE (*ORYZA SATIVA* L.)

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ABSTRACT

The field experiment was conducted at two locations: University of Agriculture, Abeokuta (UNAAB) and Olowo-Papa (OP) in Ogun state both in Forest-savannah transition zone of Nigeria to investigate the response of three upland rice cultivars (O.*sativa*) to mucuna residue incorporation and Nitrogen (N) fertilizer and the effects of residues incorporation on the soil chemical properties. The experiment was split plot in randomized complete block design in which mucuna constituted the main plot (factor A) i.e.non-mucna and mucuna plot and factorial combination of N fertilizer rates (factor B) and rice varieties (factor C) as subplot factors. Mucuna residue incorporation improved soil chemical properties such as Nitrogen (N), Potassium (K), Organic Matter (OM), Cation Exchange Capacity (CEC) and Acidity (pH) at both locations. Rice plant treated with mucuna residue alone gave higher grain yield than control (no residue) at OP while there was no significant difference at UNAAB. Fertilizer equivalent of the green manure used was estimated to be 30kgN /ha at OP. Grain yield response of the rice varieties to N-fertilizer were linear and curvilinear at OP and UNAAB, respectively. The yield of the two improved varieties (ITA150 and ITA257) were significantly higher than *OFADA* variety at both locations. Mucuna residue from the dry season fallow appeared to improve soil chemical properties as well as grain yield.

INTRODUCTION

Rice is the leading cereal crop in the world. One third of the world's population depends on rice for nearly two third of its food. Rice is grown in more than 146.5 million hectares (Labrada, 1996). World production reached 527.8 million tones in 1992 with 95% produced in the developing world (Labrada, 1996). About 19.3million hectares of the total rice area of the world is planted to upland rice (Moody, 1996). There are about 2.2 million hectare of upland rice in Africa (IRRI, 1988), which constitute 49.8% of the total rice land. In West Africa, 40% of the total area grown to rice is devoted to upland rice, whereas in Nigeria, 26% of the total land area grown to rice is devoted to upland rice (WARDA, 1999).

A major constraint to the use of planted herbaceous fallows is that they take land out of production (Casky *et al.*1998). This reduces the potential for short –term food crop supply that many small farmers need. Thus, it is necessary to search for a niche in which mucuna can be grown without reducing short-term food production. There is dearth of information on dry season mucuna fallow in combination with the late rains.

Mucuna is a vigorous annual legume whose primary functions is soil fertility maintenance, soil protection and weed suppression. Mucuna can achieve nearly 100% ground cover in two months (Casky *et al.,* 1998). Because of it rapid decomposition, mucuna is a good source of N to subsequent crops in rotation. Van Noordwijk et al. (1995) estimated that 83% of mucuna N was available to a subsequent crop and then very little for the second crop. Tian *et al.* (1995) found 6% N, 4% polyphenols, and 16.8% lignin in mucuna leaves and petioles. They observed mucuna decomposition rate to be among the highest in a group of ten herbaceous and woody species leaves and petioles. Therefore, the objectives of this study are to:

investigate the effects of mucuna residues incorporation and N-fertilizer levels the performance of upland rice,

determine the fertilizer equivalent value of the mucuna residue and

determine the effect of the mucuna residue incorporation on the soil chemical properties.

MATERIALS AND METHODS

The experiment was conducted at the University of Agriculture, Abeokuta (UNAAB) and Olowo-Papa (OP) in southwestern Nigeria in 1997/98 cropping season. Olowo-Papa (OP) village is about 70km away from (UNAAB). It is popular for rice production. Both locations are in the forest-savannah transition zone. The surface soils in both locations are loamy sand OP (86.6% sand, 5.3% clay and 8.1% silt) and UNAAB (85.5% sand, 3.1% clay and 11.4% silt). The field on which the two experiments were conducted had previously been cultivated to rice continuously for three years. Land preparation in OP was slash and burn; that of UNAAB was plough and harrow.

The experimental design was split-plot in randomized complete block design in which the dry season mucuna fallow as pre-rice treatment constituted the main plot (factor A) i.e. non-mucuna and mucuna plots. This was factorial combined with four levels of N fertilizer (factor B) and three varieties of rice (factor C) as subplot factors. This was replicated three times. The mucuna fallow treatment was planted toward the end of 1997 season (18th September) at two locations. Half of the experimental area 252m^2 was planted to *mucuna utilis* at 0.5m X .05m spacing. The mucuna plant remained on the field till the beginning of 1998 cropping season (15th April). The mucuna plants (dry plant or residue) were uprooted, weighed about 6.67t/ha and incorporated *insitu* into the plot size. The residues 6.67t/ha were chopped and incorporated into each plot size of 1m X 3m using hoes to open 10cm topsoil of each plot.

