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Response of corn (*Zea mays* L.) to various organic-based fertilizers in the marginal upland of Sta. Rita, Samar

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ABSTRACT

Organic farming is one of the management strategies that improve productivity of marginal uplands. The study aimed to: (1) evaluate effects of various organic-based fertilizers on the growth and yield of corn; (2) determine the appropriate combination for optimum yield; and (3) assess changes on the soil physical and chemical properties. Experiment was laid out in Randomized Complete Block Design, with 3 replications and 7 treatments, namely; T_0=(0-0-0); T_1=1t ha^{-1} Evans + 45-30-30kg N, P_2O_5, K_2O ha^{-1}; T_2=1t ha^{-1} Wellgrow + 45-30-30kg N, P_2O_5, K_2O ha^{-1}; T_3= 15t ha^{-1} chicken dung; T_4=10t ha^{-1} chicken dung + 45-30-30kg N, P_2O_5, K_2O ha^{-1}; T_5=15t ha^{-1} Vermicast; and T_6=10t ha^{-1} Vermicast + 45-30-30kg N, P_2O_5, K_2O ha^{-1}. Application of organic-based fertilizers with or without inorganic fertilizers promoted growth of corn than the control. But due to high infestation of corn silk beetle (*Monolepta bifasciata* Horns), its grain yield was greatly affected. In the second cropping, except for Evans, any of these fertilizers applied alone or combined with + 45-30-30kg N, P_2O_5, K_2O ha^{-1} appeared appropriate in increasing corn ear yield. Soil physical and chemical properties changed with addition of organic fertilizers. While bulk density decreased irrespective of treatments, pH, total N, available P and exchangeable K generally increased more with chicken dung application.

Keywords: chicken dung, corn, marginal upland, organic-based fertilizer, vermicast

INTRODUCTION

Corn (*Zea mays* L.) is considered as the second staple crop after rice and is the major source of income for a number of Filipino farmers. Poultry and livestock

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industry greatly rely on this crop as the main source of feeds and is increasingly utilized as raw materials in the manufacturing sector (Gerpacio et al 2004). With these multiple uses and ongoing economic growth and urbanization, the projected demand for corn in the country is highly expected. Relative to this, nutrient management trials using different kinds of organic fertilizer have been done to ascertain productivity of corn, especially when grown in barren or marginal soils.

The low fertility status of marginal uplands is commonly neglected. Farmers keep on utilizing these upland areas for crop production despite their vulnerability to soil degradation. To attain and boost the quality of produce, the use of organic-based fertilizers is encouraged due to its beneficial effects on soil properties. Organic farming can promote sustainability in marginal uplands as it encourages ecological processes that provide nutrients, conserve soil and water resources (Altiere et al 2012, Mercati 2016). Organic system offers resource poor farmers the opportunity to improve production by increasing soil fertility and biodiversity, with less reliance on external inputs, as well as gain premium prices of produce (Knudsen et al 2005, Altiere et al 2012). It also improves the environment and on-farm profitability (Mercati 2016, Arguilera 2013, Reganold 1995).

Globally, there is growing interest in the use of organic fertilizers due to the negative impacts of continuous use of inorganic fertilizers. Although the latter can provide high and immediate release of nutrients, heavy usage of synthetic or chemical fertilizer and pesticides caused ill effects not only to consumers' health but also to the environment (Pimentel 2005). In addition, extensive use of agrochemicals brought more degradation, depleted groundwater, triggered pests' resurgence and eroded biodiversity (FAO 2013). Thus, a sustainable management strategy is needed to help conserve and enhance natural resources of marginal uplands. Making use of natural inputs like organic-based fertilizers may invoke processes that reduce negative impacts to the environment, thus increase resilience of an agricultural production system.

