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RESEARCH ARTICLE

Performance of three corn (*Zea mays* L.) varieties as influenced by the combined application of organic and inorganic fertilizers

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Abstract

An experiment on corn varieties to the combined application of organic and inorganic fertilizers was conducted. The study was laid out in a split plot arranged in RCBD with three corn varieties as the main plot while six fertilization strategies as subplot treatment such as follows; S_1 - No fertilizer application; S_2 - 90-60-60 kg ha^{-1} N, P_2O_5, K_2O; S_3 – 5 t ha^{-1} V_4 Organic Fertilizer; S_4 - 3.75 t ha^{-1} V_4 Organic Fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O; S_5 - 2.50 t ha^{-1} V_4 Organic Fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O and S_6 - 1.25 t ha^{-1} V_4 Organic Fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O. The hybrid corn variety "Macho F_1" developed longer, bigger, and heavier ear weights; produced the highest marketable ear and total ear yield (t ha^{-1}), and achieve a higher gross margin of USD 2,782.15. The application of 1.25 t ha^{-1} V_4 organic fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) and 2.50 t ha^{-1} V_4 organic fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) enhanced remarkably the agronomic characteristics, and the yield and yield component parameters especially the weight of marketable ears (t ha^{-1}) that result to achieve higher gross margins. The combined application of fertilizers is recommended to corn growers not only in helping their financial production constraints but this will support an adaptation strategy in reducing the ill effect of climate change in their corn production undertaking in the tropics

Keywords: Combined application; Macho F_1; open-pollinated variety; sweet corn; Tiniguib.

1. Introduction

Corn (*Zea mays* L.) is one of the most important food crops worldwide and is considered the principal cereal crop cultivated in the tropics and subtropical countries. This crop is of high economic value due to its high source of energy, minerals, vitamins, and essential amino acids (Hossain *et al.*, 2018).

Sweet corn (*Zea mays* L. var. saccharata) particularly Macho F_1 hybrid variety is one of the most popular corn types because of its sweet taste, nutritional content, and economic value (Najeeb *et al.*, 2011). The kernels contain a high amount of carbohydrates, proteins, vitamins, and minerals (Nuss & Tanumihardjo 2010). The stalk is processed into silage for livestock which eventually adds income for the farmers (Chaudhary *et al.*, 2011). Sweet corn can be grown easily for a shorter period and is more profitable than corn intended for grain production (Lucas *et al.*, 2018). However, the milky corn type or variety is "Tiniguib" or native Visayan white corn which is used as an ingredient in cooking mostly for desserts and specialty foods, such as Maja Blanca, corn and coconut milk pudding, pintos-a milk and young white corn pudding wrapped in a corn husk. It can also be roasted to produce a corn drink resembling coffee

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in a flavor called "kapeng mais". A tea may be made from corn silk. The "Tiniguib" variety is a healthier staple than rice because of its low glycemic index. It is slower to digest resulting in a gradual release of glucose into the bloodstream, thus lessening the risks of diabetes. It is sold in local markets both as ears of corn and milled as corn grits. It is believed that an increase in white corn consumption could help reduce the Philippines' dependence on rice imports.

The acceptance of the produced crop can be influenced by the source of nutrients involved during production. Generally, in developing countries, a kilogram of crop produced using organic fertilizers commands a better price than the same quantity of production using inorganic fertilizers. This is because the former is devoid of synthetic chemicals than the latter. Besides, the organic matter produced during decomposition can be beneficially added into the soil in supplying essential macro and micronutrients to the growing crops. In most studies, organic fertilizer application has been observed to have a positive effect on soil's physical and biological properties. However, with a high application rate of nutrients, it will often lead to a risk of water and soil pollution. Thus, integrated nutrient management (INM) by complementary utilization of chemical fertilizer and organic materials seems to be the best way to solve this problem. The INM involves the combination of both inorganic and organic fertilizers to increase crop production according to Janssen (1993). A crop production system with high-yield targets cannot be sustainable unless balanced nutrient inputs are supplied to soil against nutrient removal by crops (Bhuiyan *et al.*, 1991). Neither organic manure nor chemical fertilizer alone can increase satisfactory yield under intensive farming. Therefore, a judicious combination of both organic and chemical fertilizers helps to maintain soil and crop productivity (Kumar *et al.*, 2011). The combined application of available organic sources along with an optimal dose of inorganic fertilizer assures high and sustained productivity due to regulated nutrient supply and reduced losses (Manna *et al.,* 2003). Balanced usage of fertilizer helps increase crop yield from 30 to 60 percent in different regions of the country. Based on the above facts, this study is designed to investigate and quantify the effects of the combined application of organic and inorganic fertilizers on the growth and yield performance of three corn varieties under tropical conditions.

