Response of Potted Tomato on CRH-Treated Oxisols

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***Abstract*—This experiment evaluated the effects of Carbonized Rice Hull (CRH) on the agronomic and fruiting performance of potted tomatoes. The pots were arranged using completely randomized design with four replications. ANOVA and LSD were used to determine differences among treatments and differences within treatments, respectively. Results indicate that oxisols applied with 10 g of complete fertilizer in a 5:5 CRH-Soil ratio (T_3) got the significantly tallest plant height and fruit yield compared to oxisols that received also 10 g of complete fertilizer but without CRH (control). But plant heights and fruit yields of T3 and T2 (3:7 CRH-Soil ratio) were not statistically different. The control treatment (T_0) had the shortest increase in plant height and produced the least fruit yield. Plant height was particularly significant from the sixth week of measurement. Prior plant heights (first to fifth week) were not statistically different among treatments. Such result could be due to the fact that CRH being a form of organic matter requires more time to react with the soil. Mixing the soil with CRH was seen as a cheaper and practical method of improving the productivity of the marginal condition of some agricultural lands. The application of CRH to infertile and highly acidic soils is a good alternative in enhancing the usefulness of problem soils.**

***Index Terms*—biochar, rice hull, soil conditioner, soil fertility, soil remediation**

I. Introduction

Rice hull is thought to be the most 'unwanted' rice by-product by many rice millers and some farmers throughout the regions. Annually, we dump or burn about 2.5 million tons of rice hull that pile up from the milling of 13 million tons of palay [1]. However, this "waste material" can be converted into a soil conditioner and bio-organic fertilizer termed carbonized rice hull (CRH). CRH is a hydrophilic substance made from the incomplete or partial burning of rice hull. It contains potassium, phosphorus, calcium, magnesium, and other microelements needed for growing crops [2]. As soil conditioner, CRH replenishes air and retains water in the soil. Because of the heat it undergoes, it is sterile and thus, free from pathogens.

As such, it makes an excellent host for beneficial microorganisms, and an ingredient for bio-organic fertilizer [3]. According to the International Biochar Initiative (IBI), biochar is a charcoal which can be applied to soil for both agricultural and environmental gains [4].

Oxisols is one of the 12 soil orders in the USDA soil taxonomy. It is the most highly weathered soils in the world with a deep oxic subsurface horizon. It is reddish or yellowish in color due to the high concentration of hydrous oxides of iron and aluminum. Oxisols form in hot climates with nearly year-round moist conditions [5]. This study aimed to find out the fruiting of tomato as affected by the application of CRH on highly degraded old soils which are widely distributed worldwide.

In the world of organic farming, recycling is the key to sustainability and from this recycling, we can make a new material that can be used in farming and one of those stuff is the carbonized rice hull [6]. In a study on the effects and fate of biochar from rice residues in rice-based systems revealed that the application of untreated and carbonized rice husks increased total organic carbon, total soil N, C:N ratio, and available P and K [7]. While in a hydroponic experiment on cucumbers using different containers and substrates showed that a combination of perlite and CRH got the lesser incidence of abnormal fruits as compared to pure perlite substrate [8]. This finding was upheld in a similar experiment in Lee *et al.* [9] about the effects of substrates on the growth and fruit quality of hydroponically-grown tomatoes. The findings disclosed that except in pure perlite, a mixture of carbonized rice hull and perlite got the second best results in terms of growth and fruit quality of tomatoes.

A research on remediation and management of diesel-contaminated ricefields showed positive results. It disclosed that carbonizing rice straw residue into biochar and incorporating it into the soil can enhance rice productivity and N retention in a paddy field. Amendment with rice straw biochar resulted in higher rice yields [10]. A review of the effects of biochar on soil bacteria in Lehmann *et al.* [11] disclosed that in most cases microbial biomass increases in the presence of biochar. The presence of adequate microbial fauna in the soil brings forth improved physical and chemical properties of the soil. Interestingly, in a study conducted in Kang *et al.* [12] on the effect of CRH and wood charcoal on the yield, antioxidant and nutritional quality of rice showed that mixture of wood charcoal and pyroligneous acid (MWPA), and mixture of rice hull charcoal and pyroligneous acid (MRPA), increased both

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the antioxidant property and nutritional quality of rice. Though the use of MWPA was favored than MRPA.