Organic fertilizers have many advantages. Aside from providing essential nutrients to plants, they also improve soil tilth, aeration, water holding capacity and promote microbial activity in the soil that make nutrients readily available (Choudhary 1994, Lal 1997 & Warren et al 2006). Organic fertilizer management also affects the enzymatic activities (Yang et al 2008, Zhu et al 2008) and the physical condition of the soil by lowering bulk density, as well as increasing porosity and buffering capacities (Edmeades 2003). In the Philippines, full organic farmers have considerably higher on-farm crop diversity than conventional farmers, better soil fertility, less soil erosion, increased crops' tolerance to pests and diseases and have better farm management skills (Altiere et al 2012).

Several studies have been done on the use of farm wastes. Composted chicken manure was found to be superior in influencing the yield components of corn than using composts of straw and palm fronds (Jasim et al 2014). This is due to the poultry manure's contribution in increasing soil organic matter which leads to the increase availability of some elements, as well as increased root penetration and nutrient absorption (Dikiny & Mufwanzala 2010). Increasing compost increased photosynthetic efficiency due to nutrient availability in the soil brought by decaying organic matter, thus increased the number of grains per cob (Farhad et al 2009).

A number of organic-based fertilizers are now commercially available in the market and locally in the farm. Claims have been posted about their promise yet there is limited scientific information on its use in a specific site. In Inopacan, Leyte, promising results on corn were obtained with the use of either chicken dung or vermicast at 10t ha^{-1} but supplemented with 45-30-30kg N, P_2O_5, K_2O ha^{-1} inorganic fertilizer (Ratilla et al 2014). Hence, to have a location-specific result, the study was expanded in Brgy. Caticugan, Sta. Rita, Samar to: 1) evaluate the effects of organic fertilizers on the growth and yield performance of corn when applied singly or in combination with inorganic fertilizer; 2) determine the appropriate combination that will give optimum yield of corn; and 3) evaluate their effects on the physical and chemical condition of the soil. This was done in Sta. Rita, Samar as it has marginal uplands that are adjacent to the highway for awareness among people in the community on organic agriculture. The area has no fertility management trials yet, hence this study.

MATERIALS AND METHODS

Description of the Study Site

The experimental site in Sta. Rita, Samar was established in a gently sloping area which had been left idle for about 7 years. It is considered marginal as characterized by its being strongly acidic with low amounts of organic matter, total Nitrogen and available P contents (Asio et al 2015). It belongs to a Type IV climate where rainfall is more or less evenly distributed throughout the year, with an average monthly rainfall of 2545mm. The area has relative proximity to the highway so it would be easier for people in the community to see and be aware of this organic agriculture set-up.

Land Preparation, Soil Sampling and Analysis

The experimental area was plowed and harrowed twice, using a tractor at weekly interval, to provide a good soil condition for seed germination and seedling establishment. After the last harrowing, furrows were made at a distance of 0.75m apart. For the initial soil analysis, ten soil samples were collected randomly from the experimental field at depths 0-20cm. These were composited, airdried, pulverized, sieved at 2mm wire mesh and analyzed at the Central Analytical Services Laboratory for soil pH, organic matter content, total nitrogen, available phosphorus and exchangeable K. The bulk density of the soil was determined by getting samples using a core sampler. Soil samples were oven-dried at 105^0C for 72h and weighed. Bulk density values were computed using the formula:

$$D_b = \frac{Ms}{Vt}$$

where: Ms = mass of soil (final oven dry weight)
$Vt = \pi r^2 h$; $\pi = 3.1416$; r = radius; and h= height of the core

For the final soil analysis, three samples were collected from each treatment plot within the harvestable area, after harvesting the crop. These were air-dried, composited per treatment and processed to determine the same soil parameters mentioned above.

Experimental Design, Treatments and Field Lay-out

The experiment was laid out in Randomized Complete Block Design (RCBD), with three replications and seven treatments. Each replication was divided into seven plots, consisting of 6 rows per plot at 16 hills per row, with a plot size of 4m x 4.5m. Alleyways of 1m between plots and 1m between replications were made to facilitate farm operations and data gathering.

