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Improving Up Land Rice Yield Under Integrated Nutrient Management Practices In Liberia

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Abstract: Research on soil amendment to improve crop productivity in Liberia is limited with less emphasis on rice. To improve on this, a field experiment was therefore carried out at the Central Agricultural Research Institute (CARI), Suakoko, Liberia to improve up land rice yieldunder manures and integrated fertilizers nutrient management practices.The experiment consisted of a factorial Randomized Complete Block Design (FRCBD) with three replications. Field size of 892.5 m^2 (15 m x 59.5 m)was used with each plot demarcated as 2 m x 3 m (6 m^2). There were 12 treatments such as Control, 100% N120, 0% NPK + 8.1 t cow dung ha-1, 25 NPK + 6.1 t cow dung ha-1, 50% NPK + 4.1 t cow dung ha-1, 75% NPK + 2 t cow dung ha-1, T7: 0% NPK + 5.5 ton poultry manure ha-1 25% NPKS + 3.4 ton ha-1 poultry manure NPK 50% + 2.75 tons ha-1 poultry manure and 75% NPK + 1.4 ton ha-1 poultry manure. An improved upland rice cultivar (NERICA 14) was used as the planting material. At harvest the tallest plant (109.45), maximum grain yield (5.59 tons/ha), and panicle weight (23.25) were found in plot supplied with,NPK 50% + 2.75 tons ha-1 PM. Number of effective tillers per hill (8) were developed in plots imposed with 100% N120 P18 K18. Although the highest biological yield was recorded from PM + MF1 treatment, but statistically similar result were found from 0% NPK + 8.1 t CD ha-1, 50% NPK + 4.1 t CD ha-1 and NPK 50% + 2.75 tons ha-1 PMtreatments. It was obvious that yield of rice can be increased significantly with the judicious use of organic manure with chemical fertilizer.

Key words: Poultry manure, Cow dung Mineral fertilizer, yield and NERICA 14.

1. INTRODUCTION

In sub-Saharan Africa, decline in the ability to adequately produce food is a serious challenge to food security. Rapid increases in human population and poor fertility of lands available for agricultural purposes among other political and socio-economic factors have intensified the situation (Partey et al., 2013). Crop yield had declined as a result of low soil fertility in smallholder farming systems in sub-Saharan Africa (Sanchez, 2010) of which Liberia is of no exception. Leaching of essential nutrients as the result of high rainfall, nutrient mining without replenishment, and mineral toxicities, iron toxicity have been identified as major causes of declining soil fertility in the region. Rice is the world's most important crop serving as staple for more than half of the world's human population (FAO, 2009) and is becoming an increasingly important food crop in Africa which Liberia is of no exception Despite the significant importance of this crop, domestic production is far lower than consumption in Liberia. Eighty five percent of calories consumed in Liberia come from rice, but after decades of turmoil and civil war the country relies mostly on imported rice to feed itself and—at a steep cost (Shor 2012). According to USAID (2009) the agricultural sector of Liberia receives an aid from several organizations to increase rice production (yield), increase farmers' income and reduce poverty. Farmers receive training as well as high yielding rice varieties and tools for production. But the country is not still self-sufficient in rice production to feed her citizens. Countries of sub-Saharan Africa therefore import rice to fill in the gap. Liberia, for example imports bill in the year 2015 was 350,000 ton up 24% from 2014 (FAO; 2015). Domestic rice production is speciously an auspicious possibility that would reduce foreign exchange spent on rice purchase by governments in sub-Saharan African. However, rice production can be constrained by several factors; amongst which nutrient balance ranks as one of the greatest in sub-Saharan Africa (Johnson et al., 1997). In Liberia, rice farmers have largely contained nutrient balance through the traditional practice of shifting cultivation, wherein lands previously cultivated were allowed to lay fallow for some extended period to allow recovery of fertility through natural processes. Unfortunately, the sustainability of such farming system is becoming increasingly low due to increased competition for rice expansion and alternative uses of the limited land resources of the country. In gearing towards sustaining soil fertility in Liberia, deliberate application of organic matter (compost, cover crops, mulches, manure, biochar etc.) and biological nutrients cycling could be a possible alternative (Goyal et al., 1999; Trujillo, 2002). The return of plant biomass such as litter under conditions of the long traditional fallow periods restore the fertility of soil by the recycling of nutrients. Similar processes can be enhanced in sedentary farming systems, due to rapid decomposition of organic matter in the tropics (Jenkinson and Ayanaba, 1977), the sole dependence on organic residues in building or maintaining soil fertility is quite challenging. On the other hand, the continuous use of chemical fertilizers for increasing crop yield in the West African agro-ecosystems without recycling of organic material is not sustainable (Bationo et al., 2004), as crop yield eventually drops following the attainment of higher yields. Thus, there is a need for an adaptability of an integrated soil fertility management to augment sustainable soil fertility and increase crop productivity in Sub-Sahara Africa. The current project therefore seeks to develop new and scalable organic-inorganic fertilizer products that could increase rice yield and production at minimal costs and at the same time maintain both the physical and chemical health of rice soils in sedentary farming systems in Liberia. The specific objectives of the project are to develop and evaluate the impact of new organic-inorganic fertilizer products on nutrient use efficiency, the growth and productivity of rice, and soil health.