On the other hand, tomato is an excellent subject matter in soil-plant studies as it is easy to obtain and can resist many diseases that would introduce unwanted variables into the experiment. It is also easy to set up, but contain enough data to support even a high-level research [13]. In this study, CRH was used to test the biochemical response of tomatoes planted on an infertile, highly-weathered acidic soil (oxisols) set in potted condition.

II. Materials and Methods

Response – refer to the growth and yield of potted tomatoes.

1. Experimental Design and Layout. The experiment was laid out using the Completely Randomized Design (CRD) with four (4) replications. The following treatments were used:

T_0 = control (no CRH); only 10 g Complete fertilizer/8 kg-pot (applied in 2 splits)

T_1 = 1:9 CRH-Soil mixture (10% CRH/pot) + 10 g Complete fertilizer/8 kg- pot (applied in 2 splits)

T_2 = 3:7 CRH-Soil mixture (30% CRH/pot) + 10 g Complete fertilizer/8 kg- pot (applied in 2 splits)

T_3 = 5:5 CRH-Soil mixture (50% CRH/pot) + 10 g Complete fertilizer/8 kg-pot (applied in 2 splits)

2. Mixing of CRH with soil. Appropriate amount of CRH was mixed with the soil (Oxisols). The soil and CRH in T_1, T_2, and T_3 was mixed by emptying the contents of every pot and putting them separately in suitable container. The CRH-soil mixture was put back to the same labeled pots.
3. Reaction Period. After putting back to the plastic pots of the mixed soil and CRH, they were set aside for one month to allow the CRH react with the soil. The mixture was watered every other day.
4. Transplanting the Tomato Seedlings. One tomato seedling was transplanted to every pot after the lapse of one month reaction period including the control treatment.
5. Application of Complete Fertilizer. Five (5) g of complete fertilizer was applied to every treatment at transplanting time and another 5 g two weeks after transplanting.
6. Care and Maintenance of the Potted Tomatoes. Necessary care of the potted plants was done to ensure the objective gathering of data.
7. Harvesting. All mature tomato fruits were harvested in every treatment and weighed. The harvesting of mature fruits was continued for three consecutive weeks since the initial harvesting.
8. Data Analysis.
   a. ANOVA was used to determine significant differences among treatments, and
   b. Least Significant Difference (LSD) was employed to test differences in treatment means.

III. Results and Discussion

Selected agronomic and yield parameters of potted tomato grown on CRH-treated oxisols are presented below:

TABLE I. Agronomic and Fruiting Data of Ptomato Grown on CRH-Treated Oxisols

TREATMENTS	Initial plant eight (cm)	Weekly increase in plant height (cm)						Fruit yield (g)
		1 -5	6	7	8	9	10	
T0 = control (no CRH); only 10 g Complete fertilizer/ 8 kg-pot (applied in 2 splits)	6.75	ns	33.90 c	37.50 c	41.25 c	42.78 c	48.62 b	20.00 c
T1 = 1:9 CRH-Soil mixture (10% CRH/pot) + 10 g Complete fertilizer/8 kg-pot (applied in 2 splits)	5.50	ns	39.48 bc	47.55 bc	55.08 b	58.12 b	65.12 a	44.25 b
T2 = 3:7 CRH-Soil mixture (30% CRH/pot) + 10 g Complete fertilizer/8 kg-pot (applied in 2 splits)	5.00	ns	43.42 b	55.75 b	66.35 a	71.12 a	74.38 a	53.75 a
T3 = 5:5 CRH-Soil mixture (50% CRH/pot) + 10 g Complete fertilizer/8kg-pot (applied in 2 splits	6.00	ns	54.12 a	67.25 a	73.85 a	75.58 a	76.75 a	54.50 a
p-value (0.05)	0.263	ns	0.017*	0.001*	0.000*	0.000*	0.003*	0.000*
CV (%)	0.220	ns	0.240	0.249	0.233	0.231	0.208	0.351
S.E. (random effects)	0.373	ns	4.271	6.303	1.513	7.372	6.378	8.054

Means within a column with a different letter are significantly different at 0.05 level of significance based on ANOVA and LSD.

Agronomic parameters shown in Table I bare that plant height (from initial up to the fifth weekly measurement) were not significantly different at 0.05 level. Significant differences started to show from the sixth up to the tenth week of observation. Plant height on the sixth and seventh week showed significant differences particularly between T_0 (control treatment) and T_2 and with T_3. The latter two treatments were also significantly different. But T_0 and T_1 did not reveal a significant difference.