The treatments were designated as follows: T_0=No fertilizer applied; T_1=1t ha^{-1} Evans + 45-30-30kg N, P_2O_5, K_2O ha^{-1}; T_2=1t ha^{-1} Wellgrow + 45-30-30kg N, P_2O_5, K_2O ha^{-1}; T_3=15 t ha^{-1} chicken dung alone; T_4=10t ha^{-1} chicken dung + 45-30-30kg N, P_2O_5, K_2O ha^{-1}; T_5= 15t ha^{-1} vermicast; T_6=10 t ha^{-1} vermicast + 45-30-30kg N, P_2O_5, K_2O ha^{-1}.

Organic fertilizers were applied in each treatment plot, following the rates specified in the treatments and not on dry weight basis. These were evenly distributed along furrows and covered thinly with soil, two weeks before planting. For T_1, T_2, T_4 and T_6, complete fertilizers at the rate of 30-30-30kg N, P_2O_5, K_2O ha^{-1} were drilled in furrows at planting, then covered with soil before sowing the seeds. The remaining 15kg N ha^{-1} was sidedressed using urea at 25 days after planting to satisfy the recommendation. T_1 and T_2 were following the respective manufacturer's recommendation, in terms of the amount of organic fertilizer used.

Planting and Thinning

Corn seeds of IPB Var. 11 were sown at a distance of 75cm between rows and 25cm between hills. Two to three seeds were planted and thinned to one plant per hill, one week after germination to satisfy the desired plant population of 53,333 plants per hectare.

Weeding and Harvesting

Weeds were controlled by hand weeding, while hilling up was done manually in each treatment plot after sidedressing. In the first cropping, harvesting was done when the corn plants had reached maturity. Only plants from the four inner rows (excluding the end hills) were harvested. Harvested corn ears were dehusked, sun-dried and shelled. Afterwards, the grains were sundried again before gathering the necessary data. For the second cropping, corn was harvested when it reached green cob stage for boiling.

Data Gathered

The following agronomic characteristics were evaluated for corn: number of days from seeding to tasseling, silking and maturity, plant height (cm), leaf area index (LAI) and fresh stover yield (t ha^{-1}). The yield and yield components included: ear length (cm), ear diameter (cm), weight of 1000 seeds (g), grain yield (t ha^{-1}) and harvest index. But in the second cropping, since corn was harvested when at green cob stage, the data gathered were ear size, number and weight of both marketable and non-marketable ears, as well as harvest index.

Data Analysis

The consolidated data was analyzed using SAS version 6.02 and treatment means for significant parameters were compared using Tukey's Studentized Range (HSD) test.

RESULTS AND DISCUSSIONS

Soil Analysis

Initial soil test results revealed that the experimental site in Sta. Rita, Samar was highly acidic and had low nutrient status (Table 1). The soil was very strongly acidic, medium in organic matter, very low in nitrogen and phosphorus, but had medium amount of exchangeable K (Landon 1991). Generally, soil analysis after harvest showed an increase in pH, nitrogen, extractable phosphorus and exchangeable potassium more in treatment plots added with chicken dung. The organic matter content, however, decreased which could possibly be due to the decomposition of the added organic materials. The bulk density values decreased relative to the initial determination in all treatments, which could be due to the addition of organic materials and cultivation that somehow improved the physical condition of the soil. The pH increased from very strongly to strongly acidic, total N and exchangeable K from low to medium and high amount, respectively, while available P was from very low to high content, especially in plots treated with chicken dung, based on Landon (1991) reference values. This could be related to the high inherent nutrient content of chicken dung as compared to the other organic materials.

