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Nutrient Use Efficienty, Yield and Fruit Quality of Sweet Corn (Zea mays saccharata Sturt.) Grown Under Different Fertilizer Management Schemes

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Proper fertilizer management strategy is a very important consideration for optimizing crop productivity, food production sustainability, maximizing farm economic returns, and reducing adverse impacts of nutrients on soil fertility, health and the environment. A field experiment was conducted to evaluate the nutrient efficiency, yield and nutritive quality of sweet corn grown under different fertilizer management schemes in Baybay City, Leyte, Philippines. The treatments were: Main plot- sweet corn variety: Sweet Pearl and Sweet Grande; and Sub-plots- fertilizer management schemes: T_1 – control, T_2 – conventional fertilizer management scheme (CFMS), T_3 – organic fertilizer management scheme (OFMS), T_4 – organic – based fertilizer management schemes 1 ($OBFMS_1$), T_5 – organic-based fertilizer management scheme 2 ($OBFMS_2$), and T_6 – organic-based fertilizer management scheme 3 ($OBFMS_3$). The study was done in a Split Plot Design with three replications arranged in Randomized Complete Block Design (RCBD). Results showed that growth parameters (plant height, leaf area, growth rate, and dry matter yield) and yield and yield components (ear height, ear width, weight of ear/plant with and without husk, fresh ear yield/plot with and without husk, and stover) were significantly increased with application of organic (OFMS), organic-based (OBFMS) and conventional (CFMS) fertilizer management schemes. Application of CFMS resulted to highest increase in starch and sugar content, while application of $OBFMS_2$ gave the highest protein content in the sweet corn kernel.N use efficiency of Sweet Pearl was higher (543.2) than that of Sweet Grande (125.2) because of higher N recovery efficiency. Decrease in nitrogen use efficiency was attributed to low physiological efficiency as levels of nitrogen fertilizer increased. The highest P and K recovery efficiency, physiological efficiency and use efficiency among different rates of P and K (kg ha^{-1}) were observed when applied at rates of 30 and 60 kg ha^{-1} for Sweet Pearl and Sweet Grande. Results also revealed a decreasing pattern in P and K use efficiency values with increasing rates of P and K application indicating that maximum crop production can be attained with lower fertilizer applications.

Keywords: nutrient use efficiency, fertilizer management schemes, fruit quality

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Introduction

Sweet corn is classified as one of the most promising high valued horticultural crops because of its short maturity and faster economic returns particularly for small farmers. Nowadays, sweet corn has been grown commercially, it is a profitable farming enterprise and a good cash crops with high year- round price (Domingo and Hagerman, 1983). The kernels are usually eaten fresh in cob and are used as ingredients in most food preparations and can also be processed as canned products. Sweet corn has a short growth duration, thus, farmers can grow four or more croppings a year. There is high demand for sweet corn in the market and is expected to increase in the future. Thus, development of production technologies is needed to meet the increasing demand in the market.

Proper fertilizer management strategy is very important consideration for optimizing crop productivity, food production sustainability, maximizing farm economic returns, and reducing adverse impacts of nutrients on soil fertility, health, and the environment (Dela Cruz, 2015). With the adverse effects of continued and excessive use of inorganic fertilizer, the productivity of the soil declines as well as its overall health soil, and the environment.

To address this problem, government pushes organic agriculture by using alternative organic fertilizer like vermicompost and fermented plant extracts that are commercially available. This technology is a sustainable solution for management of organic wastes which are major sources of environmental pollution (Lazcano *et al*., 2012). Hence, this study was conducted to evaluate the effects of different fertilizer management schemes on the growth, yield, and quality parameters in two sweet corn varieties and determine the effects of different fertilizer management schemes on nutrient use efficiency in two sweet corn varieties.

Materials and Methods

Location and History of the Experimental Area

The study area was located at the research experimental site of PhilRootCrops, Visayas State University, Visca, Baybay City, Leyte, Philippines (10°45'03.5"N 124°47'22.6"E). The climate is characterized with rainfall that is evenly distributed throughout the year (Type IV). The experimental area was previously grown with sweet potato (germplasm project) every year.

Land Preparation

The area was plowed twice and harrowed by tractor 3 times at one week interval to thoroughly decompose plant residues and have good soil tilth. Thirty six (36) plots with dimensions of 5m x 6m were prepared and small canals (20cm x 20cm) which served as drainage were constructed along the side of the raised beds.

Soil Sampling

One (1) kilogram of composite soil samples was collected after land preparation using standard soil sampling procedure. The samples were then air-dried, sieved, packed, labeled, and submitted for analyses to the Central Analytical Services Laboratory, Visayas State University, Visca, Baybay City, Leyte, Philippines.

Seed Sowing and Seedling Management

Seeds of sweet corn varieties, Sweet Pearl and Sweet Grande, were separately sown in 50-cells plastic trays filled with sterilized germination medium containing 1:1 ratio of carbonized rice hull and vermicast. Plastic trays containing the sown seeds were arranged in an enclosed improvised screen house for protection against astray animals and adverse environmental conditions. A prepared starter solution containing 10 g of urea (45-0-0) dissolved in 4 liters of water was sprayed to the seedlings two (2) days after emergence (DAE). Watering was done whenever necessary and monitoring of presence of insect pests and diseases was done daily. Soil drenching of fungicide was done on seedlings when first symptoms of damping-off disease occur. The seedlings were hardened by gradually exposing the trays to direct sunlight at 6-8 days after sowing (DAS). Seedlings of the trays were transplanted at nine (9) DAS.

Experimental Design and Layout

The experiment was laid out in split plot in Randomized Complete Block Design (RCBD) with three (3) replications. Sweet corn variety was assigned in the mainplot while the fertilizer management schemes were assigned in the subplots (5m x 6m). The distance between blocks and mainplots was 2m, while between subplots was 1 m.