While on the eighth and ninth week of reading the plant heights, T_2 and T_3 were no longer significantly different. And on the tenth week it was only T_0 (control) whose plant height was significantly different from all the other three treatments. The fruit yields also revealed significant differences among the different treatments except between T_2 and T_3. The treatment with 5:5 Soil:CRH ratio (T_3) added with 10 g complete fertilizer obtained the tallest plant height of 76.75 cm and fruit yield of 54.50 g but were not statistically different from T_2 (3:7 Soil:CRH ratio with 10 g complete fertilizer). Soil not combined with CRH but with 10 g complete fertilizer (T_0) got the lowest plant height of 33.90 cm and fruit yield of 20 g which were significantly lower than those of the CRH-treated soils.

In a study of Jha [14] about the prospects of biochar (carbonized rice hull) in agriculture, results indicates that black carbon can produce significant benefits when applied to agricultural soils in combination with some fertilizers. It further revealed that the application of biochar increased the soil water retention properties, saturated hydraulic conductivity, and nutrient availability. These facts may have caused the generally significant taller plants and better fruiting of tomato in the CRH-applied treatments (T_1, T_2, and T_3).

The above claim was supported in Liang *et al.* [15] stating that anthrosols from the Brazilian Amazon containing high amount of biomass-derived black carbon had greater potential Cation Exchange Capacity (CEC) than adjacent soils with low black carbon content. In Kampf and Jung [16], CRH was used as a horticultural substrate for rooting under intermittent mist due to its good drainage and high permeability. The above result was further backed up in a meta-analysis conducted in Biederman [17] on biochar and its effects on plant productivity and nutrient cycling. It was found that despite variability introduced by soil and climate, the addition of biochar to soils resulted in increased aboveground productivity, crop yield, soil microbial biomass, rhizobia nodulation, plant K tissue concentration, soil phosphorus (P), soil potassium (K), total soil nitrogen (N), and total soil carbon (C) compared with control conditions.

An experiment conducted in Yeboah *et al*. [18] on biochar for soil management: its effect on soil available nitrogen and soil water storage revealed that biochar amendments increased soil moisture storage by 14% relative to sole inorganic fertilizer applications. Biochar plus inorganic fertilizer relative to sole inorganic fertilizer increased soil available nitrate concentration by 85% at 0-15 cm soil depth. It also led to an increase of okra fresh fruit yield by 100% compared to sole inorganic fertilizer.

While the study in Kannan *et al.* [19] on biochar as an alternative option for crop residues and solid waste disposal reported that biochar is a viable organic material to use to combat climate change and sustain the health of soil and crop production. Application of biochar could increase the carbon capture and storage, reduce greenhouse gas emissions and enhance crop yields.

Appearance of tomato plant samples grown on the different treatment media are shown below (Fig. 1-Fig. 4):

Figure 1. Tomato plant without CRH but with complete fertilizer at eight weeks

Figure 2. Tomato plant with 10% CRH plus complete fertilizer at eight weeks

Figure 3. Tomato plant with 30% CRH plus complete fertilizer at eight weeks

Figure 4. Tomato plant with 50% CRH plus complete fertilizer at eight weeks

Compared to other studies that have been cited in the literature, it was noted that though this experiment was simple yet the results have been found very useful. This is so because unwanted organic matter such as rice hull could afterall become a good source of appreciable materials for plant nutrition.

IV. Conclusion

Mixing adequate amounts of carbonized rice hull (CRH) to highly acidic and infertile soils, e.g. oxisols, could significantly restore or improve the productivity of those severely-weathered soils. The slightly alkaline pH of CRH makes it a good alternative in reclaiming unproductive lands which are known to be acidic and deficient of the required organic matter and soil elements. Thus, the utilization of rice hull into CRH could turn the otherwise unwanted by-product from milling into a more useful and practical substitute of expensive and long-term soil reclamation process.

Thus, it is recommended that instead of throwing away the by-product of rice milling elsewhere (rice hull), the same may be converted using simple process into a Carbonized Rice Hull (CRH) and mixed with acidic soils. Such practice could be a cheaper method of improving the physical and even the chemical attributes of unproductive soils caused by too much acidity and lack of organic matter content. This process aside from being economical, is also realistic and ecofriendly.

Studies delving into the 1) soil microbial population as affected by CRH application, and 2) the chemical attributes of the problematic soil after a certain period of time the carbonized rice hull has been combined with it, may be a good research foci.

Further, it appears that the use of other forms of biochar aside from carbonized rice hull, could be a highly potential direction for research.

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