Table 1. Initial and final physical and chemical analysis of soil planted to corn as affected by the application of various organic-based fertilizers in Sta. Rita, Samar

Treatments	Bulk density (g cc^{-1})	pH (water) (1:2.5)	OM (%)	Total N (%)	Available P (mg kg^{-1})	Exchange-able K (mg kg^{-1})
Initial	1.19	4.72	7.33	0.14	2.47	25.50
T_0 = 0-0-0 (control)	0.72	5.31	3.28	0.202	9.61	53.40
T_1 = 1t ha^{-1} Evans + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	0.65	4.86	3.12	0.158	7.35	23.90
T_2 = 1t ha^{-1} Wellgrow + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	0.64	4.92	3.35	0.158	3.35	25.73
T_3 = 15t ha^{-1} chicken dung alone	0.66	5.25	3.67	0.216	24.56	205.18
T_4 =10t ha^{-1} chicken dung + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	0.58	5.12	3.43	0.202	28.70	262.20
T_5 = 15t ha^{-1} Vermicast alone	0.67	5.09	3.12	0.187	12.98	68.43
T_6 = 10t ha^{-1} Vermicast + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	0.65	4.99	3.51	0.187	17.02	60.15
Mean	0.65	5.08	3.35	0.19	14.80	99.86

Agronomic Characteristics of Corn

Figure 1 shows the plant height of corn as affected by the application of different organic-based fertilizers. Initially, no significant variations were observed, however, in the succeeding monthly gathering periods, those treated with organic or its combination with inorganic fertilizers were significantly taller than the untreated control (T_0). This indicates that the applied fertilizer inputs promoted the growth and development of corn plants. Although there was limited moisture during the first month of corn growth, (Figure 2) rainfall scarcity was partially solved by watering. The LAI and stover yields were also significantly affected (p<0.05) by the treatments (Figure 3). LAI values were markedly bigger that resulted to heavier stover yields (p<0.05) when corn was applied with organic fertilizers combined with inorganic fertilizers than the untreated control. However, the application of Evans + inorganic fertilizer had comparable LAI and stover yields with the control. This could be due to the inherent acidic characteristics of Evans, having a pH value of 4.66 (Ratilla et al 2014) which further increased soil acidity (Table 1). This possibly lowers the availability of total N for vigorous crop growth as manifested by shorter plants, comparable with the untreated control.

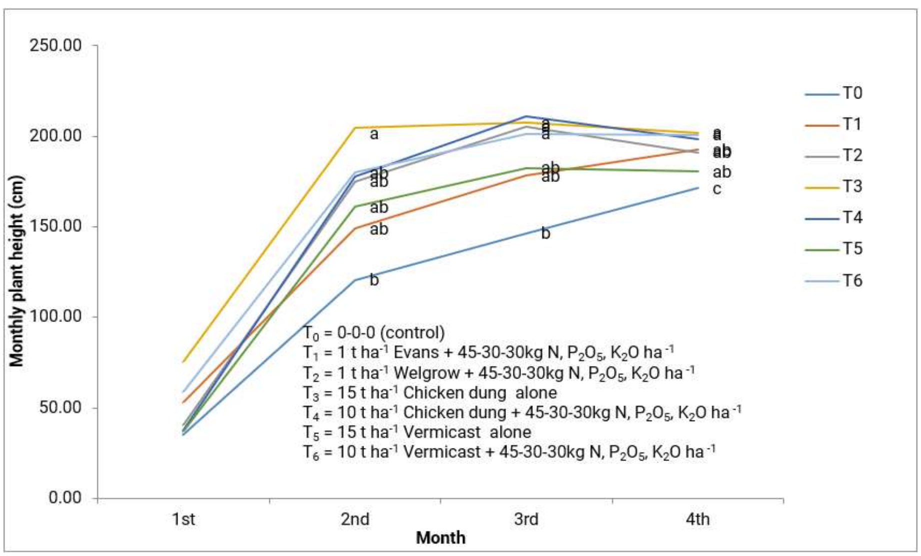

Figure 1. Monthly plant height of corn grown under various organic-based fertilizers in Sta. Rita, Samar (first cropping)

