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Yield and post-harvest quality of sweet corn (*Zea mays* L. var. saccharata) to vermicompost and fermented weed teas application

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Abstract The application of vermicompost revealed significant results on the plant height, ear yield, and total soluble solids (6 & 24 hours) of sweet corn. On the other hand, fermented weed teas did not influence the yield and post-harvest quality of sweet corn. Furthermore, the interaction effects of rates of vermicompost and fermented weed teas did not influence the abovementioned parameters. Based on the results, 15 t ha^{-1} vermicompost gave the highest plant height at 234 cm ($P<0.05$). The synthetic fertilizer (90 kg N -60 kg P_2O_5-60 kg K_2O) produced the highest ear height at 76.83 cm ($P<0.01$) and ear yield at 11.79 t ha^{-1} ($P<0.01$). Vermicompost at 15 t ha^{-1} obtained the highest total soluble solids at 19.8 and 14.25% ($P<0.01$) during six and 24-hours storage duration, respectively. The results implied that vermicompost is not comparable to inorganic fertilizer in ear height and yield. Hence, there is a trend to increase in yield as the rate of vermicompost increased. Moreover, the vermicompost at 15 t ha^{-1} produced sweet corn's highest total soluble solids than synthetic fertilizer. Further studies may be conducted to increase the duration of corn ear storage up to 3 to 5 days to test the total soluble solids accumulation.

Keywords: Fermented weed teas, Sweet corn, Total soluble solids, Vermicompost, Yield

Introduction

For the past decades, the indiscriminate use of synthetic fertilizers and chemical pesticides in crop production has been recognized as the leading contributor to pollution, soil depletion, and global warming. This situation results from poor farming practices, insufficient knowledge on the use of safe alternatives, and poor policy implementation by the government. Synthetic fertilizers may not be eliminated immediately but may be minimized to a certain extent by introducing organic fertilizers.

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The use of synthetic fertilizers and pesticides increases the productivity of the crops; however, it also leads to a decline in the different physicochemical parameters of soil and water (Mall *et al*., 2005). Moreover, the regular cultivation of land without incorporation of organic matter caused deterioration of the soil quality (Meena, 2007). Therefore, it is deemed necessary to start a gradual shift in farming practice from synthetics to organic fertilizers and homemade organic pesticides to attain a sustainable solution to this growing worldwide problem in agriculture.

Sweet corn (*Z. mays* L. var. saccharata), also known as sweet maize, is a popular cereal crop (Muhumed *et al*., 2014). This type of maize is high in sugar and carbohydrates. It is usually cultivated as a horticultural crop since it is harvested before reaching its full maturity stage (Remison, 2005). This crop is cultivated and grown extensively in tropical regions (Haghighat *et al*., 2012). This type of corn is very popular due to its sweetness and softness when cooked (Oktem *et al*., 2010). Its delightful sweetness is the most important factor in consumer satisfaction which generates the demand for three distinct markets- fresh, canning, and freezing (Lertrat and Pulam, 2007).

Sweet corn is a high nutrient user crop (Akintoye and Olaniyan, 2012); therefore, essential nutrients needed by the crop must be available in the soil in sufficient amounts. Applying synthetic or organic fertilizers maintains and improves soil fertility (Efthimiadou *et al*., 2010). Nevertheless, farmers still widely prefer inorganic fertilizers because they have a faster effect and are more efficient on plants (Villaver *et al*., 2021). However, the farmers should consider precautions in applying inorganic fertilizers since it very expensive input and have a withering effect on plants when applied at a higher level.

Vermicompost has been one of the good organic fertilizers for sustainable agriculture even if the nutrients are in slow-release condition. The nutrients present are nitrogen, phosphorus, and calcium. It also contains a high percentage of humus and humic acid. This ingredient provides binding sites for plant nutrients and aids in the prevention of harmful pathogens like some species of fungi, nematodes, and bacteria.