2. Materials and Methods

Description of the study area

The research was conducted on an upland field at Central Agricultural Research Institute, Suakoko Bong County, Liberia. The site is characterized by a rainy and dry season. The rainy season extends from mid-May to end of November. The dry season begins in December and ends in May. NERICA 14 (85-90 day duration) an upland rice variety was obtained from Central Agricultural Research Institute (CARI), Suakoko, Bong County and used in this study. The experiment was laid out in a factorial Randomized Complete Block Design (FRCBD) with three replications. Field size of 892.5 m^2 (15 m x 59.5 m)was used with each plot demarcated as 2 m x 3 m (6 m^2). There were 12 treatments such as Control : Control,: 100% N120 P18 K18 (Recommended dose) (Fertilizer Recommendation Guide, 2005), 0% NPK + 8.1 t cow dung ha-1, 25 NPK + 6.1 t cow dung ha-1, 50% NPK + 4.1 t cowdung ha-1, 75% NPK + 2 t cow dung ha-1, 0% NPK + 5.5 ton poultry manure ha-1 25% NPKS + 3.4 ton ha-1 poultry manure NPK 50% + 2.75 tons ha-1 poultry manure and 75% NPK + 1.4 ton ha-1 poultry manure. Urea was applied in 3 equal splits: one third was applied at basal before planting, one third at active tillering stage (30 DAP) and the remaining one third was applied before panicle initiation stage (55 DAP).The rates of manure for cow dung and poultry manure per plot were calculated as per the treatments, respectively. Cow dung and poultry manures initial physico-chemical properties and nutrient composition were determined before treatment imposition to experimental plots. The nutrient contents of the manures are depicted in Table 1. Well decomposed cow dung and poultry were applied to the plots as per the treatments by mixing with the soil well before two weeks of final land preparation.All other mineral fertilizers were also applied two days before sowing while the organic materials were incorporated two weeks before sowing. Weeding was manually done at every frequent interval so that weed invasion would not hinder plant growth.

3. Data Collection

In order to assess the impacts of amendments on the growth and yield of rice plant, the following parameters was measured: final plant height, oven-dried weight of 100 grains, sun-dried weight of grains, number of tillers per plant in each plot and number of developed panicles.

Table 1.0** Chemical properties of cowdung and **poultry manure

Name of organic manure	C	N	P	K	S	CN ratio
Poultry manure	29	2.19	1.98	0.81	0.34	8
Cowdung	36	1.48	0.29	0.75	0.21	24

4. Results and discussions

Effect of mineral fertilizer, poultry manure and cow dung on rice growth and yield

