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Influence of Chicken Manure Char and Coco Coir Char on the Growth and Yield of Sweet Pepper (*Capsicum annuum* L.) and Chemical Properties of Acidic Grassland Soils

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Abstract— Sweet pepper consumption in the Philippines is low due to nutrient-deficient soils. Since chicken manure and coco coir were widely used in the country as soil enhancers, the study determined the appropriate combination rate of chicken manure char (CMC) and coco coir char (CCC) application in enhancing the growth and yield of sweet pepper and evaluated the chemical properties of acidic grassland soil. A pot experiment was conducted with bell pepper as a test crop. The soil used was collected randomly from a depth of 0-20 cm at the grassland area of NwSSU, San Jorge Campus, San Jorge Samar. Replicated thrice, the treatments used were T1 = Control, T2 = 100% CMC 10 kg-1 soil, T3 = 100% CCC 10 kg-1 soil, T4 – 75% CMC + 25% g CCC10 kg-1 soil, T5 – 50% CMC + 50% CCC10 kg-1 soil, T6 - 25% PLC + 300 g CCC10 kg-1 soil. Charred chicken manure and coco coir were produced using a modified top lift updraft double barrel method. CMC and CCC mixture was incubated with soil for 14 days before transplanting. Sweet pepper was harvested after 90-95 days from transplanting. Plant tissue and soil samples were chemically analyzed. Results revealed that CMC and CCC addition particularly enhanced the plant height of sweet pepper; lessen their number of days from transplanting to flowering, fruiting and harvesting; and marketable yield. Moreover, CMC and CCC mixture addition significantly increased the pH, % OM, total N, extractable P, and exchangeable K of acidic grassland soil.

Keywords— Biochar, degraded soil, sweet pepper

1. Introduction

Sweet pepper is known as capsicum, kampana or lara. It is the most widely used condiment globally, and it can be cooked or eaten raw. It is also consumed as salad with other leafy vegetables, in sandwiches, and as stewed, fried and baked singly or in combination with other vegetables. At the same time, it is used essentially an essential ingredient for pizza, pasta, hamburger, hot dogs and other foods [1].

In the Philippines, consumption of sweet pepper is low due to the limited or fluctuating supply in the market because of nutrient-deficient soils, such as acid soil. Acid soils, with a pH of 5.5 or less, significantly limit crop production in many developing countries where food production is critical [2]. In the country, the production area of sweet pepper covered 2,439 ha including other sweet pepper types. Most of these areas contain toxic levels of aluminum (Al), iron (Fe), and manganese (Mn), as well as sub-optimal levels of phosphorous (P).

Phosphorus is primarily deficient in acid soils because it is fixed by Fe and Al which consequently becomes a serious problem in crop production and soil quality [3]. Without appropriate soil management strategies, intensified utilization of these acid infertile soils will likely result in severe nutrient depletion and loss of organic matter.

Since acidity of soils is among the major constraints of agriculture, much effort has been put in developing and implementing technologies to improve productivity. Such measures included the application of lime as an ameliorant together with regular applications of chemical fertilizer. However, it is often beyond the limited financial resources of small-scale farmers. This inability of farmers to pay for high chemical fertilizer for marginal lands led to other management options such as the use of organic amendments which effectiveness varies with quality and quantity applied.

Chicken manure and coco coir have been widely used as either organic fertilizer or soil ameliorant to somehow solve the problem of waste disposal. As soil amendments, they can serve as food for macro- and microorganisms and, thus, stimulate biological activities that enhance nutrient availability and improve soil quality and productivity. Moreover, the application of uncharred poultry litter can increase soil organic carbon (SOC). Yet, such benefit of SOC content is short-lived, and only a small portion of the applied organic amendment will be stabilized since it rapidly decomposes, consequently releasing CO2 [4]. Also, contaminant problems (e.g. residual hormones, antibiotics, pesticides, and pathogens) are associated with the application of uncharred poultry litter [5].