The second half of the experimental size (i.e. no mucuna residue) was also prepared by using hoes to till the soil to the same depth as the mucuna residue incorporated plot (10cm). Three weeks after incorporation of mucuna residues, three varieties of rice namely, *OFADA* (local check) ITA150 (FARO 46), and ITA257 (FARO 45) were planted into plot size of 1m X 3m. The rice was planted by dibbling method, chipping 4-6 seeds/hole and 20cm apart with 150 rice plants/plot, corresponding to 250,000 rice plant/ha. The N-fertilizer levels were 0, 30, 60 and 90kgN/ha in the form of NPK 15:15:15 and urea. The compound (NPK 15:15:15) and nitrogen (urea) fertilizer was applied in two split doses at planting and 60days after planting, respectively. The factorial combination of the treatments are listed below:

Treatment Combinations

$M_1V_1N_1$ = NO MUCUNA RESIDUES + *OFADA* + 0kgN/ha

$M_1V_1N_2$ = NO MUCUNA RESIDUES + *OFADA* + 30kgN/ha

$M_1V_1N_3$ = NO MUCUNA RESIDUES + *OFADA* + 60kgN/ha

$M_1V_1N_4$ = NO MUCUNA RESIDUES + *OFADA* + 90kgN/ha

$M_1V_2N_1$ = NO MUCUNA RESIDUES + ITA150 + 0kgN/ha

$M_1V_2N_2$ = NO MUCUNA RESIDUES + ITA150 + 30kgN/ha

$M_1V_2N_3$ = NO MUCUNA RESIDUES + ITA150 + 60kgN/ha

$M_1V_2N_4$ = NO MUCUNA RESIDUES + ITA150 + 90kgN/ha

$M_1V_3N_1$ = NO MUCUNA RESIDUES + ITA257 + 0kgN/ha

$M_1V_3N_2$ = NO MUCUNA RESIDUES + ITA257 + 30kgN/ha

$M_1V_3N_3$ = NO MUCUNA RESIDUES + ITA257 + 60kgN/ha

$M_1V_3N_4$ = NO MUCUNA RESIDUES + ITA257 + 90kgN/ha

$M_2V_1N_1$ = MUCUNA RESIDUES + *OFADA* + 0kgN/ha

$M_2V_1N_2$ = MUCUNA RESIDUES + *OFADA* + 30kgN/ha

$M_2V_1N_3$ = MUCUNA RESIDUES + *OFADA* + 60kgN/ha

$M_2V_1N_4$ = MUCUNA RESIDUES + *OFADA* + 90kgN/ha

$M_2V_2N_1$ = MUCUNA RESIDUES + ITA150 + 0kgN/ha

$M_2V_2N_2$ =MUCUNA RESIDUES + ITA150 + 30kgN/ha

$M_2V_2N_3$ =MUCUNA RESIDUES + ITA150 + 60kgN/ha

$M_2V_2N_4$ = MUCUNA RESIDUES + ITA150 + 90kgN/ha

$M_2V_3N_1$ = MUCUNA RESIDUES + ITA257 + 0kgN/ha

$M_2V_3N_2$ = MUCUNA RESIDUES + ITA257 + 30kgN/ha

$M_2V_3N_3$ = MUCUNA RESIDUES + ITA257 + 60kgN/ha

$M_2V_3N_4$ = MUCUNA RESIDUES + ITA257 + 90kgN/ha

Data Collection

Soil samples were taken at a depth of 0-15cm using soil auger before mucuna residues incorporation and three weeks after incorporation. These samples were used to determine the Organic Matter (OM) (Walk-Black method), Nitrogen (N) (Macro-Kjedahl method), Acidity (pH) (2:1wt/vol. Water), CEC (Effective CEC "sum of exchangeable bases") and available Phosphorus (P) (Bray-1). The following parameters were observed on rice:

Number of tillers/plant, days to 50% heading, days to 95% maturity, plant height, number of panicles/m^2, grains/panicles and grain yield/ha.

All the data collected were subjected to analysis of variance and the means of variables that recorded significant effects were further separated using least significant difference (LSD). Regression analysis was done on the relationship between rice grain yield and Nitrogen rates.