Treatments

Main Plot: Sweet Corn Variety
Variety 1 (Sweet Pearl)
Variety 2 (Sweet Grande)
Sub-Plot: Fertilizer Management Schemes

T_1 – Control (no fertilizer)
T_2 – Organic Fertilizer Management Scheme (OFMS)
(8.8 t ha^{-1} vermicompost + 4 L ha^{-1} organic foliar fertilizer)
T_3 – Conventional Fertilizer Management Scheme (CFMS)
(150-60-60 N, P_2O_5, K_2O kg ha^{-1}) Check
T_4 – Organic-Based Fertilizer Management Scheme 1 ($OBFMS_1$)
(4.4 t ha^{-1} vermicompost + 75-30-30 N, P_2O_5, K_2O kg ha^{-1})
T_5 – Organic-Based Fertilizer Management Scheme 2 ($OBFMS_2$)
(2 L ha^{-1} organic foliar fertilizer + 75-30-30 N, P_2O_5, K_2O kgha^{-1})
T_6 – Organic-Based Fertilizer Management Scheme 3 ($OBFMS_3$)
(2.2 t ha^{-1} vermicompost + 1 L ha^{-1} organic foliar fertilizer 75-30- 30 N, P_2O_5, K_2O kg ha^{-1})

Transplanting and Cultural Management

The seedlings were transplanted at 9 DAS at distances of 60 cm between rows and 20 cm between hills, at one (1) seedling per hill. Watering was immediately done after transplanting to reduce impact of transplanting shock. At three (3) days after transplanting (DAT), dead seedlings were replaced using the remaining seedlings in trays to maintain the plant population at 83,333 per hectare, age similarities and uniformity of crop stand. Manual hilling-up and weeding of each row were done 3 times after application of organic and inorganic fertilizers. Pests and diseases were monitored daily. Occasional appearance of pests and diseases were observed at vegetative stage but failed to cause economic damage.

Harvesting

At 70 DAS (20 days after silking), sweet corn ears were harvested in the net plot between 5:00 to 9:00 AM to prevent loss of sweetness in the kernel.

Plant Nutrient Uptake

Plants samples were randomly harvested for the above ground biomass within the 1 m^2 destructive sampling areas used for analysis of the plant tissue on total C, N, P, and K sampled at 15, 30, 45 and 70 DAT. The plant samples were weighed, chopped (3cm) and air-dried for 3 days prior to oven drying at 75^0C for 72 hours. The oven-dried plant samples were weighed for oven-dried-biomass, then 200 g of oven-dried plant samples were powdered using Lab Whirlwind Grinding Mill for determination of total C, N, P and K content, which were used in analyzing nutrient uptake and carbon sequestration.

Data Gathered

A. Growth Parameters.

Ten sample plants from the net plot were randomly selected and the following growth parameters were recorded at 21, 36, 51 and 70 DAT (harvest).

1. **Plant height (cm).** Measured from the base of the plant to the base of fully opened top leaf until tassel emergence and using a meter stick.
2. **Leaf area per plant (cm^2).** Length of the 3rd and 4th leaves measured from the base to tip. Leaf breath was taken at the middle point of the leaf lamina. The product of the leaf length and breadth was multiplied by the factor 0.75 and the sum of all the leaves was expressed as leaf area in cm $plant^{-1}$using the formula:

$$\text{Leaf Area} = \text{Leaf Length (cm)x Leaf Width (cm)x } 0.75$$

3. **Growth rate.** This was obtained by using data from the successive measurements of the plants at bi-weekly interval. This was computed using the formula:

$$\textbf{Growth Rate (GR)} = \frac{(HW_{2(cm)} - Hi_{(cm)}) + (HW_{3(cm)} - HW_{2\,(cm)} + HW_{4(cm)} - HW_{3(cm)} + HW_{5(cm)} - HW_{4(cm)}}{n}$$

where:

GR = Growth Rate (height $plant^{-1}$ $week^{-1}$)

HW_1, HW_2, HW_3, HW_4, HW_5 = Height of plants every two weeks

n = number of measurements

4. **Dry matter yield (g $plant^{-1}$ $week^{-1}$).** This was estimated by getting the % MC of the above ground biomass using the formula:

$$\%\text{ MC (Biomass)} = \left[\frac{\text{Fresh Weight} - \text{Oven Dried Weight}}{\text{Fresh Weight}}\right] \text{x } 100$$

$$\text{Dry Matter Yield} = \text{Fresh Weight x } \left[1 - \frac{\%\text{ Moisture Content}}{100}\right]$$

B. Yield and Yield Components

1. **Ear height at harvest (cm).** This was measured from the ground level up to the node bearing the first lower ear.
2. **Length of ear (cm).** This was measured from the base to the tip of the ear from the ten randomly selected plants.
3. **Ear width (cm).** The circumference at the center of ear was used as an estimate of the width of the ear from ten randomly selected plants.
4. **Ear weight with husk (g $plant^{-1}$).** The ears from ten randomly selected sample plants were collected, taken, and weighed with husk intact per ear.
5. **Ear weight without husk (g/plant).** The ears from ten randomly selected sample plants were collected and weighed without individual husk per ear.

6. **Fresh ear yield per plot (kg/plot).** The ears were collected from all plants per plot and then weighed to get the total fresh ear yield per plot in kg.
7. **Stover yield (t/ha).** This was obtained by weighing the above-ground portion of the plants without ears from the harvestable area in each treatment. The yield per plot in kg was converted in ton/ha using the formula:

$$\text{Stover Yield (t ha}^{-1}) = \frac{\text{Plot Yield (kg) x } 10{,}000 \text{ m}^2 \text{ ha}^{-1}}{30 \text{ m}^2 \text{ x } 1{,}000 \text{kg t}^{-1}}$$

8. **Harvest index (%).** Harvest index is the ratio of economic yield to biological yield. This was computed using the formula:

$$\text{Harvest Index} = \frac{\text{Economic yield (t ha}^{-1})}{\text{Biological Yield (t ha}^{-1}}$$

Economic Yield is defined as the fresh ear without husk
Biological Yield is defined as the fresh ear husk and the fresh stover

C. Quality Parameters

Nutrient Analyzed	**Method Used**
Protein content in Kernel	Modified Kjeldahl Method
Starch content in Kernel	Anthrone Method
Sugar content in Kernel	Anthrone Method

D. Plant Tissue Analysis

1. **Plant nutrient uptake.** Nutrient contents (carbon, nitrogen, phosphorus and potassium) of the two varieties of sweet corn sample plants at bi-weekly interval and at harvest were analyzed at the Central Analytical Services Laboratory, PhilRootCrops, VSU, Visca, Baybay City, Leyte, Philippines.