On the other hand, the main problem associated with coco fiber by-product is lack of disposal ways. Utilization of coco coir was also very limited, leading to the accumulation of heaps of coco coir dust fiber.
Therefore, the conversion of raw poultry litter and coco coir to char can be an alternative management strategy in using these resources as a soil ameliorant. There is evidence that poultry litter char biochar application has provided agronomic and ecological benefits in acid soils [5]. Additionally, coco coir char (CCC) may offer great potential for carbon sequestration when combined with charred poultry litter and applied to acidic soil. However, little information is available on their benefit to acid soils. Hence, the study aimed to determine the appropriate combination rate of CMC and CCC to enhance growth and yield of sweet pepper, and evaluate its effects on the chemical properties of acid soil after harvest.

2. Methodology

Experimental Design and Layout

The experiment was carried out at a modified shed house in the nursery area of Northwest Samar State University-San Jorge Campus (NwSSU-SJC), San Jorge, Samar. There were six treatments and three replications laid out in a randomized complete block design (RCBD). The treatments used were as follows: T1 = Control (unamended); T2 = 100% (400 g of CMC in 10 kg-1 soil); T3 = 100% (400 g of CCC in 10 kg-1 soil); T4 = 75% (300 g of CMC) + 25% (100 g of CCC) in 10 kg-1 soil; T5 = 50% (200 g of CMC) + 50% (200 g of CCC) in 10 kg-1 soil; and T6 = 25% (100 g of CMC) + 75% (300 g of CCC) in 10 kg-1 soil.

Biochar Production and Analysis

The chicken manure collected from the poultry farm in Brgy. Inuragyao, Sta. Margarita, Samar and the coco coir from Brgy. Erenas, San Jorge, Samar were air-dried at the shade house of the campus. After air-drying, the moisture content of the chicken manures and coco coir subsamples were determined. The rest of each material was charred using the Top Lit Updraft Double Barrel processing method as described by [6]. The charring employed a maximum temperature of 400 0C and achieved 50% material recovery.

After charring, both CMC and CCC were ground and screened using a 0.5 mm sieve. The screened CMC and CCC were submitted and subsequently analyzed at Central Analytical Service Laboratory, PhilRootcrops, Visayas State University for pH, OM, total N and analysis on P and K were determined by dry-ashing 0.5 g of CMC and CCC in a muffle furnace set at 550° C. The ashes were soaked overnight in 3 ml concentrated HCl. The total P content of acid-treated ash was quantified following the ascorbic acid method of [7], while total K was quantified by atomic absorption spectrophotometer.

Soil Analysis

The collected soil samples before and after harvest were submitted and analyzed at the Central Analytical Service Laboratory, PhilRootcrops, Visayas State University using the following chemical parameters. Soil pH was potentiometrically determined at a 1:2.5 soil water ratio [8]. Total nitrogen was quantified by micro-kjeldahl method [9], and organic matter content was determined using the Walkley-Black method as described by [10]. The available phosphorus was extracted using the Bray-2 method [8]. Absorbance was read using the spectrophotometer (Spectronic 20D).

Pot Preparation, Transplanting, Management, Harvesting, and Data-gathering

The experiment was conducted using a polyethylene bag filled with an air-dried 10 kg of acid soil. Before potting, a representative sample was taken and air-dried to determine the moisture content. The computed amount of fertilizer in each treatment was increased to different levels. Computed amounts of PLC and CCC were mixed with soil in each treatment. Sweet pepper) seeds were sown in a seedbox. Two weeks after emergence, the pricking of seedlings was done upon the appearance of 2-3 leaves. Hardening was also done two weeks after pricking to ensure that the seedlings were ready before transplanting. Three weeks after the emergence of the first true leaf, each healthy seedling was transplanted to separate bags. Transplanting was done in the afternoon to avoid wilting and to be able to adjust to the environmental condition. The seedlings were watered after transplanting. Weeds were removed manually on a weekly basis. Insect infestation was also controlled only by handpicking.