2. Materials and methods

This study was conducted in the experimental field of the Department of Soil Science, College of Agriculture and Food Science, Visayas State University (VSU), Visca, Baybay City, Leyte. An area of 1,306.87m^2 was plowed and harrowed twice at a weekly interval to remove the weeds and pulverize the soil. After the last harrowing, furrows were made following the planting distance of 75cm between rows for all treatment plots. An alleyway of 75cm separating each plot was provided to prevent fertilizers from contaminating other treatments. Drainage canals were constructed around the experimental area and between replications to avoid waterlogging during heavy rains.

Before the establishment of the experiment, ten soil samples were randomly collected from the experimental area before the application of treatments. The collected samples were composited, air-dried, sieved using two (2) mm wire mesh and submitted for analysis at the Central Analytical Service Laboratory (CASL), Phil Root crops, VSU, Visca, Baybay City, Leyte, Philippines. The soil samples were analyzed for soil pH (1:2.5 soil water ratio; ISRIC 1995), percent organic matter content (Modified Walkley Black Method, PCARR 1980), percent total N (Modified Kjeldahl Method, Nelson and Sommers 1982), available phosphorus (Modified Olsen Method, Olsen *et al.,* 1954) and exchangeable potassium (Ammonium Acetate Method, ISRIC 1995).

The experiment was laid out in a split plot arranged in a Randomized Complete Block Design (RCBD) with three main plots, six subplots, and three replications. Each plot measuring 4.5m x 4m (18m²) was prepared with six rows per plot. Alleyways of one meter between replications and 75cm between the main plot and subplot were provided to facilitate farm operations and management as well as data gathering. The main plot treatments were designated as follows: M_1 = Hybrid Variety (Macho F_1), M_2 = Improved OPV Variety (IPB VAR 11) and M_3 = Local OPV Variety (Tiniguib). The subplot treatments were also designated as follows: S_1 = No fertilizer application (control), S_2 = 90-60-60 kg ha^{-1} N, P_2O_5, K_2O (Recommended Rate), S_3 = 5 t ha^{-1} V_4 Organic Fertilizer, S_4 = 3.75 t ha^{-1} V_4 Organic Fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O, S_5 = 2.50 t ha^{-1} V_4 Organic Fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O and S_6 = 1.25 t ha^{-1} V_4 Organic Fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O.

Table 1. Amount of fertilizers applied per plot (18 m^2)

Subplot Treatment	Amount of fertilizer applied (kg $plot^{-1}$)		
	Organic Fertilizer (V_4)	Inorganic Fertilizer	
		Complete Fertilizer (14-14-14)	Urea Fertilizer (46-0-0)
S_1	-	-	-
S_2	-	7.77	0.12
S_3	9	-	-
S_4	6.75	0.19	0.03
S_5	4.50	0.39	0.06
S_6	2.25	0.58	0.09

V4 organic fertilizer (2.8-4.8-3.7) was used as organic fertilizer. Urea (46-0-0) and complete fertilizer (14-14-14) were purchased at St. Jude, Ormoc City, Leyte, Philippines. V4 organic fertilizer was applied before planting by equally distributing the required amount in the furrow in each designated treatment plot. Likewise, the complete fertilizer (14-14-14) was uniformly drilled in the furrows in each treatment plot at planting urea fertilizer (46-0-0) which was applied 14 days after planting. The above-mentioned fertilizers were covered with topsoil after their application**.**

Corn seeds (Macho F_1 hybrid, Improved OPV IPB VAR 11, and Local (OPV Tiniguib) were sown in furrows at a distance of 0.75m between rows and 0.25m between hills at two to three seeds per hill. Thinning to one plant per hill was done one week after emergence while replanting was also done on missing hills to meet the desired plant population of 53,333 plants ha^{-1}. Off-baring was done before hilling-up and this was employed two weeks after seedling emergence in each treatment plot. This was undertaken to put the soil towards the plant for better anchorage, stability, and suppressing weed growth. Manual weeding was performed at the base of the plants and in between rows after hilling-up operations. Harvesting of corn was undertaken when all plants in each plot reached the green cob stage. Only plants in the four inner rows in each treatment plot were harvested excluding one border row on each side and one end hill in each row. The total harvestable area is 9 m^2**.**