Nutrient Analyzed	**Method Used**
Total Nitrogen	Kjeldahl
Total Phosphorus	Vanadomolybdate
Total Potassium	Flame Atomic Emission Spectroscopy

$$\text{Nutrient Uptake(N, P, K)} = \left[\frac{\text{\% nutrient concentration in plant tissue}}{100}\right] \text{x dry matter yield (kg/ha)}$$

Dry matter content was estimated based on fresh weight of the biomass harvested from the 1m^2 destructive sampling area using the formula:

$$\%\ \mathrm{MC\ (Biomass)} = \left[\frac{\mathrm{Fresh\ Weight} - \mathrm{Oven\ Dried\ Weight}}{\mathrm{Fresh\ Weight}}\right] \mathrm{x}\ 100$$

The dry matter yield was estimated by using the formula;

$$\mathrm{Dry\ Matter\ Yield} = \mathrm{Fresh\ Weight\ x} \left[1 - \frac{\%\ \mathrm{Moisture\ Content}}{100}\right]$$

2. **Nutrient Recovery (NR)**. The nutrient recovery was computed by using the formula:

$$\mathrm{NR} = \frac{\mathrm{Uptake\ at\ Treated\ plots} - \mathrm{N\ Uptake\ at\ control\ plots}}{\mathrm{N\ applied}}$$

3. **Nutrient Use Efficiency (NUE)**. The nutrient use efficiency was estimated using the formula:

Nutrient Use Efficiency = Nutrient Recovery x Physiological Efficiency

where:

$$\mathrm{Physiological\ Efficiency} = \frac{\mathrm{Economic\ Yield}}{\mathrm{Nutrient\ Recovery}}$$

Statistical Tool and Analysis

All data gathered were statistically analyzed using Statistical Tools for Agricultural Research (Version 2013). Treatment mean differences were analyzed using Honest Significant Difference (HSD) at 5% level of significance.

Results and Discussion

Growth Rate

Table 1 presents the growth rate of the two sweet corn varieties as influenced by fertilizer management schemes. Results show there is no interaction effect between variety and fertilizer management schemes on bi-weekly growth rate of the two varieties of sweet corn but significant differences in growth rate were observed between Sweet Pearl and Sweet Grande. Sweet Grande is more superior compared to Sweet Grande. Results imply that Sweet Grande is more vigorous and responsive to fertilizer applied (organic-based and chemical fertilizer). Regardless of variety, the conventional fertilizer management scheme (T_3) gave the highest growth rate, although it was not significantly different from all the organic-based fertilizer management schemes. This result can be explained by the addition of high amount of readily available nutrients in the chemical fertilizer (75-30-30 kg ha^{-1} N, P_2O_5, K_2O), plus the organic-based fertilizer management schemes whose nutrients are released at later stages of plant growth. Organic fertilizer like vermicompost is known to contain macro and micronutrients which can enhance plant growth.

Table 1. Effects of sweet corn variety and fertilizer management schemes on the bi-weekly growth rate (g $plant^{-1}$) and plant height (cm)

Treatment	Growth Rate (cm $plant^{-1}$)	Plant Height (cm $plant^{-1}$)
Sweet Corn Variety		
Sweet Pearl	22.1b	148.0b
Sweet Grande	29.6a	164.2a
Mean	25.9	156.1
Fertilizer Management Schemes		
T_1 - Zero-Fertilizer	19.6b	119.2b
T_2 - Organic Fertilizer Management Scheme (OFMS)	27.6a	165.7a
T_3 - Conventional Fertilizer Management Scheme (CFMS)	30.5a	178.6a
T_4 - Organic-Based Fertilizer Management Scheme 1 ($OBFMS_1$)	26.1ab	163.4a
T_5 - Organic-Based Fertilizer Management Scheme 2 ($OBFMS_2$)	26.5ab	154.5a
T_6 - Organic-Based Fertilizer Management Scheme 3 ($OBFMS_3$)	24.9ab	154.8a
Mean	21.5	156.9
C.V. (a) %	13.3	4.8
C.V. (b) %	15.5	9.2

Treatment means within each column followed by common letters and those without letter designations are not significantly different at 5% level, HSD

Ansari and Sukhraj (2010) reported that due to higher amount of nitrogen in chemical fertilizers, maximum growth of plant is rapid. They further reported that chemical fertilizers have greater availability of salts like nitrate, phosphate and potash, which significantly increase plant growth.

Results show there is no interaction effect between variety and fertilizer management schemes in height at harvest. Sweet Grande variety was significantly taller than Sweet Pearl whereas application of inorganic fertilizer at 150-60-60 kg ha^{-1} N. P_2O_5, K_2O (T_3) resulted in not statistically different from the other treatments at 70 DAT (harvest). Plants that did not receive fertilizer (T_1) were significantly shorter than the fertilized plants and were generally stunted as they had to rely on the insufficient nutrients in the soil.

The superior effect of 150-60-60 kg ha^{-1} N, P_2O_5, K_2O (T_3) compared to the other fertilizer management schemes at 36 and 51 DAT can be attributed to the faster release and higher amounts of nutrients from the chemical fertilizer making these readily available for plant use during the early growth stage compared to the organic fertilizer treatments (T_2, T_4, T_5, T_6) which had lower nutrient contents coupled by a slow rate of nutrient release. However, the comparable effects of all fertilizer treatments (both organic and inorganic) during the later stage of plant growth (70 DAT) imply that the organic-based fertilizer schemes were already able to supply sufficient amount of nutrients to the plant. These findings agree with those of Hoque (1999) and Kobayashi *et al*. (1989) who observed that plant height significantly increased with application of compost along with chemical fertilizer.

Leaf Area

Results show interaction effect of sweet corn varieties and fertilizer management schemes at 21 to 70 DAT (Tables 2 to 5). Sweet Pearl variety that received 4.4 tons ha^{-1} vermicompost + 75-30-30 kg ha^{-1} N, P_2O_5, K_2O (T_4) produced the highest leaf area, although the effect of fertilizer treatments were not significantly different among the organic-based fertilizer management schemes (T_5 and T_6), but were better than the conventional fertilizer management scheme (T_3). This result may be attributed to higher levels of nutrients from the chemical fertilizer, besides the presence of growth stimulating substances (enzymes, antibiotics and growth hormones) in vermicompost. It has been reported that application of vermicompost increases the supply of easily assimilated macro-and micronutrients to plants besides mobilizing unavailable forms of nutrients into available form.

