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AGRONOMIC EVALUATION OF THE SOILS OF A TOPOSEQUENCE FOR RICE (*Oryza sativa* L) PRODUCTION IN ODEDA LGA, OGUN STATE

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ABSTRACT

A suitability evaluation of some soil used for rice production in Odeda LGA of Ogun State was carried out. The result indicated that the identified soil types were currently marginally or unsuitable (N1) for rice production because the index of current productivity I_{Pc} that ranged between 1.13 and 5.32. However, the result further indicated that, with improved agronomic and soil management technique, the suitability of these soil can be improved to S1 or S2 (highly suitable/moderately suitable). This experiment was carried out to determine the level of agronomic and soil improvement that will result in acceptable yield of rice on these soils. A 2x2x2 factorial trial was used to evaluate the performance of rice under different management and fertilizer regimes within each mapping unit for two seasons. The factors considered were two rice varieties (Ofada and NERICA1); two types of fertilizers (N: P: K 20:10:10 at 400kg/ha and cured poultry manure at 10t/ha) and two different management methods (traditional and improved agronomic methods). The performance of the rice varieties did not differ across the land suitability units but was significantly affected by management practices ($P=0.05$). Fertilizer application of both mineral and organic fertilizers ($P<0.001$) significantly improved the growth and yield of rice with

organic fertilizer having higher effects. In conclusion, the productive capacity of soils for rice production can be improved through the use of both organic and inorganic fertilizers.

INTRODUCTION

Rice (*Oryza sativa*) plays a very important role in the world food economy. It is the main staple food in many Asian countries, and rice has become a staple food in many of the African and Latin American countries. About 100 million people depend on rice for their livelihoods in sub-Sahara Africa (SSA) (Nwanze et al 2006).

Rice can be cultivated virtually in all the agro-ecological zones of Nigeria. Significant improvement in rice production in Nigeria occurred in 1980 when output increased to one million tons whilst area cultivated, and yield rose to 550 thousand hectares and 1.98 tons per hectare respectively. Throughout the 1980s rice hectrage and yield increased, but in the 1990s whilst rice output increased, the yield of rice per hectare declined, suggesting extensive rice cultivation (Akande, 2008). According to Akande (2008), out of 25 million hectares of land cultivated to various food crops in Nigeria in the year 2000, rice accounted for only about 6.7% of the area and the average National yield of rice during this

period was 1.47 tons per hectare.

Domestic production of 2.2 million metric tons has never been able to meet the demand of 3.2 million metric tons leading to considerable importation which today stands at about 1,000,000 metric tons yearly (Akande, 2008). Balance of payment position between 1991 and 1999 shows that Nigeria had spent \$4 billion on rice importation alone, an average annual import value of \$1021 million.

This shortfall is as a result of the use of low yielding traditional varieties, coupled with poor, low fertility soils for rice production amongst others (Okeleye *et al.*, 2003). This situation calls for an urgent step toward increasing domestic production of rice to avert the unfavourable socio economic scenario.

Although, Nigeria is endowed with a vast land area, all may not be suitable for rice production. Also, the world agricultural trend today is targeted at improving yield per hectare rather than increase area under cultivation. Ogun State is known for the production of OFADA rice and there is an increasing interest in the cultivating of this variety of rice outside the popular area of cultivation. Odeda LGA is one of the areas in the state where OFADA rice is cultivated, especially in the lowland areas of the LGA. However, the yields from the farmers have not been impressive; lower than one ton per hectare in most cases.

According to the study of Ajiboye *et al.*, (2011), the soils of Odeda area had index of current productivity (IPc) that ranged from 1.13 to 5.32 and adjudged to be currently unsuitable (N2) for the production of both upland and lowland rice. Furthermore, the study suggested that with improvement in the soil fertility and agronomic management, the soils of the area could be sustainably used for

profitable rice production. This study was therefore carried out to determine the level of management (fertility and tillage practices) that will be required for sustainable use of the land for rice production.

MATERIALS AND METHODS

The three mapping units which were delineated from the suitability evaluation of the area for rice production (Ajiboye *et al.*, 2011) were used for this study. The mapping units were classified as Typic Hapludalf (Lixisol; Cutanic, Hypereutric) Plinthic Kandudalf (Lixisol; Plinthic Hypereutric) and Aeric Endoaquept (Cambisol; Endogleyic, Hypereutric) in the upper, middle and lower slope, respectively.