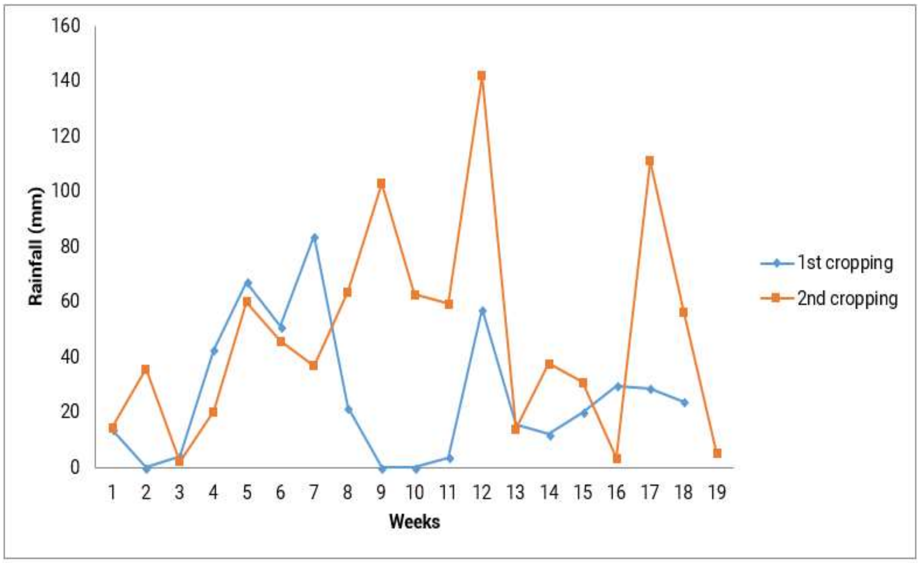

Figure 2. Total weekly rainfall in Brgy. Caticugan, Sta. Rita, Samar grown to corn applied with various organic-based fertilizers combined with inorganic fertilizers

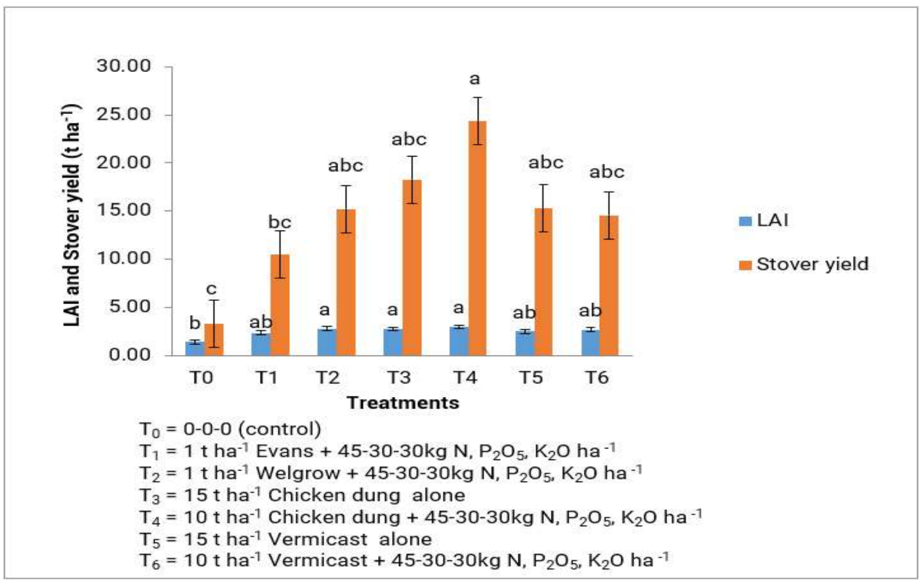

Figure 3. Leaf area index and stover yield of corn as influenced by the application of various organic-based fertilizers in Sta. Rita, Samar (1st cropping)