Further, the parameters such as plant height (cm); the number of days from sowing to flowering, fruiting, and harvesting; and marketable fruit yield (kg) were gathered.

Statistical Analysis

Data gathered was analyzed using the Statistical Tool for Agricultural Research (STAR). The effect of CMC and CCC on the growth and yield of sweet pepper and on the soil chemical properties were analyzed through analysis of variance (ANOVA). The Duncan's Multiple Range Test (DMRT) was employed to compare the treatment means at 5% level of significance.

3. FINDINGS AND DISCUSSION

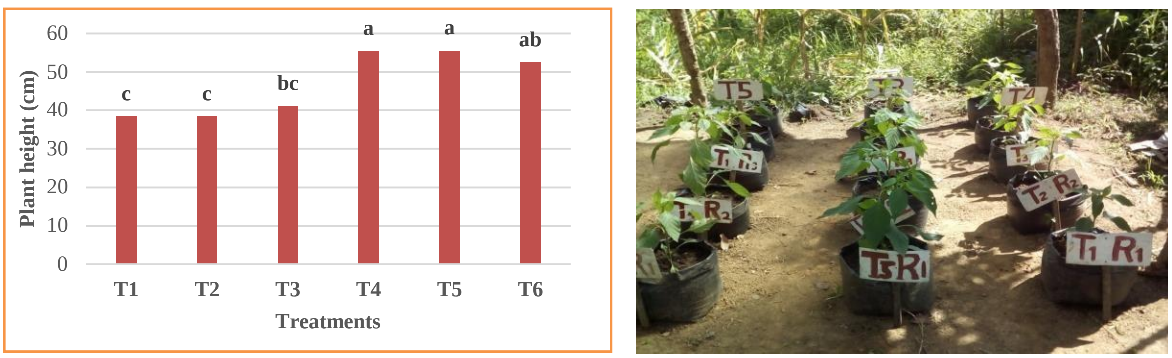
General Observations

The analysis of data obtained from the experiment showed the varied response of chicken manure char and coco coir char applied to the crop. The main effect of CMC and CCC enhanced vigorous growth and better yield of sweet pepper. The growth response of sweet pepper to different CMC and CCC levels was noted two weeks after transplanting. Sweet pepper without CMC and CCC application showed yellowing of leaves and stunted growth (T1). Moreover, sweet pepper applied with 75% CMC and 25% CCC had green leaves, normal and fastest growth, and early flowering and fruiting. The combination application also produced a better yield.

Plant Height of Sweet Pepper

The experiment showed different responses of sweet pepper growth performance from CMC and CCC applications (Fig. 1). The plant height of bell pepper was significantly influenced by the application of biochar after one month of observation. The treatment combination of 75% CMC + 25% CCC (T3) and 50% CMC+50% CCC (T4) have achieved tallest plant height as compared to control (T1), 100% CMC (T2) and 100% CCC (T3). This revealed that the combination of CMC and CCC could promote better growth performance of sweet pepper. This was reported by [11] that 77.3% of the studies revealed that a higher percentage of biochar as a mixture promotes better plant growth. This could be due to the influence of better nutrient content of biochar as soil amendments in improving soil nutrient status.

However, after two months, there is no significant effect on plant height was observed. This is because the plant has reached the reproductive stage and thereby, optimum growth was met (Fig. 2).



Means with the same letter are not significantly different at 5 % level significance

a b

Figure 1 Plant height of sweet pepper one (1) month after transplanting.