The performance of rice in the mapping units were evaluated experimentally using a 2x2x2 factorial experiment. The factors were methods of land management, varieties of rice and type of fertilizers. There were two levels of each factors; namely, improved traditional management methods and traditional management method (land management); Ofada rice, NERICA rice (rice varieties), inorganic fertilizer and organic fertilizer (fertilizer types).

The treatment combinations were as follows:

1. OT= Ofada + Traditional method
2. NT= Nerica + Traditional method
3. OM= Ofada + Organic manure
4. NM= Nerica + Organic manure
5. OTMP= Ofada + Improved Traditional method
6. NTMP= Nerica + Improved Traditional method
7. Of= Ofada + N; P; K Fertilizer
8. Nf= Nerica + N; P; K Fertilizer

Traditional method involves land clearing and weeding by Hoe and Cutlass without application of fertilizer whilst Improved

Table 1: Mean Square from ANOVA tables of growth parameter of rice varieties grown on the different Mapping Units at Odeda

SV	DF	PHT4	NLF4	LA 4	PHT 8	NLF 8	LA 8	NP 8	PHT 12	NLF 12	LA 12	NF 12
REP	2	9.94	1.882	84.77	65.70	6.76	1.80	1.03	406.10	13.01	108.60	3.69
YEAR	1	1331.16***	354.69***	4274.44***	22718.0***	802.78***	33.10	53.78***	39377.80***	1418.73***	1709.90*	448.03***
PEDON	2	158.65***	80.55***	1695.25***	5019.1***	58.88***	136.20	10.23*	4154.90***	90.76***	1170.00*	82.59***
FERT	2	181.24***	74.93***	296.00*	3110.3***	187.40***	30018.0***	72.49***	6814.40***	203.46***	8152.90***	197.04***
CULT	1	230.93**	40.24**	254.10	90.9	9.39	51.10	0.222	164.80	18.00	596.50	6.72
RICE	1	63.57	32.11*	7.12	738.8*	13.44	199.90	20.25*	1384.60*	11.11	390.20	38.03***
PEDON. RICE	2	7.39	4.09	21.45	95.8	0.34	69.10	1.90	290.20	0.55	128.00	1.97
PEDON. CULT	2	274.46***	25.02**	237.26*	93.8	1.91	31.00	0.10	161.00	3.31	7.80	2.27
Residual	130	22.67	3.98	72.47	108.5	6.31	181.90	2.14	261.20	7.15	270.60	3.58

SV= source of variation; DF = Degree of freedom; PEDON = Mapping Unit; FERT = Fertilizer; CULT = Cultural practices; RICE = Rice variety

PHT = Average Plant Height; NLF = Number of Leaves per plant; LA = Leaf Area per plant; NP = Number of plants per plot

Table 2: Mean treatment effects on growth parameters and yield component of rice grown on different Mapping Units at Odeda

