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Soil Organic Carbon Dynamics in Different Production Systems in VSU

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ABSTRACT— Soil organic carbon (SOC) plays a significant role in soil fertility. Changes in SOC are associated with carbon input from organic materials. This study was conducted to assess the organic carbon dynamics of lowland soil from first to sixth cropping. A lowland area devoted to rice production under different production systems in six (6) successive croppings was evaluated. Results revealed that SOC changes with cropping. The second cropping generally showed higher SOC than the rest of the cropping period. In the sixth cropping, SOC in all production systems was comparable. The results suggest that organic amendments can be a good substitute for inorganic fertilizers in improving soil fertility aside from producing safe food to eat.

KEYWORDS: lowland rice, lowland soil, sequestration.

1. INTRODUCTION

Soil organic carbon (SOC) influences the soil's physical, chemical, and biological properties, thus affecting fertility. Soil organic carbon accounts for 50% of the total soil organic matter (SOM). High SOC usually results in an increased crop yield, thus benefiting agricultural production, food security, and climate mitigation [11], [17]. Therefore, production sustainability depends on maintaining high SOC levels [12].

However, the efficiency of agricultural management practices to store SOC depends on the carbon input level and saturation levels of soils [15]. For instance, in wetland rice cultivation, the sustainability of the soil fertility is excellent due to prolonged periods of submergence [14]. Yet, it is often dried two weeks before harvesting until land preparation for successive cropping. Frequent cycling between soil drying and wetting can stimulate microbial activity and enhance the rate of CO_2 evolution and organic matter decomposition [13].

To increase the organic carbon in the soil, sustainable management, including mulching, cover cropping, judicious fertilization and irrigation must be done [2], [5]. Inorganic fertilizer can increase the organic carbon in the soil, but only to a limited extent. On the other hand, applying organic amendment improves microbial biomass and soil fertility, and increases yield [19]. Under field conditions, applying organic inputs like crop residues, green manure, straw, compost, and other organic manures renewed SOM [1], [18], increasing the organic carbon of the soil. Furthermore, studies by [7], [8], [3], [4] claimed that the application of organic amendments enriched the organic carbon content of lowland soil.

Assessment of the dynamics of organic carbon in the soil after successive croppings under different production systems are essential. The information generated can help farmers adopt the most appropriate SOC management practice that will improve the stability and capacity of soils to store organic carbon. This is especially timely with the escalating prices of inorganic fertilizers. It is hypothesized that various production

systems under VSU conditions will have a different effect on the SOC dynamics after six successive croppings.

2. MATERIAL AND METHODS

2.1 Study Site, Experimental Design and Treatments

This study was conducted in the experimental area of the Department of Agronomy, Visayas State University, Visca, Baybay City, Leyte, Philippines (10º44'45''N 124º47'33''E) from 2016 to 2017. It was laid out in Randomized Complete Block Design (RCBD) with four replications and three treatments. A total of 12 plots measuring 30m^2 (5m x 6m) with an alleyway of 2m between replication and treatment plots. The same treatments were used for the croppings except for the fifth or residual cropping. The designated treatments are as follows:

T1: best bet production system (green leaf manuring + vermicast [37.26–508.25–13.07 kg N, P_2O_5, K_2O/ha] + vermitea [0.06–4.87–0.32 L N, P_2O_5, K_2O/ha] + fermented plant juice [0.94–23.70–7.02 L N, P_2O_5, K_2O/ha] + fermented fruit juice [0.67–3.42–39.06 L N, P_2O_5, K_2O/ha])

T2: organic farmers' practice in Leyte (vermicast [10.35–141.18–3.63 kg N, P_2O_5, K_2O/ha] + vermitea [0.04–3.13–0.21 L N, P_2O_5, K_2O/ha] + fermented plant juice [0.35–8.88–2.63 L N, P_2O_5, K_2O/ha] + fermented fruit juice [0.67–3.42–39.60 L N, P_2O_5, K_2O/ha])

T3: conventional farmers' practice in Leyte (109.04–17.5–17.5 kg N, P_2O_5, K_2O/ha)

The organic fertilizers used in the study were submitted to the Central Analytical Service Laboratory, PhilRootcrops, Visayas State University, Visca, Baybay City, Leyte for the determination of pH, total N, available P, exchangeable K and moisture content (MC) content. Results of the nutrient analysis (Table 2) revealed that vermicast had a near-neutral pH of 6.83 while FPJ was the most acidic (pH 4.20). Likewise, vermicast had the highest total N (0.69%) and P (4.11%), while FFJ had the highest K (18.18%). The analyses indicate that among the nutrient sources used, vermicast has the highest capacity to supply nutrients to rice crops.