Data gathered relative to the agronomic characteristics were the number of days from sowing to tasseling, silking, and green cob stage; plant height (cm), leaf area index (LAI), and fresh stover yield (t ha^{-1}). However, the yield and yield components gathered were the ear length (cm), ear diameter (cm), ear weight (g), number of marketable ears $plot^{-1}$ and non-marketable ears plot^{-1}, the weight of marketable ears and non-marketable ears (t ha^{-1}), the total weight of marketable and non-marketable ears (t ha^{-1}). Cost and return analysis focusing on the calculation of gross income and gross margin was done. Meteorological data based on total weekly rainfall, minimum and maximum temperatures, and relative humidity throughout the conduct of the study were taken from the Philippine Atmospheric Geophysical and Astronomical Services (PAGASA) Station, Visayas State University, Visca, Baybay City, Leyte, Philippines. Then, the analysis of variance (ANOVA) of all data was done using the Statistical Tool for Agricultural Research (STAR) version 2.0.1 2014. Honestly Significant Difference (HSD) was used for comparison among treatment means.

3. Results and discussion

Total weekly rainfall (mm), average weekly minimum and maximum temperatures (°C), and relative humidity (%), throughout the experiment (January 29 to May 06, 2020) were obtained from Philippine Atmospheric Geophysical and Astronomical Services (PAGASA) Station, Visayas State University, Visca, Baybay City, Leyte, Philippines (Figure 1). The total amount of rainfall of 442.00mm throughout the study was lower than the optimum rainfall requirement of corn which is 610mm (PCARRD 1986). This means that the amount of rainfall was not sufficient for the growth and development of the crop. The average minimum and maximum temperatures were 25.14°C and 30.21°C, respectively which were within the range of 18-30°C favorable for corn production (Sanchez *et al.*, 2013). Likewise, the average relative humidity of 82.36% is also within the range considered favorable for the growth of corn at 71-85% (Leipzig 1996).

During the first week of sowing, soil moisture was limited which caused uneven germination of seedlings in all treatments. The presence of weeds was observed at the early vegetative growth of the crop and was eliminated by off-baring followed by hilling-up which were done three to four weeks after planting, respectively. Irrigation was done during the silking stage to the green cob stage since rainfall was minimal during the growing period. Yellowing of leaves was noticed in the corn plants that were not treated with inorganic fertilizers, applied with pure 5 t ha^{-1} V_4 organic fertilizer, and those plants applied with a high amount of organic fertilizers + limited amount of inorganic fertilizer. However, plots that were applied with pure inorganic 90-60-60 kg ha^{-1} N, P_2O_5, K_2O (recommended rate) and 1.25 t ha^{-1} V_4 organic fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) and 2.50 t ha^{-1} V_4 organic fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) showed greener leaves and vigorous growth and development.

3.1. Soil Chemical Properties

Table 2 shows the initial soil analysis before crop establishment. Initial soil analysis revealed that the soil had a pH of 6.60 with 0.50% organic matter content, 0.098% total N, 40.74 mg kg^{-1} available P, and 0.27 me 100g^{-1} exchangeable K. Results indicated that the soil pH was neutral with a very low level of organic carbon and nitrogen, high amount of available P and a moderate amount of exchangeable K (Landon J.R. 1991).