Fermented weed tea is a preparation that is synonymous with the common fermented plant juice (FPJ), except that it uses indigenous weeds growing elsewhere along with the field crops. The considerable amount of nitrogen and other minerals coupled with beneficial microorganisms and plant chemical components make it a potent foliar fertilizer and pesticide for crops. However, at present, little is known about the utilization of weeds as foliar fertilizer and pesticide. This study was conducted to determine the effects of vermicompost and fermented weed teas to the yield and post-harvest quality of sweet corn.

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Materials and methods

From October 1 to December 15, 2019, the experiment was conducted at the Misamis University Agroforestry Farm (8^0 11' 4" N longitude 123^0 45' 59" E latitude) at Capucao Proper Ozamiz City, Philippines. The area was analysed before the conduct of the study. A sample of one kilogram was taken and air-dried for chemical analysis at the Bureau of Soil and Water Management (BSWM), Cagayan de Oro City, Philippines. Among the test methods employed were Walkley and black spectrometric method, Kjeldahl method, Bray method, Cold H_2SO_4 Extraction Method, and Potentiometric method. Results of soil analysis is shown in Table 1. The study used a hybrid sweet corn seed, vermicompost, fermented weed tea preparations, water sources, big plastic containers, glass containers, sprinklers, garden tools, wooden sticks, scissors/cutting tools, plastic twines, weighing scales, and meter stick. The experiment was arranged in a 4 x 4 factorial design in Randomized Complete Block Design (RCBD).

The field experiment utilized a total land area of 1,285.76 m^2 divided into the main plot representing A_1 – synthetic fertilizer (90 N-60 P_2O_5-60 K_2O), A_2 – 5 t ha^{-1} vermicompost, A_3 – 10 t ha^{-1} vermicompost, and A_4 – 15 t ha^{-1} vermicompost. The subplots are B_1 – control (no fermented weed tea), B_2 – 20 ml fermented *Chromolaena odorata* per liter of water, B_3 – 20 ml fermented *Wedelia trilobata* per liter of water, and B_4 – 20 ml fermented *Lantana camara* per liter of water. Fermented weed tea preparations were also submitted to the BSWM, Cagayan de Oro City, Philippines for chemical analysis to determine its pH as well as its nutrient composition (%NPK). The methods carried out in the laboratory are Kjeldahl, Vanadomolybdate, Flame photometry, and Potentiometric. Detailed of its chemical analysis are presented in Table 2. Each treatment (main and subplot) was replicated three times with ten sample plants taken from the three inner rows in each plot. Each plot measured 4.9 m x 4.8 m, having seven rows, 70 cm apart with a 30 cm distance between hills. A composite sample of one (1) kg was taken and air-dried for chemical analysis. The field was plowed and harrowed with a carabao-drawn implement a month before planting. The second and third plowing and harrowing were followed to break big clods to ensure uniform and rapid germination of seeds. Furrowing was done a day before sowing. A soil conditioner, dolomite, was applied since the soil of the experimental area was found to be acidic (pH 4.16). The liming material was applied evenly in each plot before applying the recommended rate of fertilizer (control) and vermicompost. After thorough land preparation, the whole experimental area was laid out. Vermicompost was applied basally according to treatments. The synthetic fertilizer at 90-60-60 (N-P_2O_5-K_2O) kg per hectare was applied in three split applications to the control treatments. Half of the required ammonium phosphate (16-20-0) was applied basally during planting, while the other half was applied as side-dressing 15 days after planting (DAP). Nitrogen (N) in the form of urea (46-0-0) and potassium (P) in the form of muriate of potash (0-0-60) were applied as sidedress at 30 DAP.

Plant materials for weed tea preparations were collected early in the morning (before sunrise) while they were still fresh and the growth hormone and indigenous microorganisms were still present. First, the researchers collected the fast-growing tips (2-3 inches long) of weed plants. The shoot tips of weeds were chopped into 1-3 cm long to extract the juice easily. Next, the chopped plant materials and brown sugar were mixed together in a large basin following a 1:1 ratio (1 kg chopped weed per one (1) kg brown sugar). The two materials were mixed thoroughly to expedite the osmotic process and draw out the plant juices. The plant-material-and-brown-sugar mixture was packed in a bamboo pole. The mouth of the bamboo container was covered with manila paper and then secured with a string or rubber band. The covered containers were stored in a well-ventilated area away from artificial or natural light and extreme heat or cold. After complete fermentation (7 days), the plant materials were separated from the liquid using a filter. The fermented weed teas were stored in a loosely covered container. Fermented weed tea preparations were submitted to the Bureau of Soils and Water Management (BSWM), Cagayan de Oro City to determine their pH and nutrient composition (% NPK).