The fertilizer equivalent, which is defined as the quantity of an inorganic fertilizer needed to produce a yield equivalent to, that produced with a given amount of organic fertilizer was determined by using regression analysis trend (Sarrantonio, 1991).

RESULTS AND DISCUSSION

Incorporation of mucuna residue modified soil chemical properties at the two locations (Table 1). The increased soil pH at UNAAB and OP confirmed the finding of several workers (Hargrove and Thomas, 1981; Bell and Edward, 1987) that added organic matter reduces exchangeable Al and convert Al in the soil solution from toxic to non-toxic form. The present of base cations such as K, Ca and Mg in soil solution resulting from the addition of organic matter tend to precipitate Al as $Al(OH)_3$ and this reaction causes the pH to increase (Russell, 1973). Okeleye and Adetunji (1998) also reported that incorporation of pigeon pea and leucaena pruning increases the soil pH. Similarly, the CEC of mucuna residue treated plot at the two locations also increased. CEC enhances the soil's ability to retain and supply plant nutrients (Syer and Rimmer, 1994), hence confirming the potentials of using mucuna residue to boost the soil exchange capacity since tropical soils are dominated by kaolinitic clay (Adetunji, 1997).

The Organic Matter (OM) content of UNAAB soil was relatively high before mucuna was incorporated as compared to OP soil. Thus, additional mucuna residue had a more pronounced effect on OP soil than UNAAB soil. Increase in the Nitrogen and K from the incorporation of mucuna residue also agreed with the finding of several workers (Pradhan and Mondal, 1997; Sukar, 1996 and Rathore *et al.*, 1993). Table 2 shows the effects of mucuna residues and N-levels on the agronomic traits of the three varieties of rice. Fertilizer levels of 60 and 90kgN/ha significantly delayed maturity by two days as compared to 0 and 30kgN/ha in UNAAB. Whereas, in OP only 90kgN/ha significantly delayed maturity. Number of days to 50% heading and 95% maturity were significantly delayed in *OFADA* than the two improved varieties. N-fertilizer significantly increased yield component like number of panicles/m^2, and number of grains/panicle. *OFADA* and ITA150 varieties were significantly taller than ITA 257. Table 3 shows the effect of mucuna residue and N-fertilizer on the grain yield and yield components of the three rice varieties. Mucuna incorporation significantly increased the number of grains/panicle and grain yield at OP as compared to UNAAB location. The difference in response at the two locations could be attributed to the fact that OM in OP was below the critical level (<2%) whereas the OM in UNAAB was above critical in the control plot. The fertilizer equivalent of the mucuna residue used in OP was estimated as 30kgN/ha according to Sarrantonio (1991).

Table 1.Soil Chemical Properties as influenced by Mucuna Residue.

Locations	pH	CEC(mole(+)	N(%)	P(ppm)	K	OM
UNAAB1	6.15	1.17	0.04	10.4	0.01	02
UNAAB2	6.40	2.43	0.11	9.90	0.019	3.90
OP1	6.18	0.99	0.04	4.10	0.006	1.19
OP2	6.42	1.15	0.05	4.00	0.009	3.34

1 = Before incorporation, 2 = 3 week after incorporation.

Table 2. Agronomic Traits of Upland Rice as influenced by Mucuna Residue Incorporation

Treatment	Tiller Number		Days to 50% Heading		Days to 95% Maturity		Plant height (cm)	
Mucuna	UNAAB	OP	UNAAB	OP	UNAAB	OP	UNAAB	OP
0(t/ha)	1.56	1.56	84	82	103	104	100.7	97.0
6.67(t/ha)	1.61	1.78	84	82	104	104	99.6	101.2
Mean	1.59	1.6784	82	104	104	100.3	99.1	
LSD	NS	NS	NS	NS	NS	NS	NS	NS
N-Levels								
0	1.11	1.06	83	82	102	103	96.5	93.3
30	1.67	1.83	84	82	103	103	100.4	97.4
60	1.67	1.94	84	82	105	104	100.1	101.3
90	1.89	1.83	84	82	105	105	103.5	104.4
Mean	1.59	1.67	84	82	104	104	100.1	99.1
LSD	NS	NS	NS	NS	2	2	NS	NS
Rice								
OFADA	1.88	1.54	105	103	125	125	106.0	104.9
ITA150	1.39	1.75	74	71	94	94	109.6	110.7
ITA257	1.50	1.71	73	71	93	93	84.5	81.8
Mean	1.59	1.67	84	82	104	104	100.1	99.1
LSD	NS	NS	4	2	4	4	11.9	14.0
MXV	NS	NS	NS	NS	NS	NS	NS	NS
NXV	NS	NS	NS	NS	S	S	NS	NS
MXNXV	NS	NS	S	NS	NS	NS	NS	NS

S = Significant (0.5%), NS = Non-significant.