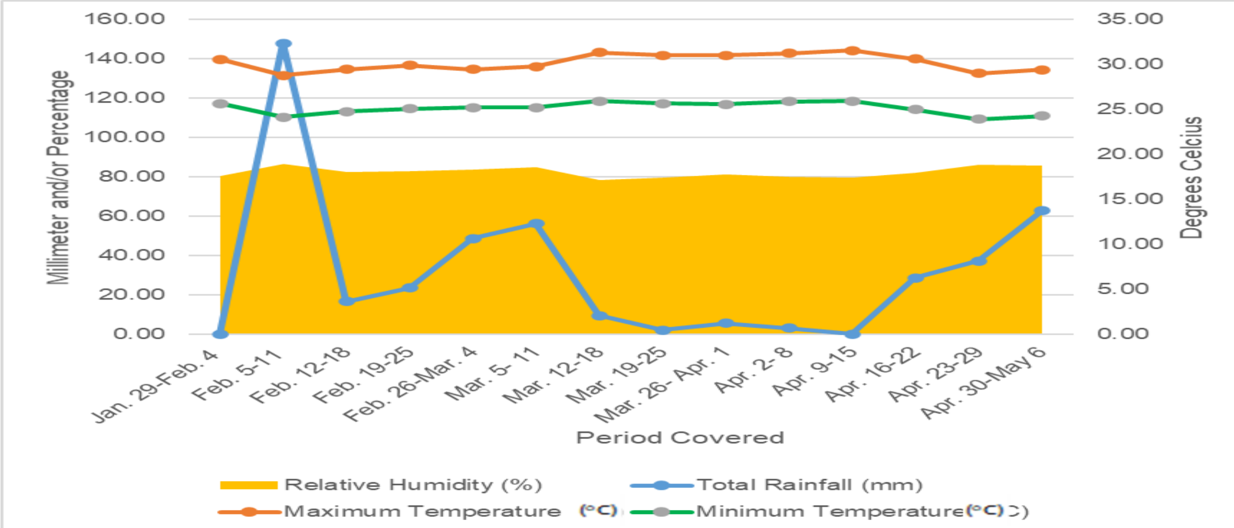

Figure 1. Total weekly rainfall (mm), average weekly minimum and maximum temperatures (°C), and relative humidity throughout the experiment from January 29 to May 06, 2020, obtained from the Philippine Atmospheric Geophysical and Astronomical Services (PAGASA) Station, Visayas State University (VSU), Visca, Baybay City, Leyte, Philippines

Table 2. Soil test results before crop establishment of three corn varieties as influenced by combined application of organic and inorganic fertilizers

Sample	Soil pH (1:2.5)	Organic Carbon (%)	Total N (%)	Available P (mg kg^{-1})	Exch. K (me $100g^{-1}$)
Initial Analysis	6.60	0.50	0.098	40.74	0.27

3.2. Agronomic Characteristics

Statistical analysis revealed that the number of days from sowing to tasseling and during the green cob stage was significantly affected by different varieties of corn (Table 3). However, days from sowing to silking, plant height, LAI, and fresh stover yield (t ha^{-1}) were not significantly affected by the different corn varieties tested.

The hybrid variety (Macho F_1) remarkably enhanced earlier tasseling (58.78 days) than the other varieties used. For the number of days from sowing to the green cob stage, the local OPV variety (Tiniguib) attained a significantly earlier green cob stage (76.28 days) than that of the improved OPV variety (IPB Var. 11) with 81.83 days. The number of days from sowing to the green cob stage was not significantly different from the Hybrid variety (Macho F_1) with 78.06 days.

Relative to fertilization, statistical analysis revealed that all agronomic parameters were significantly affected by fertilization except the number of days from sowing to the green cob stage. Several days from sowing to tasseling revealed that corn plants applied with 1.25 t ha^{-1} V_4 organic fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) significantly developed earlier tasseling when compared to unfertilized (control) plants, but this was comparable with all other sub-plot treatments tested. For the number of days from sowing to silking, application of 90-60-60 kg ha^{-1} N, P_2O_5, K_2O (S_1) significantly emanated the earliest production of silk (62.78 days) compared to the unfertilized plants (control), plants applied purely with V_4 organic fertilizer (S_3) and those plants applied with 3.75t ha^{-1} V_4 Organic Fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O (S_4), but this was comparable to corn plants applied with 2.5 t ha^{-1} V_4 organic fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) and 1.25 t ha^{-1} V_4 organic fertilizer + 45-30-3 kg ha^{-1} N, P_2O_5, K_2O (S_6). Although the application of 5 t ha^{-1} V_4 organic fertilizer (S_3) to corn plants significantly delayed the production and/or appearance of silk to about three days compared to those plants applied with inorganic fertilizer at the recommended level (S_2). This result could be due to the high amount of fertilizer that provided readily available nutrients for crop absorption. Chaturvedi (2004) as cited by Gaurama (2016) reported that readily available nutrients from inorganic fertilizers enhanced plant growth resulting in increased dry matter accumulation.