The effect of mineral fertilizer, poultry manure and cow dung on rice dry grain weight (DGW), panicle weight (P Wt.) plant height (PH) and tiller are presented in Table 2.2. It was evident that all treatment levels significantly influenced the performance of the growth and yield characteristics. Upland rice increased as a result of the incorporation of poultry manure, cow dung and mineral fertilizerThehighest grain yield (5.59 ton) was obtained from plant amended with 50%NPK integrated with poultry manure at 2.7 ton per hectare and the lowest yield (2.42 ton) was seen in the control plots and 100% applied plots 2.83 tons, respectively. This significant increase might be due to the presence of uric acids in poultry manure that hastens the release of nutrients from poultry manure than cow dung (Yakubet. al. (2010) found 6% increase of grain yield by applying urea-N and manures. Haqueet al. (2001), Asitet al. (2007) and Bodruzzamanet al. (2010) also found increased grain yield with the application of manures and fertilizers in an integrated way. The second highest grain yield (5.10 ton) was produced by 8.1 ton cow dung per hectare applied plots. The measure in panicle weight shows significance difference among treatments. However, panicle weight increased from 12.5 to 23.25using the integrated approach. Thus the 50% NPK combined with 2.75 tons per hectare poultry manure and 75% NPK integrated with 2 ton cow dung per hectare significantly produced the highest panicle weight. Result from this section indicates that the addition of 25 % NPK to the 50 % integrated with 2 ton cow dung per hectare compensated for the remaining nutrients to create a balance in rice nutrient. This result also reveals that the efficiency of NPK at 75 % when any organic product is applied will increase yield performance. Nevertheless, the increase in panicle weight in this study, the latter value (12.5) was seen in the control plots. This observation indicates that integration in plant nutrient management is very significant in soil fertility and cropping systems. This result is in line with Yanquoi etal. (2018) who reported that poultry manure plots produced higher results in terms of grain yield, fresh grain plus straw weight, above ground biomass and panicle weight, but it was latter to grain weight. Interestingly there was a consistent result in this study. Throughout the study, significant performance in upland rice was observed in plots that were amended with both organic and inorganic fertilizer. Even their interaction yielded a significant result in an orderly trend. Such observation point out the need for soil conditioning inputs at the experimental site. It can also be evident from the sole application of mineral fertilizer that increased rice dry grain weight, panicle weight, plant height and tiller over the control plots. On the other hand, tiller count in this study followed an awkward trend than expected, where there was reduction in yield because of vigorous tiller growth. Comparatively, the highest yield (5.587 ton) was produced under 50% NPK integrated with 2.75 tons ha-whiles the highest tiller was produced under 100 % sole application of NPK. This incident could be as a result of leaching of cation from the colloidal surface and leaving the nitrogen in abundance to cause high vegetative growth and production of undeveloped tillers.

***Table 2.2** Effect of mineral fertilizer, poultry manure and cow dung on performance*

TMTS	DGW(tons/ha)	P Wt (g)	PH (cm)	TILLER
Control	2.42 d	12.50 b	80.78 d	5 c
100% N120 P18 K18	2.83 cd	19.65 ab	93.05 bc	8 a
0% NPK + 8.1 t CD ha-1	5.10 ab	19.25 ab	93.77 bc	8 a
25 NPK + 6.1 t CD ha-1	3.95 abcd	21.00 ab	95.47 bc	7 abc
50% NPK + 4.1 t CD ha-1	4.90 ab	20.00 ab	101.47 ab	7 abc
T6: 75% NPK + 2 t CD ha-1	3.45 bcd	23.25 a	94.72 bc	6 abc
0% NPK + 5.5 ton PM ha-1	4.14 abcd	18.25 ab	84.62 cd	5 bc
25% NPKS + 3.4 ton ha-1 PM	4.83 ab	20.25 ab	95.75 bc	6.83 abc
NPK 50% + 2.75 tons ha-1 PM	5.59 a	23.25 a	109.45 a	7.83 ab
75% NPK + 1.4 ton ha-1PM	4.37 abc	19 ab	92.05 bcd	7.40 abc
CV%	5.9	4.9	3.5	3.5

Dry grain weight (DGW), panicle weight (P Wt), Plant height (PH)

Conclusion

The Integrated use of mineralfertilizer and manures improve the soil health and fertility status that in turns improvecrop yields. The overall results indicate that the yield of rice in the upland varied considerably among the treatments Control, NPK 50% + 2.75 tons ha-1 PM and0% NPK + 8.1 t CD ha-1.Poultry manure in combination with chemical fertilizers (NPK 50% + 2.75 tons ha-1 PM) produced the highest grain and panicle weight and taller height of rice and was significant, in all other parameters studied including yield components. Therefore, it can be concluded that poultry manure in combination withchemical fertilizers can be used successfully in an integrated way for the successful cultivation of rice.

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