Figure 1 indicates that regardless of fertilizer management schemes, the Sweet Pearl variety produced significantly higher leaf area than Sweet Grande at 21 and 36 DAT, although the two varieties were comparable at 70 DAT. Moreover, regardless of variety, T_3 (conventional fertilizer management), T_4 (organic fertilizer management scheme 1), T_5 (organic-based fertilizer management scheme 3) and T_6 (organic-based fertilizer management scheme 3) were comparable to each other at 21 and 36 DAT, but they were superior to T_2 (organic fertilizer management scheme) and (T_1) the control. The higher the leaf area of Sweet Pearl at the early stage of growth suggests that it is less sensitive to nutrient content of the soil compared to Sweet Grande and also it could be due to differences in genetic characteristics.

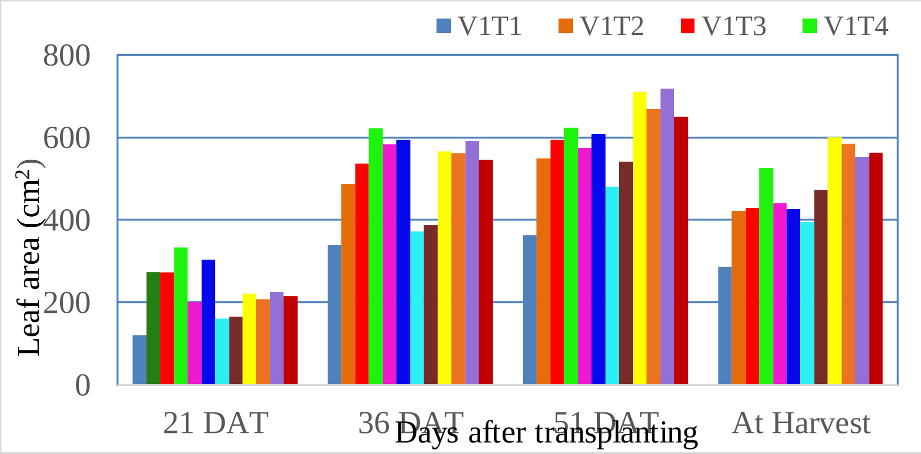

Figure 1. Leaf area (cm^2) of two varieties of sweet corn at different days after transplanting

The superior effect of T_4 at the later stage of growth (70 DAT) implies the favorable effect of vermicompost in combination with chemical fertilizer (75-30-30 kg ha^{-1} N, P_2O_5, K_2O). Chemical fertilizer supplies nutrients which are readily soluble in the soil solution which can be available to the growing plant. Application of vermicompost probably also contributed macro and micronutrients which enhanced growth of the sweet corn. Ratilla *et al.* (2014) reported that application of 10 t ha^{-1} vermicast in combination with 45-30-30 kg ha^{-1} N, P_2O_5, K_2O enhanced the agronomic growth of corn in a marginal upland in Leyte.

On the other hand, for Sweet Grande, application of 2L ha^{-1} liquid organic fertilizer + 75-30-30 kg ha^{-1} N, P_2O_5, K_2O (T_5) tended to produce higher leaf area compared to the other fertilizer management schemes, although this was not anymore significant at 70 DAT. The above results imply the effect of varietal differences on the response of sweet corn to fertilizer application.

Dry Matter Yield

Results likewise revealed that application of T_3, T_4 and T_6 fertilizer management schemes was superior to the control throughout the growth stages of the test plants. In addition, conventional fertilizer management scheme (T_3) tended to produce higher dry matter yield (DMY), although it was not significantly different to T_4, T_5 and T_6 during later stages of growth (51 and 70 DAT). Better effect of T_3, T_4, T_5 and T_6 compared to the control can be attributed to high amount of readily available nutrients applied through the chemical fertilizer (75-30-30 kg ha^{-1} N, P_2O_5, K_2O), which provide nutrients during the early vegetative growth stages, while the organic component provided nutrients at the later stage of the plant development.

Table 2. Interaction effect of sweet corn variety and fertilizer management schemes on leaf area (cm^2) at 21 DAT

Sweet Corn Variety	Fertilizer Management Schemes						Mean
	T_1	T_2	T_3	T_4	T_5	T_6	
	Control	OFMS	CFMS	$OBFMS_1$	$OBFMS_2$	$OBFMS_3$	
Sweet Pearl	120.5d	272.1b	271.5b	332.7a	200.7c	303.6ab	250.1a
Sweet Grande	161.0b	164.7b	221.2a	207.0ab	226.2a	214.5a	199.1b
Mean	140.8d	218.4bc	246.4ab	269.9a	213.4c	259.0a	

Treatment means with common letters are not significantly different at 5% level, HSD

Table 3. Interaction effect of sweet corn variety and fertilizer management schemes on leaf area (cm^2) at 36 DAT

Sweet Corn Variety	Fertilizer Management Schemes						MEAN
	T_1	T_2	T_3	T_4	T_5	T_6	
	Control	OFMS	CFMS	$OBFMS_1$	$OBFMS_2$	$OBFMS_3$	
Sweet Pearl	338.9d	486.7c	537.1bc	621.4a	582.6ab	593.7ab	526.8a
Sweet Grande	371.8b	387.4b	566.6a	561.2a	591.1a	545.6a	503.9b
Mean	355.3d	437.1c	551.9b	591.3a	586.9ab	569.7ab	

Treatment means with a common letters are not significantly different at 5% level, HSD

Table 4. Interaction effect of sweet corn variety and fertilizer management schemes on leaf area (cm^2) at 51 DAT