As the plants attained the green cob stage, application of 2.50 t ha^{-1} V_4 Organic Fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) produced significantly the tallest plants (221.39cm) when compared to unfertilized control plants (170.77cm), and also those plants applied purely with organic fertilizer (S_3) with 178.83cm. However, plants applied with 2.50 t ha^{-1} V_4 Organic Fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) were comparable to those corn plants applied with 90-60-60 kg ha^{-1} N, P_2O_5, K_2O (S_2), 3.75 t ha^{-1} V_4 Organic Fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O (S_4) and 1.25 t ha^{-1} V_4 Organic Fertilizer + 67.55-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) subplot treatments. For leaf area index (LAI), corn plants applied with 1.25 t ha^{-1} V_4 Organic Fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) significantly produced greater LAI (2.78) than those unfertilized control plants (S_1), plants applied purely with organic fertilizer 5 t ha^{-1} V_4 Organic Fertilizer (S_3) and those plants applied with 3.75 t ha^{-1} V_4 Organic Fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O (S_4). Although comparable to those plants applied with pure inorganic fertilizer at the recommended rate of 90-60-60 kg ha^{-1} N, P_2O_5, K_2O (S_2) and those plants applied with combined application of 1.25 t ha^{-1} V_4 Organic Fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5).

Table 3. Agronomic characteristics of three corn varieties as influenced by combined application of organic and inorganic fertilizers

Treatment	Number of days from sowing to tasselling	Number of days from sowing to silking	Number of green cob	Plant Height (cm)	LAI	Fresh Stover Yield (t ha^{-1})
Variety						
M_1	58.78 b	63.50	78.06 b	194. 14	2.10	7.27
M_2	61.50a	64.50	81.83a	203.03	2.29	10.47
M_3	60.72a	64.11	76.28 b	206.21	2.22	7.44
Fertilizer Application						
S_1	61.89a	64.56ab	78.00	170.77 b	1.41 c	5.25 c
S_2	59.78 b	62.78 c	79.22	219.62a	2.70a	9.88ab
S_3	60.89ab	65.11	79.44	178.83 b	1.63 bc	6.15 bc
S_4	59.56 b	64.56ab	77.56	195.64ab	2.07 b	7.47abc
S_5	60.44ab	63.44 bc	79.11	221.39a	2.65a	9.91ab
S_6	59.44 b	63.78abc	79.00	220.49a	2.78a	11.68a
C.V. (a) %	2.33	2.45	3.19	9.08	15.05	53.20
C.V. (b) %	1.88	1.80	2.14	12.45	14.17	36.04

Means in a column with the same letter and no letter designations are not significantly different based on a 5% level of significance in HSD.

Legend:
M_1 = Hybrid Variety (Macho F_1)
M_2 = Improved OPV Variety (IPB VAR 11)
M_3 = Local OPV Variety (Tiniguib)
S_1 = No fertilizer application (control)

S_2 = 90-60-60 kg ha^{-1} N, P_2O_5, K_2O (Recommended Rate)

S_3 = 5 t ha^{-1} V_4 Organic Fertilizer

S_4 = 3.75 t ha^{-1} V_4 Organic Fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O

S_5 = 2.50 t ha^{-1} V_4 Organic Fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O

S_6 = 1.25 t ha^{-1} V_4 Organic Fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O

Corn plants applied with much amount of inorganic fertilizers plus a limited amount of organic fertilizers (S_6) significantly produced heavier fresh stover (11.68 t ha^{-1}) when compared to unfertilized plants (5.25 t ha^{-1}) and corn plants applied with pure organic fertilizer (S_3) with 6.15 t ha^{-1}. However, this was comparable to corn plants applied with inorganic fertilizers at recommended level (S_2), plants applied with 3.75 t ha^{-1} V_4 organic fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O (S_4), and 2.5 t ha^{-1} V_4 organic fertilizer + 45-30-30 kg ha $^{-1}$ N, P_2O_5, K_2O (S_5) with fresh stover yields of 7.47 t ha^{-1} and 9.91 t ha^{-1}, respectively. These results corroborate with Paul and Beauchamp (1993) as cited by Akintoye and Olaniyan (2012) who observed that corn yields were higher in plots amended with urea compared to those amended with organic fertilizer source. Warman and Havard (1996) also reported that in two out of three years, sweet corn is grown with conventional fertilizer out-yielded organically grown sweet corn.