An application rate of 20 ml fermented weed tea per liter of non-chlorinated water was followed. A 16-liter knapsack sprayer was used to spray the mixture on plant leaves in the late afternoon, an hour before sunset. From the 14th day after planting, weekly spraying was done until the pre-tasseling stage. Harvesting corn ears was done on the 75th day after planting at 4:00 PM to avoid fast quality deterioration. Large perforated sacks were used to contain the harvested ears. Upon arrival at the packinghouse, the harvested ears were weighed and dehusked individually to determine the size and quality. Sorting of ears was also carried out. A digital weighing scale was used to classify ears into small (200-250g), medium (251-300g), and large (301g and above). One sample ear from each plot was subjected to total soluble solids determination (% Brix) using a refractometer. The gathered data were plant and ear height, ear diameter, number of kernel rows, ear yield, and total soluble solids. The data were analyzed using analysis of variance to test the significance of treatments. Comparison among treatment means was determined using Tukey's or honestly significant difference test (HSD) in Statistical Tools for Agricultural Research (STAR) software version 2.0.1.

Table 1. Soil analysis of the area

Parameters	Test method	Before planting
Soil pH	Potentiometric	4.16
Organic matter (OM) %	Walkley and Black Spectrophotometric	3.28
Nitrogen (N)	By calculation (% OM x 0.05)	0.164
Phosphorus (P) ppm	Bray Method	0.53
Potassium (K) ppm	Cold H_2SO_4 Extraction	77

Source: Integrated Laboratories Division DA RFO – 10

Table 2. Special assay results on the fermented weed teas

Fermented weed teas	Test methods	Test requested	Result
Chromolaena (*C. odorata*)	Kjeldahl	Total N (%N)	0.11
	Vanadomolybdate	Total P (P_2O_5)	<0.007
	Flame Photometry	Total K (%K_2O)	0.24
	By Calculation	Total NPK	0.35
	Potentiometric	pH	4.14
Wedelia (*W. trilobata*)	Kjeldahl	Total N (%N)	0.06
	Vanadomolybdate	Total P (P_2O_5)	<0.007
	Flame Photometry	Total K (%K_2O)	0.15
	By Calculation	Total NPK	0.21
	Potentiometric	pH	3.66
Lantana (*L. camara*)	Kjeldahl	Total N (%N)	0.02
	Vanadomolybdate	Total P (P_2O_5)	<0.007
	Flame Photometry	Total K (%K_2O)	0.22
	By Calculation	Total NPK	0.24
	Potentiometric	pH	4.83

Source: Integrated Laboratories Division DA RFO – 10)

Results

Plant height and ear height (cm)

Data on plant height and ear height is presented in Table 3. The height of sweet corn plants is significantly affected by applying varying levels of vermicompost. It shows that the plants with 15 t ha^{-1} vermicompost attained the tallest height of 244.07 cm. The application of different fermented weed teas did not significantly affect the height of sweet corn plants, which shows that the plants exhibited almost the same height.

For the ear height of sweet corn plants, it was significantly affected by the application of rates of vermicompost. Synthetic fertilizer exhibited the tallest ear height with 76.82 cm, closely followed by vermicompost (15 t ha^{-1}) at 72.64 cm. No interaction effect was observed between the rates of vermicompost and fermented weed teas on the plant height and ear height of sweet corn.