Number of panicles/m^2 from the plot treated with 60 and 90kgN/ha were both significantly higher than those that received 0and 30kgN/ha at OP. The differences in panicles /m^2 grains /panicle and grain yield response to fertilizer in the two locations could be attributed to the difference in the N contributed by mucuna residue (Table 1). The soil's N-level as a result of incorporation of mucuna at UNAAB was a bit lower than the critical value of <0.15% (Enwezor et al., 1989). This implies that little quantity of inorganic fertilizer would be needed to raise the soil N-level above the critical value where the response is unlikely and fertilization may not be necessary. Whereas the soil N status as a result of incorporation of mucuna residue to OP soil was far below the critical value. Hence response of rice to N fertilizer application was pronounced and significant at OP. Regression analysis shows that relationship between grain yield and applied N was linear and curvilinear at OP and UNAAB, respectively. The co-efficient of determination (r^2) of 0.96 and 0.75 accounted for 96% and 75% variability of grain yield at OP and UNAAB, respectively.

The model parameter (y = a + bx) from the two equations (Fig.2) showed that interception (a) at UNAAB was 1.3 times greater than that of OP,

thus indicating that fertility status of UNAAB soil was higher than that of OP. The slope (b) for OP was 1.94 times greater than that of UNAAB. This suggests that a unit increase in N will lead to a higher output at OP than at UNAAB.

The interactions of mucuna residue X N-fertilizer (M X N) for panicles/m^2 and grain yield (kg/ha) in OP were significant (Tables 4 and 5). This implies that the response of rice to nitrogen fertilizer in OP depends on mucuna residue. The significant interactions of mucuna X variety (M X V) and variety X N-fertilizer (N X V) on number of grains/panicle and grain yield in OP suggests that the varieties tested responded differently as expected to the nitrogen fertilizer (Fig.3 and 4). maturing) was due to the august break (moisture stress) that occurred when OFADA was at flowering and grain filling stage, whereas the two improved varieties were already matured before the august break (Fig.1)The significant interaction of mucuna X N-fertilizer X variety (M X N X V) on number of grains/panicle and grain yield in OP suggests that 6.67t/ha + 30kgN/ha and 6.67t/ha +60kgN/ha were the best combination of mucuna and N-fertilizer for ITA 150 and ITA257, respectively Table 6).

Table 3. Grain Yield and Yield Components as influenced by Mucuna Residue Incorporation.

Treatment	No of Panicles/ m^2		No of Grains/ Panicle		Grain Yield(kg/ha)		MeanYield (kg/ha)
Mucuna (t/ha)	UNAAB	OP	UNAAB	OP	UNAAB	OP	
0	97	76	108	98	1251.97	918.11	1085.04
6.67	115	101	106	113	1236.20	1372.62	1304.41
Mean	106	89	107	106	1244.09	1145.37	1194.73
LSD	NS	NS	NS	10	NS	101.93	
N-Levels							
0	92	73	104	95	1132.09	867.92	1003.51
30	104	82	106	102	1276.41	1076.31	1176.36
60	114	99	109	109	1238.55	1243.45	1243.00
90	114	101	112	117	1327.29	1393.77	1358.03
Mean	11	1 89	108	106.	1244.09	1145.36	1194.73
LSD	21	13	NS	5	NS	175.60	
M X N	NS	S	NS	NS	NS	S	
Variety							
OFADA	106	86	72	65	236.07	206.09	221.08
ITA150	111	91	114	124	1765.02	1632.02	1698.52
ITA257	102	89	137	128	1731.16	1597.08	1664.12
MEAN	106	89	108	106	1244.08	1145.36	1194.72
LSD	NS	NS	41	5	903.01	154.12	
M X V	NS	NS	NS	S	NS	S	
N X V	NS	NS	NS	S	NS	S	
MXNXV	NS	NS	NS	S	NS	S	
CV (%)	11.96	9.49	11.86	2.87	31.81	9.25	

S= Significant (5%), NS = Non-significant.