During the second cropping, corn was only up to green cob stage. The application of various organic-based fertilizers significantly (p<0.05) influenced plant height, leaf area index and stover yield (Table 2). Plants applied with fertilizers either from organic & inorganic materials were significantly taller, have bigger leaf area indices and heavier stover yields than the untreated control. Highest stover yield was obtained with 10t ha^{-1} chicken dung + inorganic supplement but comparable to all other treatments, except for the untreated control. The results indicate that under marginal uplands, addition of nutrients is necessary to cause a considerable response of the crop. Supplementation with a half dose of the recommended inorganic fertilizer was seen indispensable under this marginal upland so as to provide a quick head start of crops. With a very strongly acidic soil (pH4.72), some essential elements like N and P are expected to become limiting, thus needs addition of inorganic supplements.

Table 2. Agronomic characteristics of green corn as affected by the application of various organic-based fertilizers in Sta. Rita, Samar (2nd cropping)

Treatments	Plant Height (cm)	Leaf Area Index	Fresh Stover Yield (t ha^{-1})
T_0 = 0-0-0 (control)	197.58b	2.88b	10.60c
T_1 = 1t ha^{-1} Evans + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	206.28ab	3.43ab	15.18bc
T_2 = 1t ha^{-1} Wellgrow + 45-30-30kg N, P_2O_5, $K_2O ha^{-1}$	233.97ab	3.62a	20.71ab
T_3 = 15t ha^{-1} Chicken dung alone	232.58ab	3.73a	22.76ab
T_4 = 10t ha^{-1} chicken dung + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	245.43a	3.77a	25.23a
T_5 = 15t ha^{-1} Vermicast alone	235.95ab	3.29ab	18.18abc
T_6 = 10t ha^{-1} Vermicast + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	231.55ab	3.41ab	18.63abc
Mean	226.19	3.44	18.76
CV (%)	7.03	7.28	18.12

Means in a column followed by a common letter or without letter designations are not significantly different at 5% level of significance using Tukey's Studentized Range (HSD) test.

Yield and Yield Components and Harvest Index

In the first cropping, ear size, grain yield, as well as harvest index of corn were not significantly affected by the treatments (Figure 4 & 5). During its early phase of growth for more than one month period, the crop was affected by drought and at silking stage, it was heavily infested with corn silk beetle (*Monolepta bifasciata* Hornst **)** (Figure 6). The severe infestation of corn silk beetle inhibited pollination and fertilization that resulted in the production of ears with unfilled grains. This consequently led to a very low yield which did not even reach 1t ha^{-1}.

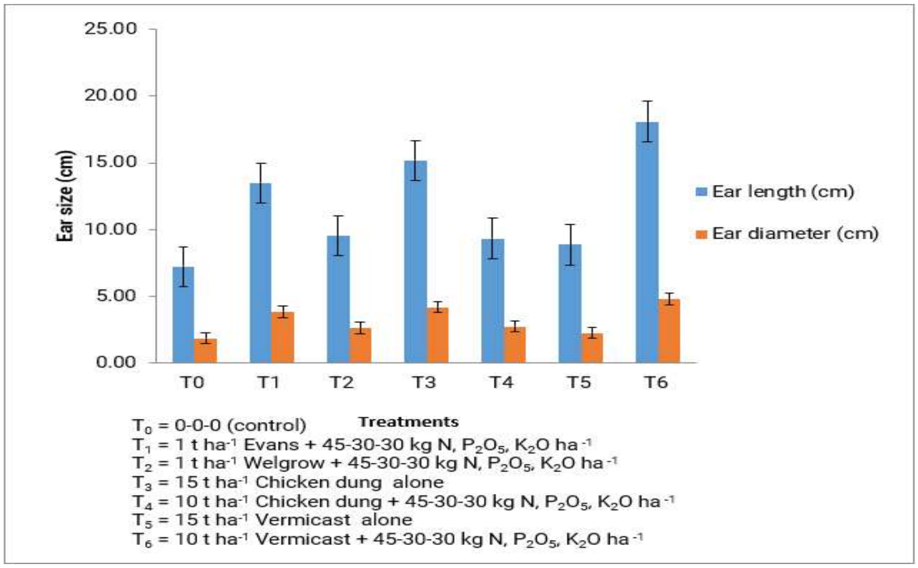

Figure 4. Ear size of corn as influenced by the application of various organic-based fertilizers in Sta. Rita, Samar (1st cropping)