Fertilizer Type	PHT4 Cm	NLF4 cm ²	LA 4 cm ²	PHT 8 Cm	NLF 8 cm ²	LA 8 cm ²	NP 8	PHT 12 cm	NLF 12 cm ²	LA 12 cm ²	NP 12	SWT_100 (g)	PADDY YIELD (kg/ha)
No Fertilizer	14.67	3.67	8.57	25.09	5.36	19.90	2.69	30.40	5.94	27.10	3.94	2.62	2024.00
Organic fertilizer	18.62	6.32	13.63	40.15	9.31	35.70	5.14	54.20	10.03	53.10	7.94	2.62	2490.00
NPK	17.28	5.18	11.48	35.49	6.92	25.60	3.75	39.70	7.81	37.50	5.89	2.78	2125.00
SED	1.04	0.42	1.79	2.46	0.59	3.18	0.344	3.81	0.63	3.88	0.45	0.12	152.80
Pedon UPP	15.15	6.50	9.73	29.88	7.98	26.60	3.04	37.00	8.81	37.60	4.27	2.73	2419.00
Pedon MD	18.77	4.06	7.16	42.38	6.37	25.90	3.77	48.60	7.42	40.20	6.85	2.68	2490.00
Pedon LS	16.65	4.52	18.15	22.11	5.85	23.40	1.90	30.20	6.06	30.70	5.17	2.58	2125.00
SED	0.97	0.41	1.74	2.13	0.51	2.75	0.30	3.30	0.55	3.36	0.39	0.10	132.30
Trad	15.00	4.25	9.40	29.77	6.19	24.00	1.49	36.40	6.68	31.80	4.97	2.64	2115.00
Improved Trad	18.71	5.50	13.29	32.02	6.92	25.70	3.60	39.40	7.68	37.60	5.58	2.67	2422.00
SED	1.16	0.49	2.01	2.45	0.59	3.18	0.34	3.81	0.63	3.88	0.45	0.12	152.80
Ofoda	17.52	4.25	11.12	33.72	6.43	26.40	3.19	41.70	7.15	37.80	4.92	2.65	2259.00
NERICA	16.19	5.80	11.57	29.19	7.04	24.10	3.94	35.50	7.71	34.50	5.94	2.68	2430.00
SED	0.79	0.33	1.42	1.74	0.42	2.25	0.24	2.69	0.47	2.74	0.32	0.08	108.00
2007	13.82	3.46	16.79	18.90	4.37	25.70	4.18	22.10	4.29	32.70	7.19	2.80	2434.00
2008	19.90	6.60	5.90	44.20	9.10	24.80	2.96	55.20	10.57	39.60	3.67	2.53	2255.00
SED	0.79	0.33	1.42	1.74	0.42	2.25	0.24	2.69	0.47	2.74	0.32	0.08	108.00

UPP = Upper slope; MD = Middle slope; LS = Lower slope; SED = Standard error of differences of mean; SWT_100 = 100 grain weight

PHT = Average Plant Height; NLF = Number of Leaves per plant; LA = Leaf Area per plant; NP = Number of plants per plot

Table 3: Means square from ANOVA table for yield and yield component

Source of variation	d.f.	SWT_100	Paddy Yield
REP	2	0.5216	571097.00
YEAR	1	2.5662*	1153476.00
PEDON	2	0.2980	1800537.00*
FERT	2	0.3598	8475665.00***
CULT	1	0.0143	1697710.00*
RICE	1	0.0352	1049942.00
PEDON RICE	2	0.0208	379323.00
PEDON CULT	2	0.2922	805982.00
Residual	130	0.2443	420205.00

*,*** = significant at 5% and 1% probability level respectively

SWT_100 = 100 grain weight; PEDON = Mapping Unit; FERT = Fertilizer;

CULT = Cultural practices; RICE = Rice variety.

The performance of rice varieties in terms of plant height (PHT) at 4WAP, 8WAP, 12WAP were significantly affected ($P < 0.001$) by the application of both inorganic (NPK) fertilizer and manure (Table 1). Fertilizer application resulted in rice plants that were taller (Table 2) than those planted without fertilizer application. However, the application of organic manure had higher effects (Table 2) on the performance of crop than the application of NPK. The effects of applied fertilizer on number of leaves per plant (NLF) at 4WAP, 8WAP and 12 WAP and leaf area per plant (LA) at 4 WAP, 8 WAP, and 12 WAP were similar to the trend observed in PHT. Application of fertilizer resulted in significantly ($p < 0.001$) wider leaf area per plant and more leaves per plant (Tables 1 and 2). Considering the overall performance, the application of organic manure produced a higher or better result than either the application of inorganic fertilizer (NPK) or non-application of fertilizer. The higher effects of organic fertilizer on rice growth over that of NPK may have resulted from the presence of micronutrients in the organic fertilizer and this may have rectified the micro nutrients

deficiencies observed in the soils (Ajiboye *et al.*, 2011). Also, the slower rate of release of nutrients from the mineralization of the organic fertilizer may have synchronized nutrient requirement by the crop with nutrient release, thereby minimizing nutrient loss through leaching. The differences between the effects of organic fertilizers and inorganic fertilizers on crop performance have been reported to be caused by the carbon-hydrogen, linkage in organic fertilizers, which causes slow release of the nutrient elements from the organic fertilizer. According to this author, this slower rate of nutrient release result in more sustained availability of the nutrients, and lower leach potential compared to their inorganic counterparts. In addition, organic fertilizers may act as an organic source for micro organisms in the soil, which can improve soil structure and plant growth (Fagbola and Dare, 2003).

