**RUFORUM Working Document Series (ISSN 1607-9345), 2019, No. 18 (1) 312-317**
***Available from http://repository.ruforum.org***

Research Application Summary

# Effect of cation rich biochar and micronutrient blended inorganic fertilizer on rice yield in an acidic soil

Umeugochukwu, O.[1*], Bala, A.[1], Bello, W.[1] & Oludade, K.[1]

' Department of Soil Science, Federal University of Techno gy Minna, P.M.B 65, Minna, 902, Nigeria
***Corresponding author:** obyume@gmail.com

## Abstract

This study investigatd the effect of rice husk biochar and sulfur (15) and Zinc (1Zn) blended inorganic fertilizer on rice yield in comparison to two treatments under normal farmers' practice. The experiment was laid out in a complete randomized block design in the field with four treatments and three replications. The treatments were control (CT), farmers normal practice with 5t/ha biochar (FPB), normal farmers practice (FP), and NPK fertilizer blended with Zn and S (NPKS). The experimental sites were Wushishi and Katcha local government of Niger State in Nigeria. At Wushishi the biochar application significantly affected the yield parameters better than the NPKS application. The Wushishi site recorded 35 % yield increase by the addition of the agro waste biochar compared to the farmers practice. The NPKS treatment performed better at Katcha site where it recorded 35 % increase in yield and 51% increase in straw biomass yield as compared to the farmer's practice. The two treatments (biocolar and NPK fertilizer) gave better performance than the normal farmers practice. Farmers are therefore advised to conduct soil test before application of fertilizers for yield increase.

Keywords. Acidity, biochar, micro nutrients, Niger State, rice, yield

## Résumé

Cette étude a examiné l'effet du biochar de balle de riz et de l'engrais inorganique mélangé au soufre (15) et au zinc (1Zn) sur le rendement du riz par rapport à deux traitements dans le cadre de la pratique courantes des agriculteurs. L'expérimentation était placée sous un dispositif complet en blocs aléatoires sur le terrain avec quatre traitements et trois répétitions. Les traitements étaient le contrôle (CT), la pratique courante des agriculteurs avec 5 t/ha de biochar (FPB), la pratique courante des agriculteurs (FP) et delle d'engrais NPK mélangé avec Zn et S (NPKS). Les sites expérimentaux étaient les gouvernements locauxWushishi et Katcha de l'État du Niger au Nigeria. À Wushishi, l'application de biochar a considérablement amélioré les paramètres de rendement par rapport à l'application NPKS. Le site de Wushishi avait enregistré une augmentation de rendement de 35 % grâce à l'ajout de biochar des déchets agricoles par rapport à la pratique des agriculteurs. Le traitement NPKS a obtenu des meilleurs résultats sur le site de Katcha où il a enregistré une augmentation de 35 % du rendement et une augmentation de 51 % du rendement de la biomasse de paille par rapport à la pratique des agriculteurs. Les deux traitements (biocolar et engrais NPK) ont donné des meilleures performances que la pratique habituelle des agriculteurs. Il est donc conseillé aux agriculteurs d'effectuer des analyses de sol avant l'application d'engrais pour augmenter le rendement.

Mots clés: Acidité, biochar, micronutriments, État du Niger, riz, rendement

## Introduction

In an acid tropical savanna soil of Niger State in Nigeria there is low nutrient status due to wea ering and the nature of parent materials. This has greatly contributed to low rice yield. Despite the increase in rice yield in Niger State, it has not reached the expected yield output compared to in other advanced countries (Merem *et al*., 2017). This necessitated a fertility survey of the two study sites with a view to increase rice production. The findings by Umeugochukwu (2017) revealed Local Government Areas (LGAs). Organic Carbon (OC) and cation content especially K in Wushishi and high heavy metal interference in Katcha Despite the high N and P in most of the surveyed soils, the soils still recorded low rice yield. This was attributed to low K content that restricted the uptake of P and N. Adequate amount of K in the soil solution allows for efficient N absorption which results in better early vegetative growth and higher grain yield. The interaction does not end with N, it extends to other nutrients. Sufficient amount of K in the soil enhances P absorption as well as absorption of other micro nutrients like Zn and Mn. The low K level affects the nutrient balance in the soil system. Also the interaction of Mn and Zn could also have contributed to the low yield experienced in the area.