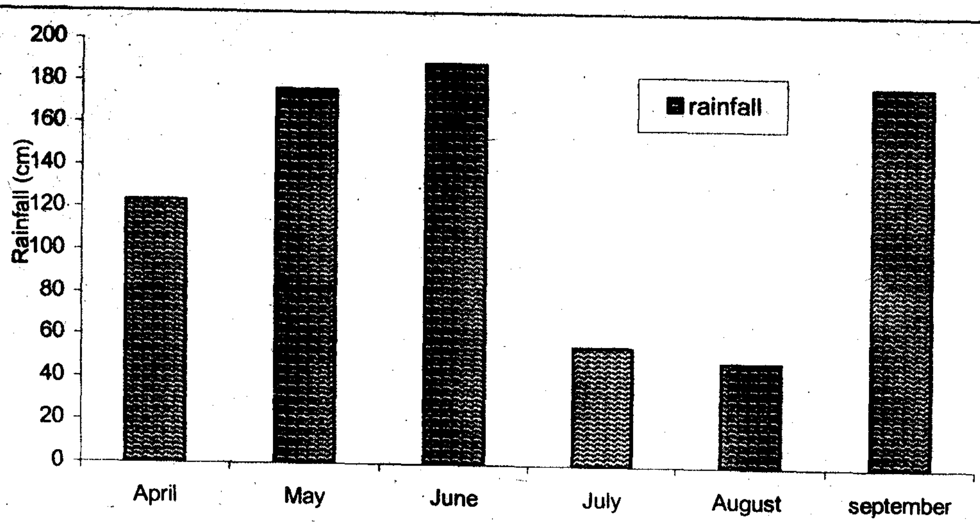

Fig.1 Rainfall during the growth period of the rice

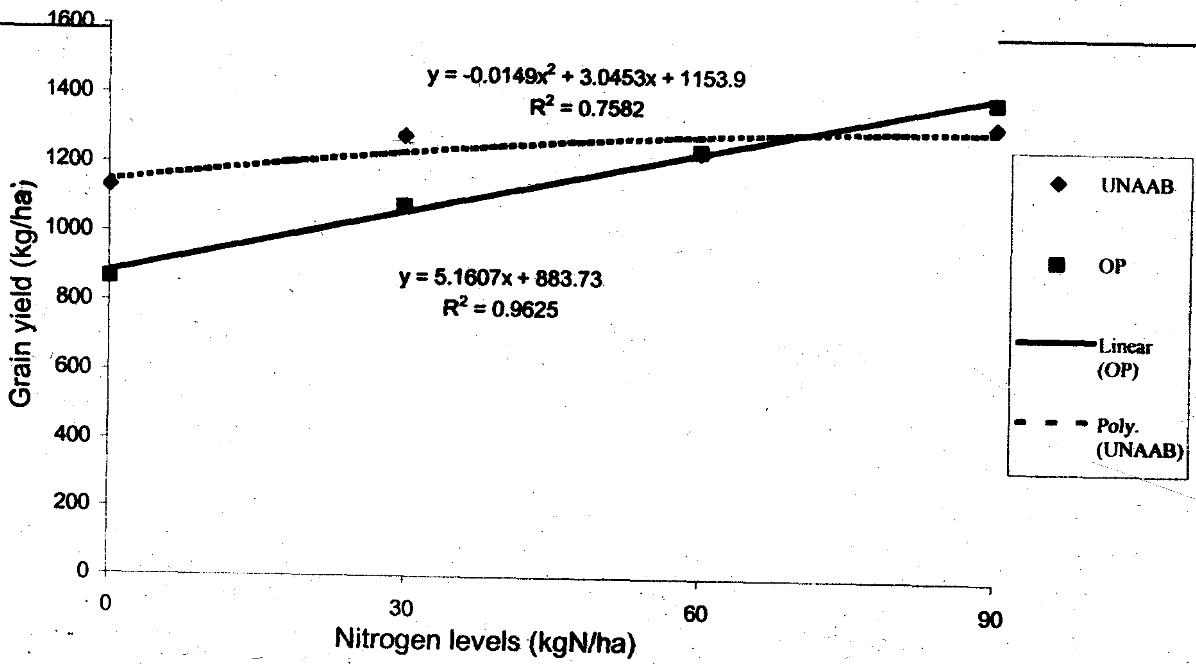

Fig 2. Regression between applied Nitrogen and Grain yield at UNAAB and OP

Table 4. The Interaction of Mucuna X N-fertilizer on Panicles/m^2

Mucuna residue	0kgN/ha	30kgN/ha	60kgN/ha	90kgN/ha
0t/ha	65b	72b	81b	85b
6.67t/ha	82a	91a	118a	117a