Prior to the experiment, the plots assigned to T1 were applied with kakawate *(Gliricidia sepium)* as green leaf manure at the rate of 2 kg/m^2 and incorporated prior to final land preparation. This was allowed to decompose for at least two weeks before transplanting. Treatment 3 was applied with inorganic fertilizers at a rate of 109.04–17.5–17.5 kg N, P_2O_5, K_2O/ha. For basal application, a mixture of 125 kg/ha complete fertilizer plus 79 kg/ha urea was split. Half of which was applied a week after transplanting while the other half at 15 days later. This was followed by a top dressing of urea at 120 kg/ha during panicle initiation. Panicle initiation was determined by dissecting and visually observing the furry tip of the panicle at the center of the stem. The applied fertilizer was incorporated into the soil after application. On the other hand, T1 and T2 were applied with vermicast (69.16% MC) at 5 t/ha and 1.5 t/ha respectively, prior to transplanting.

For foliar sprays, Fermented Plant Juice (FPJ), Fermented Fruit Juice (FFJ) and vermitea were applied to T1 and T2. Treatment 1 was sprayed weekly with vermitea, a week after transplanting and alternately with 10% (1:9 FPJ-water ratio) solution of FPJ until flowering stage at 291.66 L/ha (0.06–4.87–0.32 L N, P_2O_5, K_2O/ha) and 500 L/ha (0.94–23.70–7.02 L N, P_2O_5, K_2O/ha), respectively. Vermitea spray was prepared at the rate of 1 L vermitea in every 15 L of water. Treatment 2, on the other hand, was applied weekly with a mixture of FPJ and vermitea at 375 L/ha (0.39–12.01–2.84 L N, P_2O_5, K_2O/ha) starting two weeks after transplanting

until heading stage. At the start of panicle initiation, FFJ was sprayed in T1 and T2 at 200 L/ha (0.67–3.42–39.60 L N, P_2O_5, K_2O/ha) at seven days intervals up to two weeks before harvest. Spraying of foliar fertilizers was done late afternoon between 4:00–5:00 pm.

2.2 Soil Sampling and Assessment of SOC Dynamics

Three soil samples per treatment per replication per cropping were collected from the experimental area before land preparation and after harvesting at a depth of 0-20 cm. These samples were air-dried, pulverized, sieved, and analyzed for % organic matter (Walkley and Black method) at the Central Analytical Service Laboratory, PhilRootcrops, Visayas State University, Visca, Baybay City, Leyte. The results obtained from the analysis were used to compute the % SOC.

2.3 Statistical Analysis

The consolidated data were analyzed using Statistical Analysis Software (SAS) Version 9.2 developed by SAS Institute. Significant means were compared using Tukey's or Honestly Significant Difference (HSD) test.

3. RESULT AND DISCUSSION

Figure 1 shows that sequestered organic carbon varies with cropping. The second cropping generally showed higher SOC than the rest of the cropping periods. Noticeable reduction of SOC from the first to the fourth cropping could be due to alternate drying and wetting of the soil. The soil was exposed to dry conditions with T1 when rice was alternately planted with mungbean (*Vigna radiata* L.) as green manure about seven weeks after the rice was harvested from the previous cropping. Similarly, T2 and T3 were exposed to the same condition due to synchronous rice planting among treatments.

The increase of SOC in the fifth or residual cropping could be attributed to the temporary cessation of the application of treatments wherein it had not undergone prolonged alternate wetting and drying. The SOC was not significant among production systems in the last. Unlike the residual cropping, it was not exposed to dry conditions seven weeks after the harvest of rice resulting in an increasing SOC. This confirms the findings of [6], [9] wherein sudden wetting and drying can destabilize the older organic carbon content of the soil. [10], [16] also reported that changes in litter quality, nutrient supply, vegetation, and microbial community can rapidly destabilize older organic carbon. The result is consistent with the findings of [4] that organic amendments in lowland ecosystems can substitute inorganic fertilizer to save resources and minimize unintended environmental consequences. Although, the agro-meteorological condition varies in every cropping season, which possibly affects the SOC dynamics of the lowland soil in VSU. The result of this study therefore can be used to entice or encourage farmers to adopt organic production practices as it can promote sustainability and safety for both farmers and consumers.