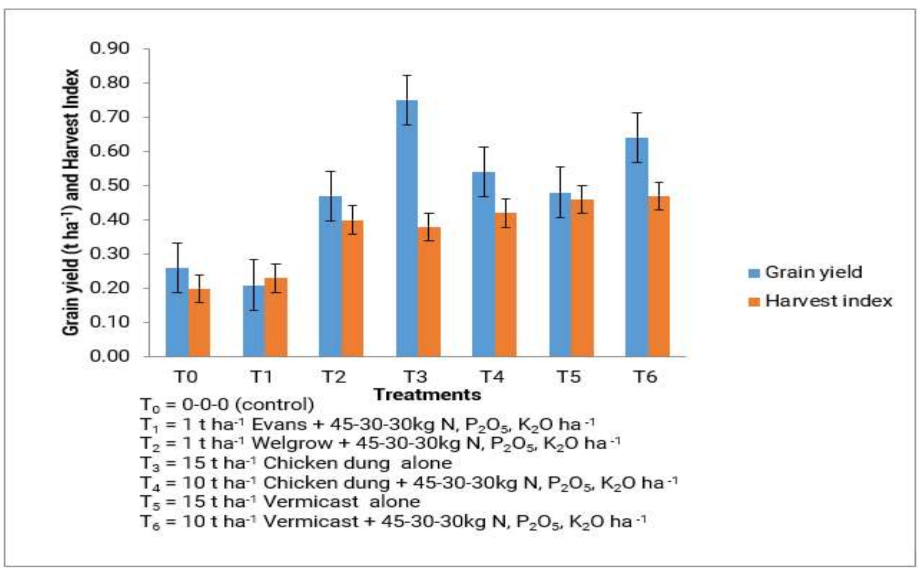

Figure 5. Grain yield and harvest index of corn as influenced by the application of various organic- based fertilizers in Sta. Rita, Samar (1st cropping)

Figure 6. Corn infested with corn silk beetle (*Monolepta bifasciata* Hornst)

Likewise, the dry spell caused some seeds not to germinate on time, that replanting was necessary. It was noted that replanted crops were the ones greatly infested at silking stage. Population of corn silk beetle was so high that they have eaten the silks of replants. Had there been no dry spell, effects would not have been so great since those which germinated and succumbed the moisture stress developed ears filled with grains. Ear length and diameter were statistically similar, irrespective of treatments. Nevertheless, treated corn plants had a fairly good stand during its vegetative growth but because of the attack of corn silk beetle, this led to failure of pollination. Most of the silks were eaten (Figure 6) which consequently led to very low productivity, as vouched by very low harvest index.

In the second cropping, corn applied with organic fertilizers alone or in combination with inorganic fertilizers was far better than the untreated control. Significantly longer and bigger ears with more marketable ears were produced per plot in the former treatments, as compared to the latter (Table 3). This consequently resulted in markedly heavier marketable and total ear yields than those treated with Evans+ 45-30-30kg N, P_2O_5, K_2O ha^{-1} and the untreated control (Table 4). The results indicate that except for Evans, the rest of the organic fertilizers used with or without supplemental inorganic fertilizers not only enhanced growth and development, but also the corn ear yield. Despite Evans having relatively higher nutrient content, its very acidic nature (Ratilla et al 2014) increased soil acidity making other nutrient elements, especially N and P, least available for corn uptake. In most cases, those treated with Evans or the untreated control was comparably inferior. There was no significant differences on the number of non-marketable ears and harvest index.