Values followed by a common letter in column are not significantly different at P=0.05 by DMRT

Table 5. The Interaction of Mucuna X N-fertilizer on Grain yield kg/ha

Mucuna residue	0kgN/ha	30kgN/ha	60kgN/ha	90kgN/ha
0t/ha	672.47b	863.03b	999.82b	1137.15b
6.67t/ha	1063.38a	1289.56a	1487.08a	1650.47a

Values followed by a common letter in column are not significantly different at P=0.05 by DMRT

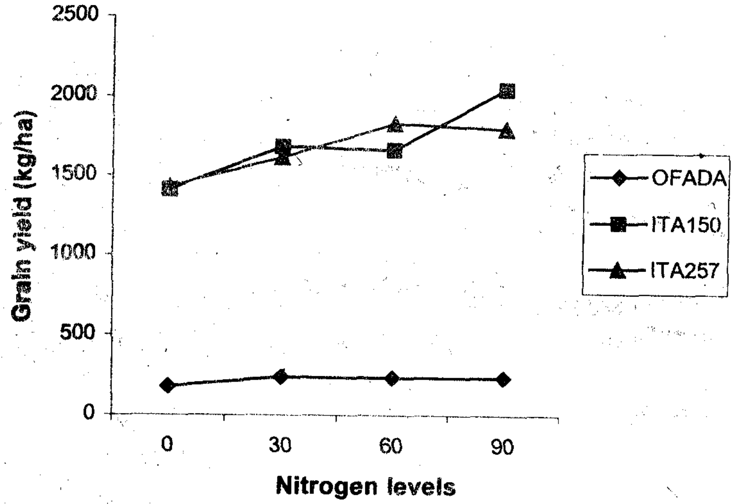

Fig.3 Grain yield response of three rice varieties to N-fertilizer in OP

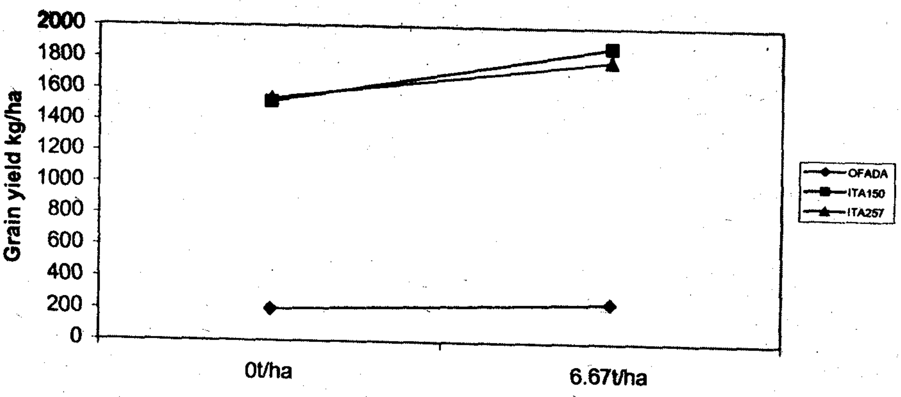

Fig.4 Grain yield response of three rice varieties to mucuna residue at OP.

Table 6. The Interaction of Mucuna X N-fertilizer X Rice on Grain yield kg/ha

Combination of Mucuna and N-fertilizer levels	OFADA	ITA150	ITA257
0t/ha + 0kgN/ha	108.49	883.47e	1025.53c
0t/ha + 30kgN/ha	202.98	1205.01de	1151.08bc
0t/ha + 60kgN/ha	220.16	1440.94cd	1332.36bc
0t/ha + 90kg/Nha	226.18	1725.40bc	1459.56bc
6.67t/ha + 0kgN/ha	209.42	1416.67cd	1564.06b
6.67t/ha + 30kgN/ha	220.18	1970.64ab	1677.89b
6.67t/ha + 60kgN/ha	231.82	2087.61ab	2141.80a
6.67t/ha + 90kgN/ha	236.77	2320.34a	2394.29a

Values followed by a common letter in column are not significantly different at P=0.05 by DMRT

CONCLUSION

This study has shown that incorporating mucuna residue into the soil improved the chemical properties of the soil. The fertilizer equivalent of the mucuna residue used in this study at OP was estimated as 30kgN/ha. Therefore, mucuna residue is a cheap means of rejuvenating the soil.

Rice responded to mucuna residue and N-fertilizer differently at different locations. Therefore, the recommendation of organic and inorganic fertilizer for any location will depend on soil fertility status.

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