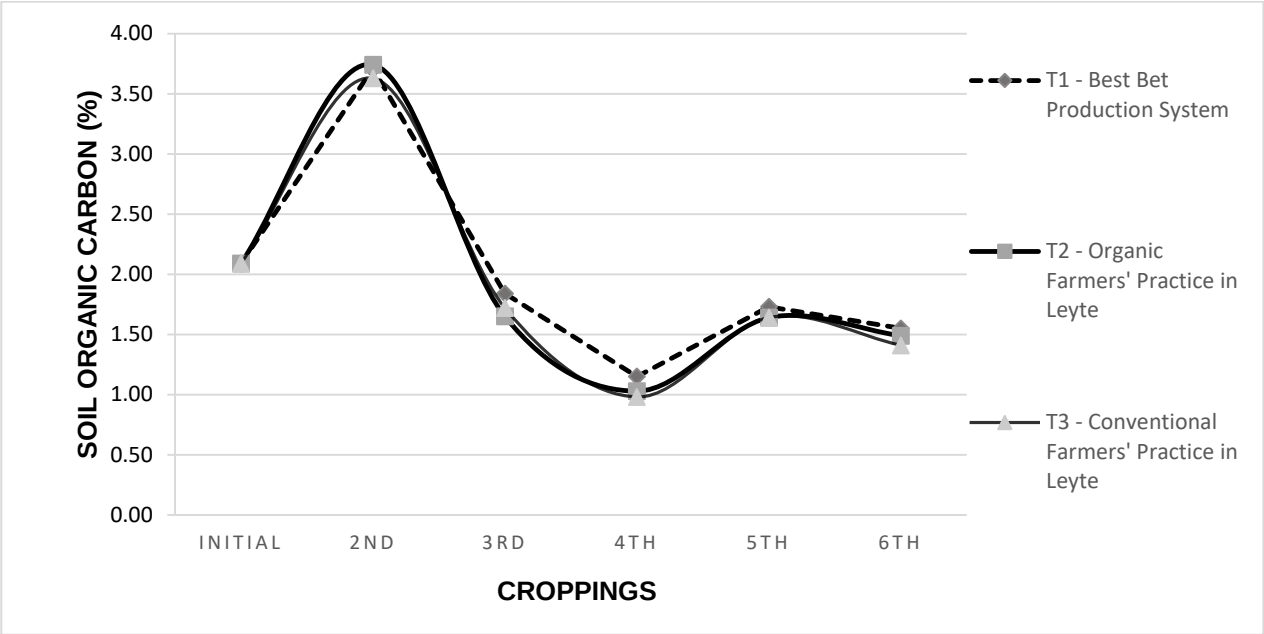

Figure 1. Soil organic carbon dynamics in lowland rice under different production systems from first to sixth cropping

Treatments:

T1: best bet production system (green leaf manuring + vermicast [37.26–508.25–13.07 kg N, P_2O_5, K_2O/ha] + vermitea [0.06–4.87–0.32 L N, P_2O_5, K_2O/ha] + fermented plant juice [0.94–23.70–7.02 L N, P_2O_5, K_2O/ha] + fermented fruit juice [0.67–3.42–39.06 L N, P_2O_5, K_2O/ha])

T2: organic farmers' practice in Leyte (vermicast [10.35–141.18–3.63 kg N, P_2O_5, K_2O/ha] + vermitea [0.04–3.13–0.21 L N, P_2O_5, K_2O/ha] + fermented plant juice [0.35–8.88–2.63 L N, P_2O_5, K_2O/ha] + fermented fruit juice [0.67–3.42–39.60 L N, P_2O_5, K_2O/ha])

T3: conventional farmers' practice in Leyte (109.04–17.5–17.5 kg N, P_2O_5, K_2O/ha)

4. CONCLUSION

Either the best bet production system (T1) or organic farmers' practice in Leyte (T2) can be highly adopted by farmers.

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