Table 3. Ear size and number of ears plot^{-1} of green corn as affected by the application of various organic-based fertilizers in Sta. Rita, Samar (2ndcropping)

Treatments	Ear size (cm)		Number of ears plot^{-1}	
	Length	Diameter	Marketable	Non-marketable
T_0 = 0-0-0 (control)	11.96b	3.88b	6.00b	14.33
T_1 = 1t ha^{-1} Evans + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	13.19ab	4.33a	18.67ab	9.67
T_2 = 1t ha^{-1} Wellgrow + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	14.53a	4.42a	31.00a	9.33
T_3 = 15t ha^{-1} Chicken dung alone	14.28a	4.54a	26.67a	5.67
T_4 = 10t ha^{-1} chicken dung + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	14.67a	4.66a	27.33a	9.67
T_5 = 15t ha^{-1} Vermicast alone	13.73ab	4.33ab	23.33ab	11.67
T_6 = 10t ha^{-1} Vermicast + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	12.75ab	4.28ab	26.00a	8.33
Mean	13.59	4.35	8.13	14.00
CV (%)	5.03	4.02	26.77	31.18

Means in a column followed by a common letter or without letter designations are not significantly different at 5% level of significance using Tukey's Studentized Range (HSD) test.

Table 4. Weight of ears and harvest index of green corn as affected by the application of various organic-based fertilizers in Sta. Rita, Samar (2ndcropping)

Treatments	Weight of Ears (t ha^{-1})			Harvest Index
	Marketable	Non-marketable	Total Ear Yield	
T_0 = 0-0-0 (control)	1.73c	0.89	2.87c	0.40
T_1 = 1t ha^{-1} Evans + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	4.01bc	0.57	4.77bc	0.45
T_2 = 1t ha^{-1} Wellgrow + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	6.67a	0.68	7.43a	0.45
T_3 = 15t ha^{-1} Chicken dung alone	6.19ab	0.78	7.08ab	0.42
T_4 = 10t ha^{-1} chicken dung + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	6.32ab	0.80	7.57a	0.41
T_5 = 15t ha^{-1} Vermicast alone	4.72ab	1.08	6.13ab	0.43
T_6 = 10t ha^{-1} Vermicast + 45-30-30kg N, P_2O_5, K_2O ha^{-1}	5.47ab	0.69	6.69ab	0.47
Mean	5.02	0.78	6.08	0.43
CV (%)	13.03	30.72	14.62	7.30

Means in a column followed by a common letter or without letter designations are not significantly different at 5% level of significance using Tukey's Studentized Range (HSD) test.

CONCLUSIONS

1. Most of the agronomic characters of corn grown in Sta. Rita, Samar during the first and second cropping were significantly affected by the treatments. Application of either wellgrow, chicken dung or vermicast, singly or in combination with inorganic supplements, promoted growth of corn far better than the untreated

control; but due to the high infestation of corn silk beetle during the first cropping, grain yield was greatly reduced.

2. In the second cropping, except for Evans, any of the organic-based fertilizers applied alone or in combination with + 45-30-30kg N, P_2O_5, K_2O ha^{-1} is considered appropriate in increasing corn ear yield the marginal upland of Sta. Rita, Samar.

3. Application of various organic-based fertilizers brought positive changes in the physical and chemical properties of the soil. Bulk density decreased in all treatment plots. An increase in pH from very strongly to strongly acidic, from low to medium and high amount for total N and exchangeable K, respectively, and from very low to high content of available P, were noted more in plots treated with chicken dung.

4. Water availability is also a key factor in enhancing the productivity of marginal uplands.

RECOMMENDATIONS

1. An extensive assessment on the use of these organic fertilizers is recommended for long- term effects in other marginal uplands.

2.To conduct the same study in other marginal uplands of more or less the same agroecoystem, at times when moisture is not a limiting factor.

3.Cost and return analysis shall be considered only after at least 3 cropping periods.

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