The two varieties of rice used for this experiment differed significantly ($P < 0.005$) in their performances across the three delineated mapping units. In terms of the average plant heights (PHT), leaf area per plant (LA) and

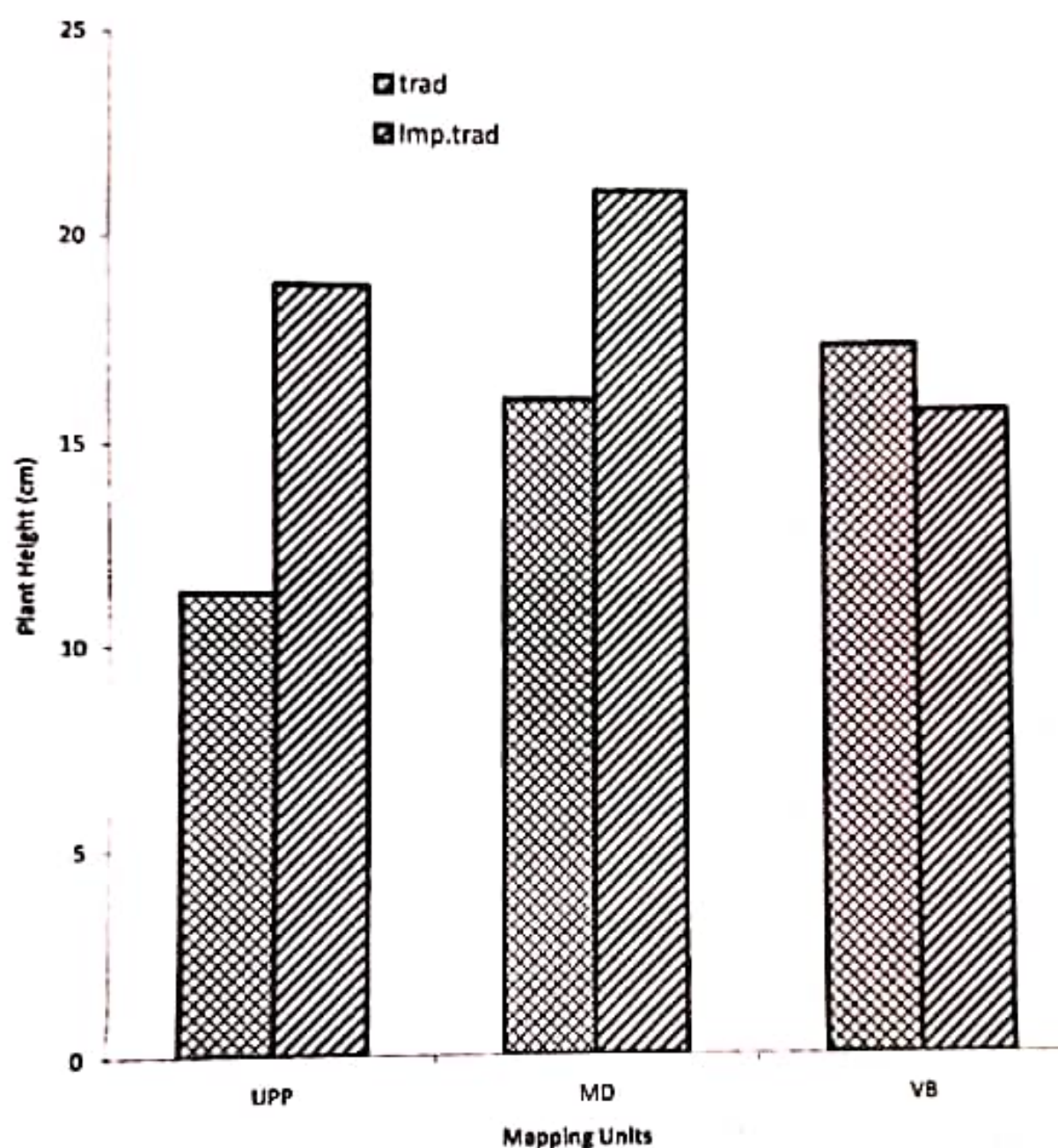
number of leaves per plant (NLF) across the three period of assessment (4WAP, 8WAP and 12WAP), the rice varieties differed significantly ($P < 0.001$) in their performances across the mapping units. The rice plants in the middle slope pedon (MD) were significantly ($P < 0.001$) taller than plants in pedons UPP and LS in all the assessment periods (Table 2). The upper slope pedon on the other hand, maintained a significantly ($P < 0.001$) higher average number of leaves per plant throughout the period of the experiment whilst the average leaf area per plant was highest at lower slope (LS) pedon at 4 WAP and smallest at 12WAP. There was no significant difference ($P < 0.005$) in the average leaf area per plant at 8WAP amongst the pedons.