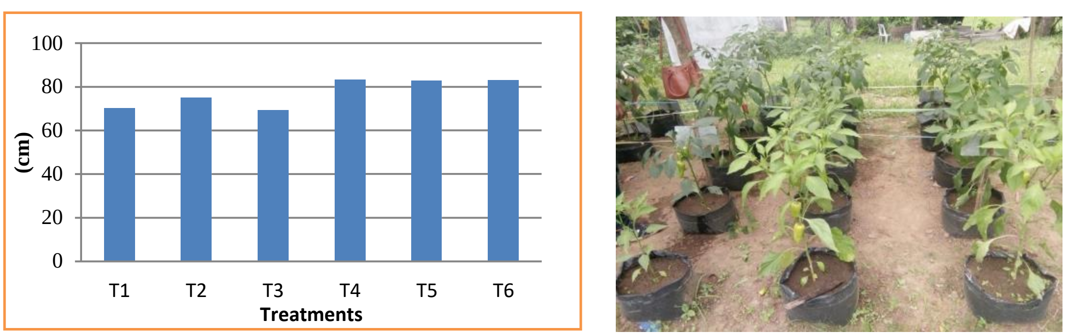


Figure 2 Plant height of sweet pepper two (2) months after transplanting.

Days from Transplanting to Flowering, Fruiting and Harvesting

Table 1 shows that the number of days from transplanting to flowering and fruiting was significantly affected by biochar addition. Early flowering and fruiting were observed in 100% CMC (T2) and 75% CMC and 25% CCC (T4). This shows that a higher amount of CMC (100% and 75%) as biochar addition enhances the production of earliness to promote flowering and fruiting of sweet pepper. It indicates that the nutrient released of a higher percentage of CMC was more efficient. This was reported by (12) poultry as biochar have higher nutrient-rich organic as an amendment to improve soil nutrient status which includes N, P, K, Ca, Mg, S, and Fe. However, no significant effect was observed on the number of days of harvesting from among the treatments.

Table 1. Number of days from transplanting to fruiting, flowering and harvesting

Treatment	Number of days from transplanting		
	Flowering	Fruiting	Harvesting
T1 - control	43.00 a	53.33 a	99.00
T2 – 100% CMC	36.67c	43.00 c	96.00
T3 - 100% CCC	43.67a	51.33a	89.67
T4 - 75% CMC + 25% CCC	36.33c	42.67 c	89.67
T5 - 50% CMC + 50% CCC	38.33b	46.00b	85.67
T6 - 25% CMC + 75% CCC	41.33b	49.00 c	85.67

Marketable Yield of Sweet Pepper

The yield of sweet pepper was significantly influenced by the application of CMC. The treatment of 100% CMC (T2) and 75% CMC+ 25% CCC (T4) have significantly achieved the higher yield as compared to the rest of the treatments (T1, T3, T5, and T6). This could be attributed by the early flowering and fruiting experienced by sweet pepper as shown in Table 1. It indicates that higher nitrogen, phosphorus and potassium build-up influenced by CMC [13] in the soil was realized throughout the growing period of sweet pepper as a vital component in increasing crop yield. The influence of CMC in increasing the yield of the crop was also reported in radish [14] and rice [15].

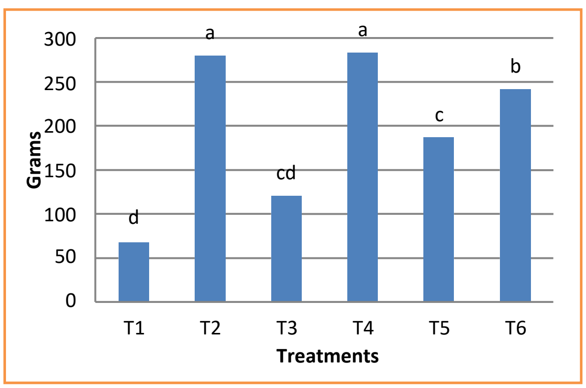


Figure 4. Marketable yield of sweet pepper per treatment

Initial Analyses of Soil, Chicken Manure Char and Coco Coir Char

The chemical properties of the soil and biochar used in the experiment are shown in Table 2. The initial soil analysis reflected that the soil used was moderately acidic, had a low amount of organic matter, a low amount of nitrogen and available phosphorus, and a high amount of potassium (Table 2). The low amount of nitrogen could partly explain the observed yellowish coloration of leaves in some plants, particularly in pots without CMC and CCC.