Table 3. Plant height and ear height of sweet corn in response to vermicompost and fermented weed teas

Treatments	**Plant Height (cm)**	**Ear Height (cm)**
A - Rates of vermicompost (main plot)		
A_1 - Synthetic fertilizer (90-60-60)	232.10^{ab}	76.83^{a}
A_2 - 5 t ha^{-1} vermicompost	226.29^{b}	58.30^{d}
A_3 - 10 t ha^{-1} vermicompost	227.68^{b}	63.88^{c}
A_4 - 15 t ha^{-1} vermicompost	234.03^{a}	72.64^{b}
F-test	*	**
CV (%)	4.33	0.49
B - Fermented weed teas (subplot)		
B_1 - 0 (Control)	233.41	67.98
B_2 - 20 ml fermented *C. odorata*	232.08	68.02
B_3 - 20 ml fermented *W. trilobata*	230.67	68.17
B_4 - 20 ml fermented *L. camara*	233.96	67.49
F-test	ns	ns
CV (%)	3.19	1.81
F-test A x B	ns	ns

Using Tukey's test, the means within each column having a common letter are not significantly different at the 5% significance level.

Ear weight (t ha^{-1})

The application of varying rates of vermicompost showed a highly significant effect on the ear weight of sweet corn (t ha^{-1}) as presented in Table 4. Synthetic fertilizers showed the highest ear yield at 11.79 t ha^{-1}, followed by vermicompost (15 t ha^{-1}) at 11.13 t ha^{-1}. The result showed that the sweet corn plants responded significantly to rates of vermicompost. On the other hand, the application of different weed teas did not significantly affect the ear yield of sweet corn. Moreover, the interaction effects of rates of vermicompost and fermented weed teas did not show any significant difference in the ear weight of sweet corn.

Ear diameter and number of kernel row

The ear diameter was not significantly affected by the application of rates of vermicompost as portrayed in Table 5. Maximum ear diameter at 4.14 cm was noted when applied with vermicompost at 15 t ha^{-1}. For the number of kernel rows, different rates of vermicompost applied to sweet corn showed that it produced a similar number of kernel rows since only one sweet corn variety was used in the study. Similarly, ear diameter and the number of kernel rows of sweet corn were not significantly affected by applying different weed teas. No significant interaction was observed between vermicompost and fermented weed teas on the diameter and number of kernel rows of sweet corn.

Table 4. Ear weight of sweet corn in response to vermicompost and fermented weed teas

Treatments	**Ear yield (t ha^{-1})**
A - Rates of vermicompost (main plot)	
A_1 - Synthetic fertilizer (90-60-60)	11.79^{a}
A_2 - 5 t ha^{-1} vermicompost	10.20^{c}
A_3 - 10 t ha^{-1} vermicompost	10.67^{bc}
A_4 - 15 t ha^{-1} vermicompost	11.13^{b}
F-test	**
CV (%)	3.30
B - Fermented weed teas (subplot)	
B_1 - 0 (Control)	11.01
B_2 - 20 ml fermented *C. odorata*	10.86
B_3 - 20 ml fermented *W. trilobata*	10.94
B_4 - 20 ml fermented *L. camara*	10.97
F-test	ns
CV (%)	2.92
F-test A x B	ns

Using Tukey's test, the means within each column having a common letter are not significantly different at the 5% significance level.

Table 5. Ear Diameter (cm) and number of kernel rows of sweet corn in response to vermicompost and fermented weed teas

Treatments	**Ear diameter (cm)**	**Number of kernel rows**
A - Rates of vermicompost (main plot)		
A_1 - Synthetic fertilizer (90-60-60)	4.13	14.72
A_2 - 5 t ha^{-1} vermicompost	4.07	14.57
A_3 - 10 t ha^{-1} vermicompost	4.12	14.33
A_4 - 15 t ha^{-1} vermicompost	4.14	14.72
F-test	ns	ns
CV (%)	4.88	6.47
B - Fermented weed teas (subplot)		
B_1 - 0 (Control)	4.04	14.47
B_2 - 20 ml fermented *C. odorata*	4.05	14.20
B_3 - 20 ml fermented *W. trilobata*	4.15	14.85
B_4 - 20 ml fermented *L. camara*	4.20	14.81
F-test	ns	ns
CV (%)	3.60	4.74
F-test A x B	ns	ns