A lot of K is extracted from the soil by plant and much of it is accumulated in the rice shoot. This is why K influences rice grain yield more than N and P. The main role of K is the osmoregulation of cells and tissues. Potassium has a number of important functions within plants, including balancing the charges of cellular anions, enzyme activation, control of stomata] opening/closing and serving as an osmoticum for cellular growth. Apart from this vital function, it interacts with the other nutrients to affect their availability and plant uptake. It is therefore good to use organic source with high K to enhance it's level in soil. Since a single K fertilizer is not commonly available. Rice husk biochar is known to contain high K and cations as well high CEC, this study employed ZnSO, blended NPK fertilizer to neutralize the effect of the Mn toxicity in the soils. The objectives of the study was therefore to determine the effect of ZnSO4 blended fertilizer and rice husk biochar amendment on rice yield at Wushishi and Katcha and compare their effectiveness against the farmers practice the were used to.

## Materials and methods

Study area. This study was carried out in two local governments of the State used for rice farming (Wushishi and Katcha LGA). The study area was situated on soils that had low fertility in terms of nutrients of interest. Katcha had two sites (Emiworo coop 9 ° 03' 12.240, 6 ° 08' 06.795 and Emi-Ndamakun 9 ° 13' 40.440, 6° 13'58.506). Wushishi also had two sites (Nakwarai 9° 40' 03.516, 6° 03' 36.168 and ImaniKutukpachi 9° 39' 11.058, 6° 03' 10.500). The sites were designated as Emiworo coop- KDG3, Emi-Ndamakun-KEG3, Nakwarai —WDG1, and ImaniKutukpachi. The average annual rainfall in Niger State is 1229 mm and average temperature is 27.5° C. The initial soil properties were as detailed in Table 1.

**Experimental set up.** Rice husk collected from a mill in Wushishi was used to locally produce biochar. The biochar yield was 38 percent and the properties of the rice husk biochar used were as detailed in Table 2. The experiment sites were prepared using standard cultivation practices. The plots were arranged in a complete randomized block design with four treatments and three replications. Treatment 1 was Biochar plus NPK plus Urea designated as FPB treatment 2- NPK plus Urea designated as F, treatment 3-20,10,10 NPK plus 1 $Zn_2$ $SO_4$, designated as NPKS and treatment 4- control designated as CT. Each plot size of 10 m x 10 m was used and each plot needed 10 kg of 20 10 10 plus $ZnSO_4$ and 5 kg of Urea applied in split applications. Rice husk biochar was incorporated into the top 0.15 cm and was evenly distributed at the rate of 5t/ha.

**Table 1. Initial proprieties of the studied soil**

| Sample Name | SAND (%) | SILT | CLAY | TEX. CLASS (USDA) | PH Ratio 1:2.0 $H_2O$ | PH 0.01M CaCl2 | OC g/kg | Total N (%) | Avail-able P (%) | Exch. Bases (Cmol/kg) Ca | Mg | K | Na | Fe2 | Mn | Micro Nutrients (mg/kg) Cu | Zn | SO4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KDG3 | 54 | 40 | 6 | SANDY LOAM | 5.24 | 3.77 | 2.7 | 0.285 | 0.014 | 0.384 | 0.150 | 0.10 | 0.16 | 164.84 | 18.80 | 0.82 | 2.97 | 10.058 |
| KEG3 | 23 | 48 | 29 | CLAY LOAM | 5.55 | 3.50 | 6.4 | 0.096 | 7.628 | 1.378 | 0.289 | 0.18 | 0.35 | 199.04 | 93.11 | 2.61 | 2.42 | 10.582 |
| WBG2 | 24 | 47 | 29 | CLAY LOAM | 4.46 | 3.88 | 18.2 | 0.651 | 7.566 | 1.599 | 0.282 | 0.25 | 0.48 | 255.28 | 143.80 | 3.50 | 3.72 | 10.584 |
| WDG3 | 21 | 42 | 37 | CLAY LOAM | 4.88 | 3.37 | 12.4 | 0.038 | 5.423 | 1.986 | 0.327 | 0.18 | 0.23 | 294.70 | 136.34 | 7.85 | 6.56 | 8.840 |

**Sampling and measurements.** After sowing, plant parameters like plant height of eight randomly tagged plants were measured from bottom to top at 3, 5, 6 and 8 weeks after planting. Only the result of the 3 and 6 WAP is reported in this paper. The data for the straw biomass and grain yield, the 2m x 2m row in the middle of the plots were used for this measurement.