Apart from the average number of leaves per plant (NLF4) at 4WAP ($P < 0.005$), average leaf area per plant (LA8) at ($P < 0.005$), average number of plant per plot (NP8) at 8WAP ($P < 0.005$), average plant height (PHT12) at 12WAP ($P < 0.005$) and average number of plant per plot (NP12) at 12WAP ($P < 0.005$), the performance of the rice varieties did not differ significantly from each other across the treatments in other growth and physiological traits. The second variety (NERICA) had significantly higher average number of plant per plot at 8WAP and 12WAP. On the other hand, the first variety of OFADA, had the taller plants at 8WAP and 12WAP (Table 3).

Cultural practices affected the average plant height and average number of leaves per plant only at 4 weeks after planting (4WAP). Thus the average plant height and average number of leaves per plant were significantly higher ($p < 0.001$) under improved traditional system

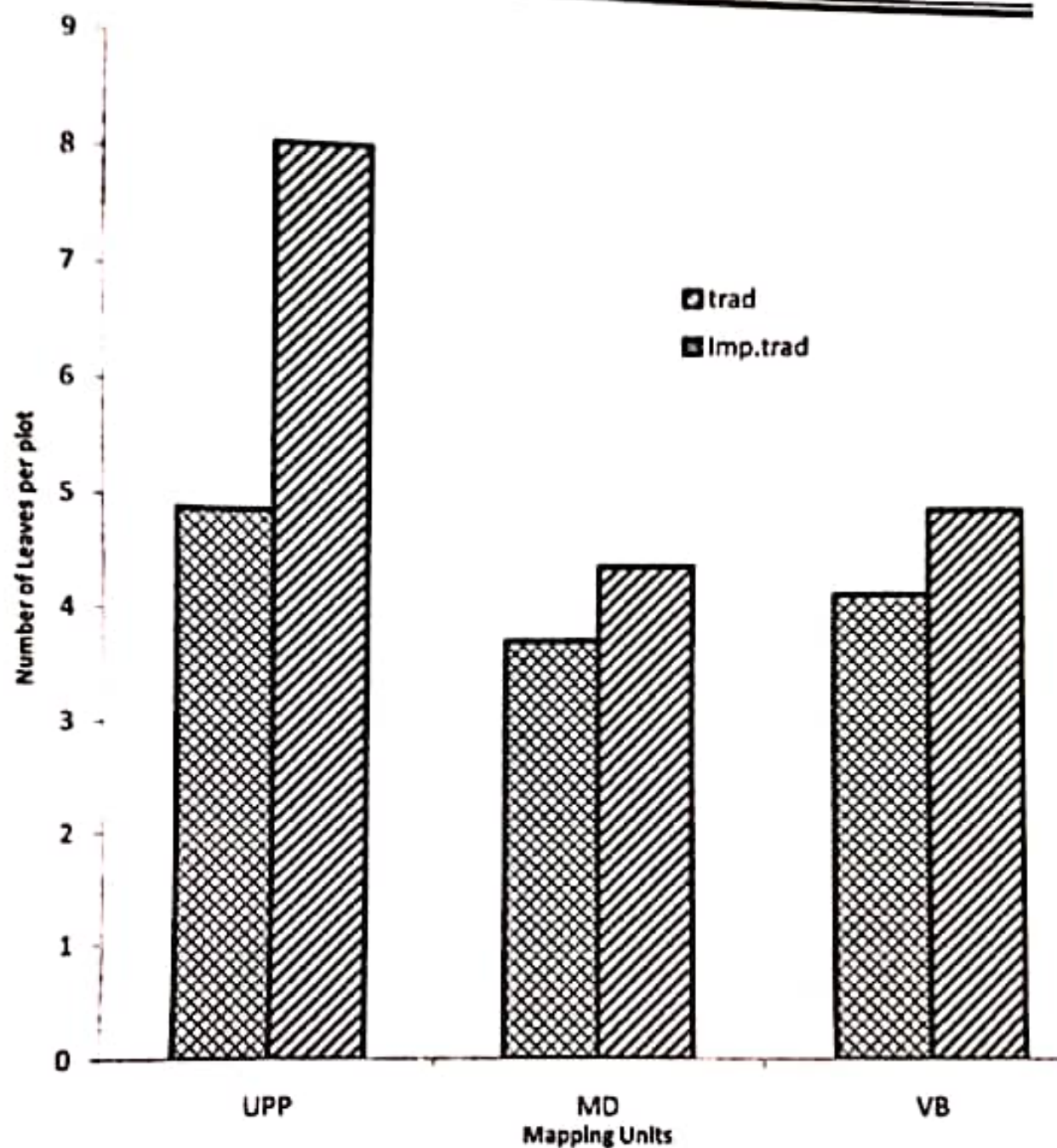
of management (Tables 1 and 3). At other periods of assessment, there was no significant difference in the performance of the rice varieties resulting from cultural practices. This indicates that the improved cultural practice is only more effective than the traditional system at 4WAP. This could probably be true if the efficacy of the herbicide applied under the improved traditional system has become reduced to such an extent that weed infestation on such plot is high enough to cause competition for nutrient uptake. This is because the application of fertilizer under the improved traditional system should have resulted in growth advantage over the traditional system. Also, the observed interactive effects between cultural practice and pedon on average plant height ($p < 0.001$), average number of leaves per plant ($p < 0.001$) and average number of plant per plot ($p < 0.005$) did not extend beyond the first assessment period at 4 WAP (Table 1). The improved traditional agronomic practices resulted in taller average rice plant in the upper slope (UPP) pedon and middle (MD) slope pedon but the traditional agronomic practice had the averagely taller plants at the lowest slope, lower slope (LS) pedon (Fig. 1.)