ns – non significant

Total soluble solids

The total soluble solids (TSS) of sweet corn at 6 hrs and 24 hrs after harvest in response to rates of vermicompost and fermented weed teas are presented in Table 6. As presented, the TSS of sweet corn at 6 and 24 hours after harvest was significantly affected by the application of rates of vermicompost. The rate of vermicompost at 15 t ha^{-1} exhibited the highest TSS of 19.08 at 6 hours and 14.25 at 24 hours. On the other hand, the TSS of the sweet corn was not affected by applying different weed teas. No significant interaction effects were observed.

Table 6. Total soluble solids (TSS) at 6 hours and 24 hours after harvest of sweet corn in response to vermicompost and fermented weed teas

Treatments	**TSS (6 hrs)**	**TSS (24 hrs)**
A - Rates of vermicompost (main plot)		
A1 - Synthetic fertilizer (90-60-60)	15.08^{c}	11.00^{c}
A2 - 5 t ha^{-1} vermicompost	16.42^{b}	12.25^{b}
A3 - 10 t ha^{-1} vermicompost	17.08^{b}	12.33^{b}
A4 - 15 t ha^{-1} vermicompost	19.08^{a}	14.25^{a}
F-test	**	**
CV (%)	4.43	6.66
B - Fermented weed teas (subplot)		
B1 - 0 (Control)	16.75	12.33
B2 - 20 ml fermented *C. odorata*	16.75	12.42
B3 - 20 ml fermented *W. trilobata*	17.00	12.58
B4 - 20 ml fermented *L. camara*	17.17	12.50
F-test	ns	ns
CV (%)	5.59	8.00
F-test A x B	ns	ns

Using Tukey's test, the means within each column having a common letter are not significantly different at the 5% significance level.

Discussion

This result agrees with the findings of Onasanya *et al*. (2009), who reported a positive increase in plant height and some other growth parameters in response to the presence of nitrogen in vermicompost. Gao *et al*. (2020) opined that nitrogen enhances crop growth by synthesizing more protein and chlorophyll. The nitrogen fertilization stimulates cell division and elongation, increasing the distance between internodes, thus, increasing the height (Thakur *et al*., 2015). Synthetic fertilizer produced the tallest ear height and ear yield because the plants responded easily to the available macronutrients present. The result conforms to (Amanullah *et al*., 2015), which observed increased ear height and yield with the highest rate of 180 kg N ha^{-1}. The increased yield was due to the positive effect of nitrogen which stimulates cell division and elongation, consequently more distant internodes, more chlorophyll content, and wider leaves that increase the photosynthetic activity of the crops. Widening of the leaves and increase in chlorophyll content is a great advantage for the crop. This condition occurs due to the sufficient nitrogen fertilizer applied to the soil for crop production. Higher phloem loading of assimilates from the wider leaves to the highly reactive sink (developing ear) occurred during the translocation process thus, increased the ear yield.

The potassium also enhances the development of ear formation and increases corn ear production (Umbarkar *et al*., 2020). The total soluble solids (TSS) were taken to measure the corn ear's sugar content at different storage durations. This study revealed that the TSS of sweet corn is higher when applied with vermicompost at 15 t ha^{-1}. The results depicted that the TSS of sweet corn applied with rates of vermicompost is much higher when compared to sweet corn applied with synthetic fertilizer. Vermicompost contains potassium which improves the sugar content of the sweet corn. The potassium uptake of sweet corn is increased with organic fertilizers (Fahrurrozi *et al*., 2018). A study by Bharathi *et al*., (2020) reported that the TSS of sweet corn increases with organic and inorganic fertilizer applications. Waghmode *et al*. (2015) also reported that the TSS of sweet corn increases with farmyard manure and vermicompost. The vermicompost application has shown a promising result in improving ear yield and post-harvest quality. Hence, increasing the storage duration of sweet corn up to 3 to 5 days is recommended to determine further the TSS accumulation.

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