**Data analysis.** The data were subjected to one way analysis of variance and means were separated using LSD.

## Results and discussions

**The effect of the treatments in comparison to farmers practice in Wushish**i. The combined application of 5t/ha of rice husk biochar and the farmers practice (FPB) gave significantly higher plant height when compared to control at three weeks after planting. This treatment did not differ from the other treatments at this stage. It also gave significant higher yield which differed from NPKS but did not differ from famers practice and control. This showed that the micro nutrient only favored the plant growth and not the yield. However, there was a 35 percent increase in yield from the biochar amendment when compared to farmers practice. This result is in agreement with the fi ndings of Oladele *et al*. (2019) who recorded 56 percent increase in plant height when rice husk biochar was added to nitrogen fertilized plot. Other studies have shown that biochar application maFkes nutrients and other cations available for plant growth (Schulz *et al*., 2013). Therefore, to improve yield in rice plots of the farmers in Wushishi, it is advisable for them to char their rice husk which is an agro waste they generate and apply it to their farm along their normal practice.

**Application of the biochar to the rice plots**. There are two methods of applying this biochar. One of the methods is shown in Figure 1. The biochar was broadcasted on the plot during land preparation, after land clearing and mixed to the depth of 15 cm. Alternatively, it could be applied using ring method after planting. It is an organic source of nutrient and will not mineralize its nutrients as fast as the inorganic fertilizer. So there should be at least one week gap after application before planting takes place. As shown in Figure 2, the plots with biochar

(FPB) were more greenish and recorded taller plants followed by the micro nutrient blended plots (NPKS). This performance was at three WAP, and similar to the yield result.

**Table 2. Chemical composition of locally pyrolyzed rice husk**

| Parameter Determined | Rice husk | Parameter Determined | Rice husk |
|---|---|---|---|
| Carbon | 33.27% | Moisture content | 0.385% |
| Nitrogen | 1.82% | Ash content | 1.770% |
| Sulphur | 0.156mg/l | Degradation profile | 137.25oC-430.24oC |
| Oxygen | 5.60mg/l | Degradation % | 68.380% |
| Hydrogen | 6.12mg/l | Peak temperature | 270.18oC |
| pH | 7.67 | Onset temperature | 214.41oC |
| EC | 0.967ds/m | H/C | 1.84 |
| O/C | 1.68 | | |

**Table 3. Effect of biochar micro nutrient blended inorganic fertilizer and farmers practice on plant height and rice yield at Wushishi**

| Treatments | Plant height at 3WAP | Grain Yield |
|---|---|---|
| FPB- Farmers practice and biochar | 56.93a | 14.20a |
| CT-Control | 43.25b | 13.75ab |
| FP-Farmers practice | 52.18ab | 10.50ab |
| NPKS- Inorganic fertilizer with micro nutrient | 50.40ab | 9.60b |
| LSD-Lease significant difference | 9.55 | 4.30 |

The results in Table 4 show that the plots with blended micro nutrient performed better than the biochar plots at Katcha. The NPKS plot also recorded significantly higher plant height at 3WAP compared to the control but did not differ from the farmer's practices and the farmer's practices with biochar. The same NPKS treatment gave the best result grain yield and straw biomass. For the yield, it did not differ significantly from the farmers practice with biochar but differed significantly from farmers practice and control. But the straw yield differed significantly from the rest of the treatments. Also application of NPKS gave a 35 % increase in yield compared to the farmers practiced. For the biomass yield, it gave 51 percent increase in yield.