Sweet Corn Variety	Fertilizer Management Schemes						Mean
	T_1 Control	T_2 OFMS	T_3 CFMS	T_4 $OBFMS_1$	T_5 $OBFMS_2$	T_6 $OBFMS_3$	
Sweet Pearl	362.4c	549.0b	593.7ab	623.7a	573.1ab	608.2ab	551.7b
Sweet Grande	480.4c	541.2c	711.0ab	668.8ab	718.3a	649.1b	628.1a
Mean	421.4c	545.1b	652.4a	646.2a	645.7a	628.7a	

Treatment means with common letters are not significantly different at 5% level, HSD

Table 5. Interaction effect of sweet corn variety and fertilizer management schemes on leaf area (cm^2) at 70 DAT (harvest)

Sweet Corn Variety	Fertilizer Management Schemes						Mean
	T_1 Control	T_2 OFMS	T_3 CFMS	T_4 $OBFMS_1$	T_5 $OBFMS_2$	T_6 $OBFMS_3$	
Sweet Pearl	286.1c	420.8b	429.0b	525.3a	440.0b	426.3b	421.2b
Sweet Grande	395.2c	472.8b	600.4a	584.1a	551.7a	562.9a	527.9a
Mean	340.7d	446.8c	514.7b	554.7a	495.9b	494.6b	

Treatment means with common letters are not significantly different at 5% level, HSD

This agrees with the findings of Jaliya *et al*. (2008) that the higher production of DMY was due to N, P, and K, being part of the essential nutrients required for the production of the meristematic and physiological activities such as leaves, roots, shoots, dry matter production leading to efficient translocations of water and nutrients, interception of solar radiation and carbon dioxide. These activities promote greater photosynthetic activities of adequate assimilates for subsequent translocations to various sinks, hence, production of higher total dry matter.

An interaction effect was also observed between the sweet corn varieties and fertilizer management schemes at 21 DAT. Sweet Pearl applied with fertilizer produced higher DMY than the control. All fertilizer treatments were comparable to each other in terms of this parameter. However, for Sweet Grande, T_3 and T_6 produced the highest DMY (Tables 6 to 7).

Table 6. Effects of sweet corn variety and fertilizer management schemes on bi-weekly dry matter yield (g plant^{-1})

TREATMENT	DRY MATTER YIELD (g plant^{-1})			
	21 DAT	36 DAT	51 DAT	70 DAT
Sweet Corn Variety				
Sweet Pearl	154.6	283.7	480.7	942.6
Sweet Grande	131.1	292.9	496.9	710.9
Mean	142.8	288.3	488.8	826.75
Fertilizer Management Schemes				
T_1 - Zero-Fertilizer	72.1d	204.1c	280.5b	603.9c
T_2 - Organic Fertilizer Management Scheme (OFMS)	105.4cd	230.3bc	429.9ab	783.0bc
T_3 - Conventional Fertilizer Management Scheme (CFMS)	195.4a	351.0ab	529.8ab	1020.1a
T_4 - Organic-Based Fertilizer Management Scheme 1 ($OBFMS_1$)	172.3a	380.8a	681.6a	831.9ab
T_5 - Organic-Based Fertilizer Management Scheme 2 ($OBFMS_2$)	147.6bc	255.1bc	488.2ab	863.4ab
T_6 - Organic-Based Fertilizer Management Scheme 3 ($OBFMS_3$)	170.3ab	308.1abc	523.1ab	857.9ab
Mean	143.9	288.2	488.9	826.7
C.V. (a) %	38.9	38.7	39.4	22.2
C.V. (b) %	22.0	25.7	30.0	13.0

Treatment means within each column followed by common letters and those without letter designations are not significantly different at 5% level, HSD

Table 7. Interaction effect of sweet corn variety and fertilizer management schemes on dry matter yield (g $plant^{-1}$) of sweet corn at 21 DAT

Sweet Corn Variety	**Fertilizer Management Schemes**						
	T_1	T_2	T_3	T_4	T_5	T_6	**Mean**
	Control	OFMS	CFMS	$OBFMS_1$	$OBFMS_2$	$OBFMS_3$	
Sweet Pearl	73.8b	136.6ab	165.7a	217.1a	159.5a	175.0a	154.6
Sweet Grande	70.4c	74.3c	225.2a	127.6bc	123.7bc	165.7ab	131.1
Mean	72.1d	105.4cd	195.4a	172.3ab	141.6bc	170.3ab	

Treatment means with a common letters are not significantly different at 5% level, HSD

Yield and Yield Components

Table 8 presents the yield and yield components of sweet corn as influenced by variety and fertilizer management schemes. Regardless of fertilizer management scheme treatments, Sweet Grande was better than Sweet Pearl in terms of average ear height, average ear width, and weight of ear per plant with husk, weight of ear per plant without husk, yield per plot with husk, and yield per plot without husk. However, the two sweet corn varieties were comparable in terms of average ear length, fresh stover yield, and harvest index.

Results also revealed that in general all, fertilizer management scheme treatments that involved fertilizer application (T_2 to T_6) were comparable to each other in most of the yield and yield component parameters measured. In addition, they were superior to the control (T_1) in terms of average ear height, yield per plot with husk, yield per plot without husk and fresh stover yield. No significant differences were observed, however, among all treatments on average ear length, average ear width, weight of ear per plant without husk and harvest index.

Table 8. Effects of sweet corn variety and fertilizer management schemes on yield and yield components