The results of this study construed with the findings of Ratilla *et al.* (2014), where plants applied with 10 t ha^{-1} of either chicken litter or vermicast supplemented with inorganic fertilizer tasseled and matured significantly earlier than those applied with organic fertilizers solely even at a higher rate. This shows that the readily available nutrients in inorganic fertilizers when used as supplements to organic materials can provide a good head start and thus promote growth and enhance the completion of the crop's life cycle.

3.3. Yield and Yield Components

Statistical analysis revealed that all yield and yield component parameters were significantly affected by the different varieties used (Tables 4 and 4a). For fertilizer management strategies adopted, all yield and yield components were significantly affected by the subplot treatments except the weight of nonmarketable ears and the total weight of both marketable and nonmarketable ears (t ha^{-1}) (Tables 4 and 4a).

The hybrid variety "Macho F_1" (M_1) produced significantly the longest ears (14.81cm) when compared to the local variety "Tiniguib" with 10.32cm but comparable to the improved variety "IPB Var. 11" with 14.35cm. For the ear diameter, still, hybrid variety produced significantly the broadest ear diameter (4.93cm) compared to all other varieties but improved variety "IPB Var. 11 produced the narrowest ear diameter of 3.99cm. Relative to ear weight (g), the hybrid variety consistently produced the heaviest ears (212.08g) than those of two other varieties tested but the local variety "Tiniguib produced the lightest ears with only 114.72g. In terms of the number of marketable ears per plot^{-1}, the improved corn variety "IPB var. 11 emanated significantly more number of marketable ears (18.00 ears plot^{-1}) than that of local variety "Tiniguib" with only 6.17 ears plot^{-1} but comparable to hybrid corn variety "Macho F_1" with 16.83 ears plot^{-1}. However, for the number of nonmarketable ears plot^{-1}, the local variety "Tiniguib" produced significantly more aforesaid ears (32.72 ears plot^{-1}) than those of hybrid and improved varieties with 24.17 ears plot^{-1} and 17.39 ears plot^{-1}, respectively.

In terms of weight of marketable ears (t ha^{-1}), the hybrid corn variety "Macho F_1 produced significantly the heaviest marketable ears (4.69 t ha^{-1}) than those of the two other varieties tested but the local variety "Tiniguib produced significantly the lightest marketable ears with only 1.15 t ha^{-1}. For the weight of non-marketable ears (t ha^{-1}), the local variety "Tiniguib" produced significantly more number of aforesaid ears (2.56

t ha^{-1}) when compared to the improved variety "IPB var. 11" with 1.43 t ha^{-1} but comparable to hybrid corn variety "Macho F_1" with 2.50 t ha^{-1}. Statistical analysis revealed that the hybrid corn variety "Macho F_1" produced significantly the heaviest total weight of both marketable and nonmarketable ears (7.19 t ha^{-1}) compared to the improved variety "IPB Var. 11" and local variety "Tiniguib" with 4.62 t ha^{-1} and 3.71 t ha^{-1}, respectively. Thereby, results on agronomic characteristics revealed that the hybrid corn variety generally performed an excellent response relative to almost all agronomic parameters gathered than those of the two other varieties tested. The results of this study confirm Szulc *et al*. (2008) as cited by Szulc *et al.* (2013) that the stay-green hybrid had a significantly greater yield of protein in comparison to the traditional cultivar.

Relative to the fertilization strategy, statistical analysis revealed that corn plants applied with 2.5 t ha^{-1} V_4 organic fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) and 1.25 t ha^{-1} V_4 organic fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) significantly produced longer cm), broader (cm) and heavier weight (g) of ears when compared to those unfertilized control plants (S_1), plants applied purely with organic fertilizer (S_3) and those plants applied with 3.75 t ha^{-1} V_4 organic fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O (S_4) as reflected in Table 4. However, this was comparable to corn plants applied with pure inorganic fertilizer at the recommended level of fertilization (S_2).