**Figure 1. Application of the rice husk biochar to the plots one week before planting**

**Figure 2. Effects of the different treatments on the growth of rice performances at Wushishi**

At Katcha, there was Mn and Fe toxicity. So the better performance of the NPKS treatment could be attributed to the presence of sulfur and Zn in the NPK fertilizer which neutralized the toxicity andf released nutrients that were formerly fixed. The addition of Zn and S to the NPK plus urea fertilizer to the farmers practice improved the crop performance (Figure 3). This performance confirms the findings of Yoshiaki and Ando (2017) who reported that interaction of Zn and Mn increased rice plants yield.

Although the NPKS yielded higher in Katcha than the FPB, it was not the best treatment in Wushishi possibly due to differences in the soil properties at the site (Table 1). Figure 3 shows the difference in the performance of the different treatments administered to the plots in Katcha. At this site, the tallest and most greenish plot were plots treated with NPKS followed by the plots treated with FPB. Therefore, to improve rice yield in Katcha, it is advisable for farmers to use the NPK fertilizer that contains 1Zn and 1S instead of only NPK.

**Table 4. Effect of biochar micro nutrient blended inorganic fertilizer and farmers practice on rice plant height and field at Katcha**

| Treatments | Plant height at 3WAP | Plant Height at 6WAP | Grain Yield | Straw Biomass Yield |
|---|---|---|---|---|
| FPB- Farmers practice and biochar | 79.42ab | 109.92a | 2.05ab | 3.45bc |
| CT-Control | 61.38b | 79.67a | 1.10c | 1.65c |
| FP-Farmers practice | 73.88ab | 94.79a | 1.85b | 4.15b |
| NPKS- Inorganic fertilizer with micro nutrient | 87.21a | 99.25a | 2.50a | 6.25a |
| LSD-Lease significant difference | 24.86s | 31.39 | 0.48 | 1.81 |

Mean in a column with similar letters are not significantly different at $P < 0.05$ WAP = Week after plantin

## Conclusion

The inherent properties of the soils in the two study sites were suitable for rice cultivation but needed amendments with biochar for optimum growth and yield of rice. There is therefore integrated management technologies to improve rice yield. Among the management practices, use of organic manure should be encouraged. The rice husk biochar used as organic amendment resulted in good performance at Wushishi plots because of no micro nutrient toxicity. That was different from the site in Katcha where the problem included both low nutrient status and micro nutrient toxicity. It was however not advisable to use the NPKS with $ZnSO_4$ in an acidic soil as this may increase

soil acidity. It would be advisable to further this research by blending the biochar with Zn SO4 to ameliorate the acidity problem.

**Figure 3. Effects of the different treatments on rice growth performance performance at Badeggi-Emiworo site**

**Acknowledgment**

The authors acknowledge the financial support of the International Fund for Agricultural Development under the Value Chain Development Program under which this project was carried out. This paper is a contribution to the Fifteenth RUFORUM Annual General Meeting held 2-6 December 2019 in Cape Coast, Ghana.

**References**

Merem, E. C., Twumasi, Y., Wesley, J., Isokpehi, R, Shenge, M., Fageir, S. and Ochai, S. 2017. Analyzing rice production issues in the Niger State area of Nigeria's middle belt. *Food and Public Health* 7 (1): 7-22.

Oladele, S. 0., Adeyemo, A. J. and Awodun, M. A. 2019. Influence of rice husk biochar and inorganic fertilizer on soil nutrients availability and rain-fed rice yield in two contrasting soils. *Geoderma* 336: 1-11

Schulz, H., Dunst, G. and Glaser, B. 2013. Positive effects of composted biochar on plant growth and soil fertility. *Agronomy for Sustainable Development* 33 (4): 817-827.

Umeugochukwu, O.P. 2017 Soil fertility survey for rice production in Katcha and Wushishi local Government areas of Niger State. Federal University of Technology, Minna.

Yoshiaki, I. and Ando, T. 1968. Interaction between manganese and zinc in growth of rice plants. *Soil Science and Plant Nutrition* 14 (5): 201-206. doi: 10.1080/00380768.1968.10432766