TREATMENTS	YIELD AND YIELD COMPONENTS PARAMETER								
	Ave. Ear Height (cm)	**Ave. Ear Length (cm)**	**Ave. Ear Width (cm)**	**Weight of Ear (g)/Plant (with husk)**	**Weight of Ear (g)/Plant (without husk)**	**Yield/Plot (kg) (with husk)**	**Yield/ Plot (kg) (without husk)**	**Fresh Stover Yield (tons/ ha)**	**Harvest Index (%)**
Sweet Corn Variety									
Sweet Pearl	47.7b	20.2	3.9b	92.7b	78.8b	16.4b	12.1b	9.5	30.1
Sweet Grande	69.2a	21.3	4.4a	150.5a	111.8a	22.4a	16.1a	11.4	31.7
Mean	58.5	20.7	4.2	121.6	95.3	19.4	14.1	10.4	30.9
Fertilizer Management Schemes									
T_1 - Zero-Fertilizer	36.7c	19.8	3.8	74.9b	58.1	12.8b	7.5b	6.4c	28.6
T_2 - Organic Fertilizer Management Scheme (OFMS)	60.2ab	21.2	4.2	122.4ab	99.0	19.1a	13.6a	9.6b	32.2
T_3 - Conventional Fertilizer Management Scheme (CFMS)	71.8a	21.5	4.4	153.3a	114.9	23.4a	17.2a	12.3a	31.6
T_4 - Organic-Based Fertilizer Management Scheme 1 ($OBFMS_1$)	62.0ab	21.7	4.4	143.9a	112.2	21.0a	16.4a	12.5a	30.3
T_5 - Organic-Based Fertilizer Management Scheme 2 ($OBFMS_2$)	56.4b	20.0	4.1	122.1ab	94.0	20.4a	14.3a	10.6ab	30.9
T_6 - Organic-Based Fertilizer Management Scheme 3 ($OBFMS_3$)	63.0b	20.0	4.1	112.7ab	93.5	21.3a	15.6a	11.1ab	31.9
Mean	58.4	20.7	4.2	121.5	95.3	19.7	14.1	10.4	30.9
C. V. (a) %	14.5	5.2	6.2	15.8	11.5	9.9	10.1	27.2	25.1
C. V. (b) %	13.7	8.4	13.4	25.6	32.1	16.5	16.2	14.0	12.8

Treatment means within each column followed by common letters and those without letter designations are not significantly different at 5% level, HSD

Kernel Quality

Kernel quality of sweet corn can be determined based on their contents of protein, sugar and starch. Table 9 shows the protein, sugar, and starch contents of sweet corn as influenced by different fertilizer management schemes. Regardless of fertilizer management schemes, Sweet Grande has higher starch and protein content than Sweet Pearl, but Sweet Pearl has higher starch content than Sweet Grande. Results also showed higher protein content of plants subjected to the different fertilizer management schemes (T_2 to T_6) but no differences were observed among treatments on sugar and starch contents.

The higher protein content of sweet corn in plots applied with fertilizers can be due to higher nitrogen uptake by the plant as a result of the availability of more nitrogen in the soil. The increase in protein content may be due to the fact that nitrogen is an integral part of amino acids. Marschner (1995) noted that plant absorbs more nitrogen when this nutrient is readily available in the soil.

Table10 reveals the interaction effect of variety and fertilizer management schemes on the protein content of sweet corn kernels. For Sweet Pearl variety, plants in plots applied with 2L ha^{-1} liquid organic fertilizer + 75-30-30 kg ha^{-1} N, P_2O_5, K_2O (T_5) had the highest protein content, although it was not different from those plants in 150-60-60 kg ha^{-1} N, P_2O_5, K_2O (T_3), 4.4 t ha^{-1} vermicompost + 75-30-30 kg ha^{-1} N, P_2O_5, K_2O (T_4) and 2.2 t ha^{-1} vermicompost + 1L ha^{-1} liquid organic foliar fertilizer + 75-30-30 kg ha^{-1} N, P_2O_5, K_2O (T_6) plots. For Sweet Grande, plants in plots applied with 4.5 t ha^{-1} vermicompost + 75-30-30 kg ha^{-1} N, P_2O_5, K_2O (T_4) had the highest protein content although it was not significantly different from plants in 8.8 t ha^{-1} vermicompost + 4L ha^{-1} liquid organic foliar fertilizer (T_2), 150-60-60 kg ha^{-1} N, P_2O_5, K_2O (T_3) and 2.2 t ha^{-1} vermicompost + 1L ha^{-1} liquid organic foliar fertilizer + 75-30-30 kg ha^{-1} N, P_2O_5, K_2O (T_6) plots.

Effect of Fertilizer Management Schemes on Nutrient Use Efficiency

Table 11 shows nitrogen use efficiency of two sweet corn varieties at different rates of N applied. Sweet Pearl applied with different rates of N applied had higher N recovery efficiency of 33.1(%) compared to Sweet Grande with only 17.1 (%) N recovery efficiency. Likewise, higher nitrogen uptake was observed in 150 kg ha^{-1} of N compared to the remaining N rate.

Table 9. Effects of sweet corn variety and fertilizer management schemes on kernel quality

TREATMENT	KERNEL QUALITY (%)		
	Protein	Sugar	Starch
Sweet Corn Variety			
Sweet Pearl	8.6b	2.5b	30.7a
Sweet Grande	10.4a	8.4a	16.0b
Mean	9.5	5.4	38.8
Fertilizer Management Schemes			
T_1 - Zero-Fertilizer	8.6c	5.2	25.6
T_2 - Organic Fertilizer Management Scheme (OFMS)	9.2b	5.4	47.9
T_3 - Conventional Fertilizer Management Scheme (CFMS)	10.0a	5.3	41.9
T_4 - Organic-Based Fertilizer Management Scheme 1 ($OBFMS_1$)	9.9ab	4.2	23.9
T_5 - Organic-Based Fertilizer Management Scheme 2 ($OBFMS_2$)	9.5ab	6.3	23.9
T_6 - Organic-Based Fertilizer Management Scheme 3 ($OBFMS_3$)	9.7ab	6.2	22.2
Mean	9.5	5.4	30.9
C. V. (a) %	9.3	23.3	38.4
C. V. (b) %	5.2	23.7	21.9

Treatment means within each column followed by common letters and those without letter designations are not significantly different at 5% level, HSD

Table 10. Interaction effect of sweet corn variety and fertilizer management schemes on the protein content of kernel

Sweet Corn Variety	**Fertilizer Management Schemes**						**MEAN**
	T_1	T_2	T_3	T_4	T_5	T_6	
	Control	OFMS	CFMS	$OBFMS_1$	$OBFMS_2$	$OBFMS_3$	
Sweet Pearl	1.2c	1.2c	1.4ab	1.3abc	1.4a	1.4ab	1.3
Sweet Grande	1.5c	1.7abc	1.8	1.8a	1.6bc	1.7abc	1.7
MEAN	**1.3**	**1.4**	**1.6**	**1.6**	**1.5**	**1.5**	

Treatment means with a common letters are not significantly different at 5% level, HSD