Table 4. Yield and yield components of three corn varieties as influenced by combined application of organic and inorganic fertilizers

Treatment	Ear length (cm)	Ear diameter(cm)	Ear weight (g)	Number of marketable ears $plot^{-1}$	Number of non-marketable ears $plot^{-1}$
Variety					
M_1	14.81a	4.93a	212.08a	16.83a	24.17b
M_2	14.35a	3.99c	140.14 b	18.00a	17.39c
M_3	10.32b	4.20b	114.72 c	6.17b	32.72a
Fertilizer Application					
S_1	10.54b	3.92 b	103.33 b	5.00 c	31.22a
S_2	15.77a	4.77a	210.83a	21.22a	17.33c
S_3	11.10 b	4.16 b	120.56 b	8.33 bc	28.22ab
S_4	11.03 b	4.17 b	119.44 b	8.78 bc	30.11a
S_5	15.35a	4.63a	193.89a	17.56ab	17.89 bc
S_6	15.18a	4.59a	185.83a	21.11a	23.78abc
C.V. (a) %	11.58	4.39	14.1	39.74	16.47
C.V. (b) %	14.37	5.94	23.01	57.44	29.69

Means in a column with the same letter and no letter designations are not significantly different based on a 5% level of significance in HSD.

For the number of marketable ears $plot^{-1}$, fertilized plants especially those applied with 1.25 t ha^{-1} V_4 organic fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) achieved a significantly more abundant number of marketable ears (21.11 ears) than those unfertilized plants (S_1), applied purely with organic fertilizer (S_3) and also those plants applied with 3.75 t ha^{-1} V_4 organic fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O (S_4) with 5.0, 8.33 and 8.78 ears, respectively. However, this was comparable to corn plants applied with 2.5 t ha^{-1} V_4 organic fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) and plants applied with 90-60-60 kg ha^{-1} N, P_2O_5, K_2O (S_2) with the number of marketable ears of 17.50 and 21.22 ears, respectively. This is in agreement with Kimeto *et al.* (2004) who also found that a combination of both organic and inorganic nutrient sources gave higher maize yield than organic fertilizer alone.

Table 4a. Yield and yield components of three corn varieties as influenced by combined application of organic and inorganic fertilizers

Treatment	Weight of marketable ears (t ha^{-1})	Weight non-marketable ears (t ha^{-1})	Total weight of marketable and non-marketable ears (t ha^{-1})
Variety			
M_1	4.69a	2.50a	7.19a
M_2	3.19b	1.43b	4.62b
M_3	1.15c	2.56a	3.71b
Fertilizer Application			
S_1	0.81c	2.23	3.04
S_2	5.56a	1.91	7.47
S_3	1.46bc	2.22	3.68
S_4	1.51bc	2.26	3.77
S_5	4.10ab	2.03	6.13
S_6	4.60a	2.32	6.92
C.V. (a) %	33.65	18.04	49.34
C.V. (b) %	70.87	36.84	49.45

Means in a column with the same letter and no letter designations are not significantly different based on a 5% level of significance in HSD.

For the number of non-marketable ears, however, generally, an opposite trend was observed wherein those sub-treatments that produced a lesser number of marketable ears, particularly S_1, S_3, and S_4 obtained a significantly abundant number of non-marketable ears (Table 4). In terms of the weight of marketable ears (t ha^{-1}), corn plants applied with 1.25 t ha^{-1} V_4 organic fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) produced significantly the heaviest marketable ears (4.60 t ha^{-1}) compared to unfertilized control plants (S_1), plants applied purely with organic fertilizer (S_3), and also those plants applied with 3.75 t ha^{-1} V_4 organic fertilizer + 22.5-15-15 kg ha^{-1} N, P_2O_5, K_2O (S_4) with 0.81, 1.46 and 1.51 t ha^{-1}, but this was comparable to those plants applied with 90-60-60 kg ha^{-1} N, P_2O_5, K_2O (S_2) and plants applied with 2.5 t ha^{-1} V_4 organic fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) with a marketable ear yields of 5.56 t ha^{-1} and 4.10 t ha^{-1}, respectively.

The result of this study agrees with Makinde *et al.* (2001) who reported that the sole application of inorganic fertilizer or a mixture of organic and inorganic fertilizer significantly increased corn yield in marginal areas. In a similar study, Zhao *et al.* (2009) found that the application of farmyard manure combined with chemical fertilizer management resulted in a higher increase in maize yield compared with those under unfertilized treatment.