The basic difference between the two agronomic practices is the application of pre-plant-soil incorporated herbicide and the application of fertilizers in the improved traditional method whilst in the traditional method, weed control was by manual hoeing and there was no fertilizer application. Fertilizer application has been demonstrated by several experiments to improve the growth and performance of rice (AL Fakhru Islam *et al.*, 2013). Similarly, effective weed control is required for good growth and yield of rice (Olofinloye, 1987; Yousefnia *et al.*, 2012).



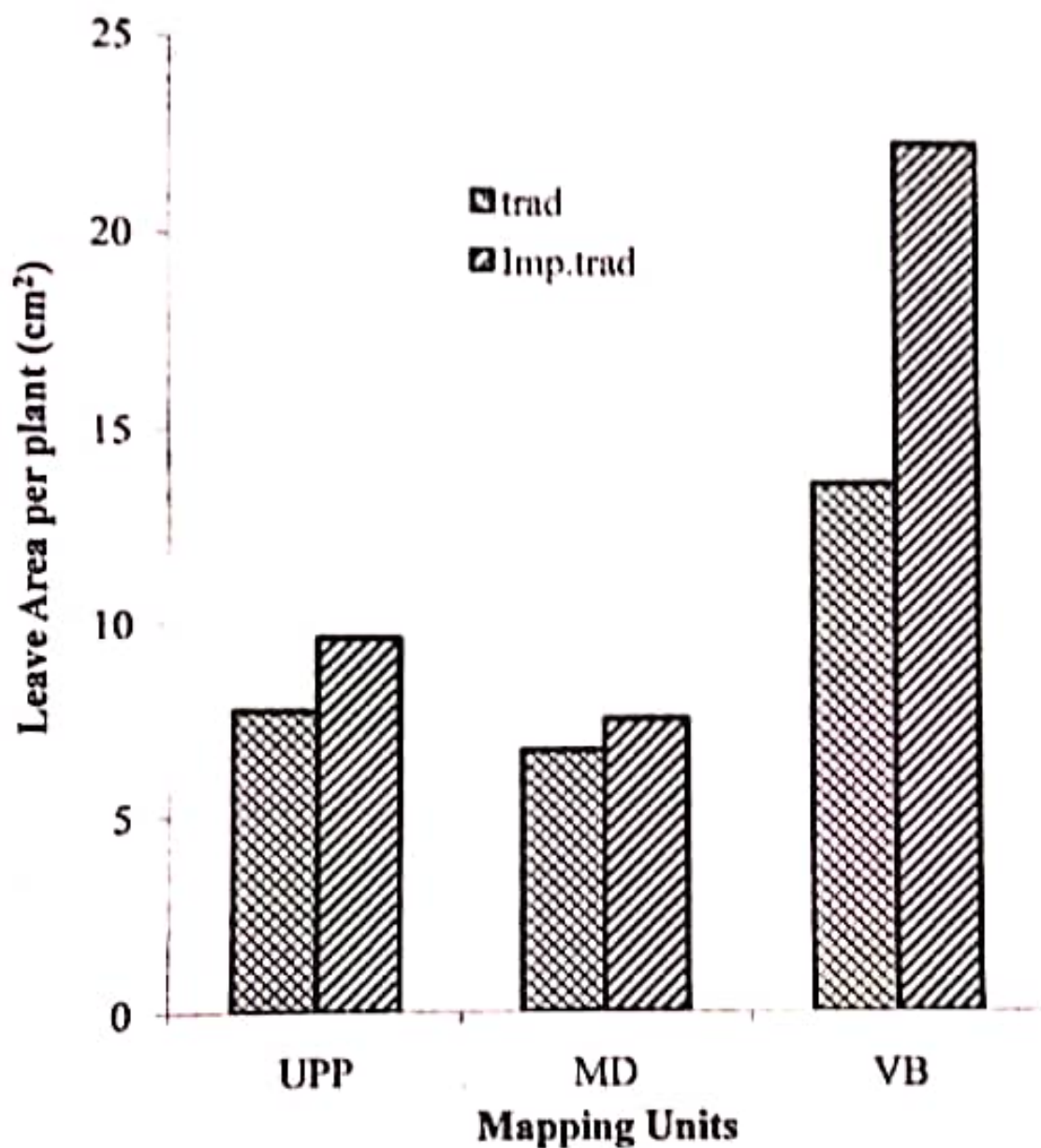
UPP = Upper Slope; MD = Middle Slope; VB = Lower Slope

Fig. 1. Interactive effects of location and cultural practices on rice plant Height at 4 weeks after sowing



UPP = Upper Slope; MD = Middle Slope; VB = Lower Slope

Fig. 2: Interactive effects of location and cultural practices on Number of leaves per plant at 4 weeks after sowing



UPP = Upper Slope; MD = Middle Slope; VB = Lower Slope

Fig. 3: Interactive effects of location and cultural practices on Leaf Area per plant at 4 weeks after sowing

Therefore, non-application of fertilizer under the traditional method should have led to lower performance of the rice. Whilst this statement was true in pedons UPP and MD, the reverse was observed in the LS pedon. It could have been that the applied herbicide was not effective in this pedon as a result of the high moisture contents of the soil or as a result of leaching of the herbicide, thereby making manual weed control more effective. The weed ecology of the LS was also observed to be dominated by sedges contrary to what was observed in the UP and MD pedons. As a result of the probable weed infestation in the plots under improved traditional practices, there could have been competition for the available nutrients between the crop and the weeds. This may have been the cause of the shorter plants observed in these plots.

CONCLUSION

The implications of the deficient nutrients status of most of the soils on which rice production is carried out in Odeda, Ogun State and Nigeria at large, cannot be ignored. There is an urgent need for fertility strategies beyond mineral fertilizer application. This can include diversification of the farming system, crop rotation and integrated fertility management techniques, rapid grain legume following legume (*Mucuna*), plant residue recycling and organic agriculture, amongst others as suggested by several researchers. It is our opinion, however, that a suitable combination of organic and inorganic fertilizer at appropriate rates after a careful study, will be of tremendous importance in solving the problems of low fertility in the major rice growing soils of Nigeria.

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