Physiological efficiency of Sweet Grande was higher of 8.3 compared to Sweet Pearl. These results are due to high fresh ear yield of Sweet Grande at harvest compared to Sweet Pearl applied with different rates of N. Thus, N use efficiency of Sweet Pearl is higher (543.2 kg ha^{-1}) compared to Sweet Grande because of higher N recovery efficiency. Decrease in nitrogen use efficiency is attributed to low physiological efficiency as the levels of nitrogen fertilizer increased. On average, all nutrient use efficiency (NUE) were higher at lower N rates and decreased at higher N rates. This indicates that rice plants were unable to absorb N when applied in excess because their absorption mechanisms might have been saturated. Under these conditions, the possibility exists for more N being subject to loss by NH_3 volatilization, leaching and denitrification. It has also been reported by Fageria *et al.* (2011) that in any experiment with nutritional variable, plants grown at the lowest nutrient concentrations will inevitably have the highest utilization quotient because of dilution effects. Decreasing NUE at higher N rates indicates that rice plants could not absorb or utilize N at higher rates or N loss exceeded the rate of plant uptake. Decreases in N uptake efficiency at higher N rates has been reported by Kurtz *et al.* (1984) and Pierce and Rice (1988) Similarly, Limon - Ortega *et al.* (2000) reported that NUE in wheat decreased as N rate increased. Eagle *et al.* (2000) reported that NUE in rice, which has both physiological and soil N supply components, decreased with increases in soil N supply, indicating that some of the decrease in NUE may have been due to the increased soil N supply. Maman *et al.* (1999) reported that applied N decreased NUE of pearl millet grain. Phosphorus and potassium use efficiency is presented in Tables 12 and 13. Sweet Pearl applied with different rates of P (kg ha^{-1}) has higher P recovery efficiency of 189.3% compared to Sweet Grande (138.9). The highest P and K recovery efficiency, physiological efficiency and use efficiency among different rates of P and K (kg ha^{-1}) was applied with rates of 30 and 60 kg ha^{-1} for Sweet Pearl and Sweet Grande. The higher P recovery efficiency, P physiological efficiency and P use efficiency are due to the utilization of decreased nutrient with increasing rate of nutrient application as stated by the law of limiting factor and Liebig's law of minimum. Likewise, the highest P uptake was noted in Sweet Pearl applied with the higher rate of 230.6 and 145.2 kg ha-^{1}, respectively. Table further reveals a decreasing pattern in phosphorus and potassium use efficiency values with increasing rates. These results indicate that maximum crop production can be attained with lower fertilizer applications. Decreasing PUE and KUE at higher P and K rates indicate that sweet corn plants can absorb or utilize P and K at higher rates or P and K loss exceeding the rate of plant uptake. Study conducted by Alam *et al.* (2003) found that mean phosphorus use efficiency of 5 wheat varieties across for P sources varied in the order. Yassen *et al.* (2014) also reported significant differences in phosphorus use efficiency among 20 wheat genotypes at deficient and adequate P levels.

Table 11. Nitrogen use efficiency of sweet corn as influenced by variety and fertilizer management schemes

Treatments	N Applied ($Kg Ha^{-1}$)	Ear Yield Without Husk ($Kg Ha^{-1}$)	N Uptake ($Kg Ha^{-1}$)	Recovery Efficiency (Re) (%)	Physiological Efficiency (Pe) ($Kg Ha^{-1}$)	Nitrogen Use Efficiency (Nue) ($Kg Ha^{-1}$)
Sweet Pearl						
T1	0	10581.7	624.0e	-	-	-
T2	134.1	18163.1	2702.8d	15.4d	2.8	43.3
T3	150.0	23857.4	5229.3a	30.7c	2.5	77.9
T4	95.0	22471.4	4901.9a	45.0a	2.4	109.1
T5	85.0	20454.6	3881.1c	38.3b	2.5	97.4
T6	105.0	22613.0	4455.0b	36.4b	3.1	112.9
MEAN				33.1	2.7	543.2
Sweet Grande						
T1	0	12362.0	738.7d	-		
T2	134.1	23832.1	1877.0c	8.4d	15.5	131.0
T3	150.0	37020.0	4093.9a	22.3a	6.0	134.7
T4	95.0	32330.5	2292.1b	16.3c	8.7	142.5
T5	85.0	27454.9	2446.0b	20.9ab	6.1	123.9
T6	105.0	26181.5	2596.6b	17.7bc	5.3	94.1
MEAN				17.1	8.3	125.2

Treatment means within each column followed by common letters and those without letter designations are not significantly different at 5% level, HSD

Table 12. Phosphorus use efficiency of sweet corn as influenced by variety and fertilizer management schemes

Treatments	P Applied (Kg Ha^{-1})	Ear Yield Without Husk (Kg Ha^{-1})	P Uptake (Kg Ha^{-1})	Recovery Efficiency (Re) (%)	Physiological Efficiency (Pe) (Kg Ha^{-1})	Phosphorus Use Efficiency (Nue) (Kg Ha^{-1})
Sweet Pearl						
T1	0	10581.7	359.2f	-	-	-
T2	230.6	18163.1	18225.0a	77.4d	0.4b	32.2e
T3	60.0	23857.4	16868.2b	275.1b	0.7a	216.5b
T4	145.2	22471.4	11691.2d	78.0d	1.0a	79.3d
T5	30.0	20454.6	12200.1c	394.1a	0.8a	318.9a
T6	87.6	22613.0	11086.7e	122.3c	1.0a	132.8c
Mean				189.3	0.8	155.9
Sweet Grande						
T1	0	12362.0	376.4f	-	-	-
T2	230.6	23832.1	12540.1b	52.7d	0.9c	48.2d
T3	60.0	37020.0	15476.9a	251.7b	1.7b	429.9b
T4	145.2	32330.5	5558.1e	35.7e	3.6a	128.1c
T5	30.0	27454.9	8650.4c	275.4a	2.0b	567.9a
T6	87.6	26181.5	7320.9d	79.2c	1.9b	149.5c
Mean				138.9	2.02	264.7

Treatment means within each column followed by common letters and those without letter designations are not significantly different at 5% level, HSD

Table 13. Potassium use efficiency of sweet corn as influenced by variety and fertilizer management schemes