3.4. Cost and Return Analysis

Cost and return analysis revealed that the hybrid corn variety “Macho F_1” achieved the highest gross income and gross margin of USD 4,221.00 and USD 2,782.15, respectively (Table 5). This was followed by the Improved OPV Variety “IPB VAR 11” while the local variety “Tiniguib” obtained the lowest gross income and gross margin of USD 805.00 and - USD 18.70, respectively.

Relative to fertilization, unfertilized control plants (S_1), S_3 and S_4 showed very low gross margins due to very low productivity on marketable ears for unfertilized plants (S_1) while low marketable ear yield and high cost of organic fertilizer incurred in S_3 and S_4 subplot treatments.

Table 5. Cost and return analysis of three corn varieties as influenced by combined application of organic and inorganic fertilizers

Treatment	Marketable Ear Yield (t ha^{-1})	Gross Income (USD)	Variable Cost (USD)	Gross Margin(USD)
Variety				
M_1 *	4.69	4,221.00	1,438.85	2,782.15
M_2 **	3.19	2,552.00	835.90	1,716.10
M_3 ***	1.15	805.00	823.70	- 18.70
Fertilizer Application				
S_1	0.81	648.00	634.40	13.60
S_2	5.56	4,448.00	865.80	3,582.20
S_3	1.46	1,168.00	1,358.40	-190.40
S_4	1.51	1,208.00	1,235.20	- 27.00
S_5	4.10	3,280.00	1,112.10	2,167.90
S_6	4.60	3,680.00	988.90	2,691.10

** Based on the current price of hybrid corn variety "Macho F_1" at USD 1.00 kg^{-1} and USD 0.80 kg^{-1} for organically and inorganically produced green cob, respectively.*

*** Based on the current price of improved OPV "IPB VAR 11" at USD 0.90 kg^{-1} and USD 0.70 kg^{-1} for organically and inorganically produced green cob, respectively.*

**** Based on the current price of the local corn variety "Tiniguib" at USD 0.80 kg^{-1} and USD 0.60 kg^{-1} for organically and inorganically produced green cob, respectively.*

The exchange rate from one USD to Peso is equivalent to PHP50.00.

4. Conclusion

Based on the results obtained, planting of the hybrid corn variety "Macho F_1" enhanced silk and developed green cob earlier than the local variety "Tiniguib". This variety also produced significantly longer, bigger, and heavier weights of ears, producing a sufficient number of marketable ears $plot^{-1}$ with a remarkable yield on marketable and total ear yield (t ha^{-1}). Regardless of corn variety, application of 1.25 t ha^{-1} V_4 organic fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) and 2.50 t ha^{-1} V_4 organic fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) enhanced remarkably the agronomic characteristics of corn through the improvement of plant height, greater LAI, and heavier fresh stover yield. Similarly, plants under S_6 and S_5 developed longer ear lengths, and broader and heavier ear weights produced an abundant number of marketable ears that achieved heavier weights of marketable ears, and total green cob yield (t ha^{-1}) comparable to plants applied with inorganic fertilizer at the recommended level of application (S_2). Planting the hybrid corn variety "Macho F_1" obtained the highest gross income (USD 4,221.00) and gross margin (USD 2,782.15) due to the high productivity of marketable ears (4.69 t ha^{-1}). This variety also achieved a high gross margin (USD 2,691.10) when applied with 1.25 t ha^{-1} V_4 Organic Fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6).

5. Recommendations

The hybrid corn variety "Macho F_1" is recommended for planting in the tropics for higher marketable ear yield as long as the necessary nutrient management is adopted. A combined application of organic and inorganic fertilizers with an option of applying either 1.25 t ha^{-1} V_4 organic fertilizer + 67.5-45-45 kg ha^{-1} N, P_2O_5, K_2O (S_6) and 2.50 t ha^{-1} V_4 organic fertilizer + 45-30-30 kg ha^{-1} N, P_2O_5, K_2O (S_5) should be followed by corn growers who aimed for higher green cob productivity. These two options are advised to corn growers since inorganic fertilizer nowadays is very expensive, and it might hamper the financial production undertaking of the corn farmers. Besides, the utilization of V4 organic fertilizer can also support the adaptation strategy in solving the climate change situation in the corn-growing areas in the tropics.

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Not applicable

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The authors disclosed no conflict of interest starting from the conduct of the study, data analysis, and writing until the publication of this research work.

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