In contrast, the initial analysis of CMC and CCC found higher pH (slightly alkaline), high organic matter, a considerable amount of nitrogen and phosphorus, and moderately high exchangeable potassium contents. Similarly, biochar gave high values of pH, N, K and P contents [16].

Table 2. Initial soil, chicken manure char and coco coir dust char analysis.

Nutrient	Sample Values		
	Soil	Chicken Manure Char	Coco Coir Char
pH (H_2O)	5.20	9.15	10.03
Organic Matter (%)	2.37	17.8	6.2
Total Nitrogen (%)	0.12	0.50	0.05
Available Phosphorus (mg kg^{-1})	6.33	303	52
Exchangeable Potassium (mg kg^{-1})	152	204	126

Table 3. Influence of CMC and CCC on soil properties of acid soil

Treatments	Soil analysis				
	pH (H_2O)	OM (%)	N (%)	Avail. P (mg kg^{-1})	K (mg kg^{-1})
T1 - control	5.00d	2.27b	0.11c	6.33f	152.00b
T2 – 100% CMC	7.39a	2.67ab	0.13b	124.33a	309.67a
T3 – 100% CCC	6.17c	2.70ab	0.15ba	19.33e	372.33a
T4 – 75% CMC + 25% g CCC	7.40a	2.73ab	0.14ab	107.67b	306.67a
T5 – 50% CMC + 50% CCC	7.28a	2.87a	0.143ab	80.67c	313.00a
T6 – 25% CMC + 75% CCC	7.02a	2.83a	0.143ab	51.67d	320.67a

Means with the same letter are not significantly different at 5 % level significance.

Soil Chemical Characteristic after Harvest

Statistically, the study revealed that any combination rate of CMC and CCC addition gave the same effects in increasing the nutrient content of acid grassland soil. The results in Table 3 showed that soil after harvest was significantly affected after biochar addition, particularly by increasing the soil pH. The pH value of acid soil increased from 5.00 (T1) to 7.40 (T4). The increase in soil pH was expected due to the high pH value of the biochar. In the same study, soil pH and EC values increased significantly with biochar applications [16]. Their study also found that biochars have high pH, CaCO3 content, and base cation concentrations, which are essential chemical properties to determine their liming potential [17].

Likewise, OM and Nitrogen content of treated CMC and CCC acid soils are significantly affected as compared to control (T1). The addition of any combination rate of CMC and CCC (T4-T6) resulted in the highest values than that of the control. However, similarities in their effects in enhancing the organic matter and nitrogen content of the soil were observed. Moreover, the PLC and CCC treated soil (T2-T6), either solely or combined, had a better nitrogen level than the control. It implies that biochar application increases the nitrogen content of acid soil after harvest.

Results also showed a higher availability of phosphorous after CMC and CCC addition. The phosphorus availability of acid soil significantly increased after biochar addition. Specifically, the addition of CMC, either solely (T2) or combined with CCC (T4-T6), significantly increased the extractable phosphorus of acid soil after harvest. In contrast, the control obtained the lowest phosphorus availability in acid soil, indicating nutrient deficiency. Results also showed that there was a directly proportional increase of P when the CMC rate increases. Meanwhile, exchangeable K of acid soil significantly increased after the addition of CMC and CCC compared to that of control. Statistically, their sole or combined addition (T2-T6) had comparable effects in enhancing the availability of exchangeable K of acid soil. Likewise, their study reported that the application of biochar on acidic soil greatly increased the cation exchange capacity [17].

4. Conclusion

Application of combined chicken manure char and coco coir char in acid grassland soil increased the growth and yield of sweet pepper. The results indicated that the application of (T4 75% CMC + 25% CCC) is the optimum recommended rate to enhance the growth and yield performance of sweet pepper particularly plant height, number of days from transplanting to flowering, fruiting and harvesting and the fruit weight. Meanwhile, the soil properties (pH, OM, N, P, and K) of acid grassland soil was also increased with any of the combined rates of CMC and CCC addition.

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