Treatments	K Applied (Kg Ha^{-1})	Ear Yield Without Husk (Kg Ha^{-1})	K Uptake (Kg Ha^{-1})	Recovery Efficiency (Re) (%)	Physiological Efficiency (Pe) (Kg Ha^{-1})	Potassium Use Efficiency (Pue) (Kg Ha^{-1})
Sweet Pearl						
T1	0	10581.7	5123.3e	-	-	-
T2	77.5	18163.1	12003.5c	88.7d	0.6c	56.0c
T3	60.0	23857.4	13425.6b	138.3c	0.9ab	136.8a
T4	68.7	22471.4	10205.5d	73.9e	1.1a	86.1b
T5	30.0	20454.6	10163.1d	167.8b	0.9ab	162.9a
T6	49.3	22613.0	15885.5a	217.9a	0.8bc	165.0a
MEAN				137.3	0.9	121.3
Sweet Grande						
T1	0	12362.0	4782.63e	-	-	-
T2	77.5	23832.1	7590.1c	36.2d	1.5c	54.7c
T3	60.0	37020.0	13253.1a	141.1b	1.9b	262.6a
T4	68.7	32330.5	6574.8d	26.0e	3.0a	79.2c
T5	30.0	27454.9	10481.6b	189.7a	1.4c	273.4a
T6	49.3	26181.5	10317.5b	112.0c	1.3c	150.3b
MEAN				101.0	1.8	164.0

Treatment means within each column followed by common letters and those without letter designations are not significantly different at 5% level, HSD

Conclusion

Based on results of the study, application of CFMS, OFMS and $OBFMS_1$ can increase growth parameters (growth rate, leaf area and dry matter yield) and yield and yield components (ear height, ear width, ear weight/plant with and without husk, fresh ear yield per plot with and without husk, and stover yield) kernel quality (starch, sugar and protein) of the two variety of sweet corns. Sweet Pearl is favorable to application of $OBFMS_1$ (T_4) compared to Sweet Grande.

Nutrient use efficiency of P and K (kg ha^{-1}) was higher with lower rate of 30 and 60 kg ha^{-1} for Sweet Pearl and Sweet Grande. Results also revealed decreasing pattern in P and K use efficiency values with increasing rates of P and K. These results indicate that maximum crop production can be attained with lower fertilizer applications.

References

ALAM, S. M., S. A. SHAH and AKTHAR. (2003). Varietal differences in wheat yield and phosphorus use efficiency as influenced by method of phosphorus application. Songklanatarin J. Sci. Technol 25 (2):175-181.

Ansari AA, Sukhraj K. (2010). Effect of vermiwash and vermicompost on soil parameters and productivity of okra (*Abelmoschus esculentus*) in Guyana. Pakistan Journal of Agricultural Resources 23:137-142.

Dela Cruz, N. E. (2015). SO 814 (Soil Health Restoration and Management) Class. 2nd Semester. Lecture Discussion, Conference Room, Office of Research, CLSU, Science City of Munoz, Nueva Ecija.

Domingo, A. A. and H. H. Hagerman. (1983). Yield, quality and profitability analysis of a continuous sweet corn production schemes. Philipp. J. Crop Sci. 8 (1): 11-15.

Eagle, A. J., J. A.Bird, W. R. Horwath, B. A.Linquist, S. M. Brouder, , J. E. Hill and C. V.Kessel. (2000). Rice yield and nitrogen utilization efficiency under alternative straw management practices. Agron. J. 92: 1096–1103.

Fageria N. K. A. Moreira and C. Castro. (2011). Response of Soybean to Phosphorus Fertilization in Brazilian Oxisol.Communications in Soil Science and Plant Analysis, 42:2716–2723

Hoque, M.A., (1999). Response of BRRI Dhan 29 to S, Zn and B supplied from manures and fertilizers. M.S. Thesis. Department of Soil Sci. BAU.

Jaliya, M.M., A. M. Falaki, M. Mahmud and Y.a. Sani. (2008). Effects of sowing date and NPK fertilizer rate on yield and yield components of quality protein maize (*Zea mays* L.). ARPN Journal of Agricultural and Biological Science3:23-29.

Kobayashi, Y., S. Abe and K. Matumoto. (1989). Growth and yield of paddy rice under natural cultivation. Tohoku Branch Crop Sci. Soc. Japan 32: 12-13.

Kurtz, L. T., L. V. Boone, T. R. Peck and R. G. Hoeft. (1984). Crop rotations for efficient nitrogen use. In ‘‘Nitrogen in Crop Production’’ (R. D. Hauck, Ed.), pp. 295–306. ASA, CSSA, and SSSA, Madison.

Lazcano, C., M. Gómez-Brandón, P. Revilla and J. Domínguez. (2012). Short-term effects of organic and inorganic fertilizers on soil microbial community structure and function Biol Fertil Soils. Retrieved on July 23, 2015 at http:DOI 10.1007/s00374-012-0761-7.

Limon - Ortega, A., K. D.Sayre and C. A. Francis. (2000). Wheat nitrogen use efficiency in a bed planting system in Northwest Mexico. Agron. J. 92: 303–308.

Maman, N., Mason, S. C., Galusha, T. and Clegg, M. D. (1999). Hybrid and nitrogen influence on pearl millet production in Nebraska: Yield, growth, and nitrogen uptake, and nitrogen use efficiency. Agron. J. 91:737–743.

Marschner, H. (1995). ''Mineral nutrition of higher plants.'' 2nd edition. Academic Press, New York.

Pierce, F. J. and Rice, C. W. (1988). Crop rotation and its impact on efficiency of water and nitrogen use. In cropping strategies for efficient use of water and nitrogen. ASA Spec. publ. 51: pp. 21-42.

Ratilla, M. D. and U. A. Cagasan. (2010). Growth and Yield Performance of Selected Lowland Rice Varieties under Alternate Wet and Dry Water Management. Annals of Tropical Research, 28 (23): 2-14.

Yassen, M., Gill, M. Siddique, Z. Ahmad, T. Mahmood and H. Rahman. (1998). Phosphorus deficiency stress tolerance and phosphorus utilization efficiency in wheat genotypes. I: Procc. Symposium Plant Nutrition Management for Sustainable Agricultural Growth, NFDC, Islamabad, pp: 211-215.

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