



Productivity of Okra (*Abelmoschus esculentus* L. cv. Smooth Green) Using Application Frequency of Vermicompost Tea

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Abstract — Vermicompost tea consists of nutrients that contribute and are necessary for good yield performance of okra. Okra is a nutritious vegetable and a good source of income. Hence, a study on okra was conducted from October 2015 to January 2016 located 18°3'47" north latitude and 120°32'56" east longitude or 23° northeast City of Batac, Ilocos Norte, Philippines. It was conducted to: a) determine the productivity of okra using application frequency of vermicompost tea; b) determine the best application frequency of vermicompost tea that contribute high yield of okra and; c) determine the production economics of growing okra using vermicompost tea. The following treatments were used: no fertilizer: 1 - once a week, 2 - twice a week and 3 - thrice a week application of vermicompost tea, and 5 - inorganic fertilizer only. Treatments were assigned in the experimental units following a Randomized Complete Block Design in three replicates with a unit plot size of 12 m². Treatment effects were evaluated by yield performance of okra and production economics. The use of inorganic fertilizer and vermicompost tea provides the necessary nutrients for good yield components. Plants with fertilizer irrespective of sources significantly produced a higher percent marketable fruits and yield than no fertilizer. In general, vermicompost tea is more profitable than inorganic fertilizer.

Keywords — Once, Thrice, Twice.

I. INTRODUCTION

Okra (*Abelmoschus esculentus* L.) also known as lady's finger, bhindi, bamia, ochro or gumbo, is a flowering plant in the Malvaceae family. The geographical origin of okra is disputed, with supporters of West African, Ethiopian, and South Asian origins. The plant is cultivated in tropical, subtropical and warm temperate regions around the world. The crop can be grown locally and commercially throughout the year due to its resistance to either drought or water logging. It is valued for its edible seed pods. The young fruits of this plant are consumed as ingredients of soups and sauces. Other parts of okra are good sources of feed and medicine. Leaves are used as for cattle, the fibers from the stem for cord making, the plant mucilage for medicinal purposes, and the seeds as a substitute for coffee (<http://www.bar.gov.ph>).

Okra is a popular and in demand vegetable ingredient in Filipino dishes such as "pinakbet". Philippine production data showed as 30,274.23 metric tons (MT) produced in 2014 wherein Ilocos Region contributed a production of 1,738.12 MT and Ilocos Norte has a share of 715.27 MT to the production of the region (<http://agstat.psa.gov.ph>). Smooth green is one of the varieties of okra that is highly productive even under sub-optimum conditions. This variety has a characteristic of round and smooth pods with

no ridges. The pods are long, slender and have a bright green color (www.eastwestseed.com).

Fertilization could be supplied using organic or inorganic sources. The application of fertilizer will supply nutrients that the native soil can't provide, therefore ensures good crop production. The capacity of the soil to produce a good crop is directly related to the availability of nutrients that are beneficial to productivity. Farmers cannot afford to buy commercial fertilizers due to its high price but this problem can be solved by using organic fertilizers made from materials that are readily and locally available.

High crop yield can be attained if the nutrient requirements of the plant are applied but because of the perception and reality of the potential environmental impacts of those inputs the crop performance is sacrificed. Yet, maintaining food production for the growing world population requires new technology and intensifying production and management to grow more food on current cropland (<http://www.cropnutrition.com>). Chemical or inorganic fertilizer is the most widely used form of fertilizer because they contain higher available nutrient content compared to most organic fertilizer. They are readily soluble hence; effects on plant growth are usually immediate. However, the excessive use of chemical fertilizers can cause pollution of ground water and other bodies of water like rivers and lakes. Besides the deleterious effect on our water, fertilizer use has caused the decline of soil productivity. Organic fertilizer on the other hand, has low element content and its nutrient composition varies within the material used that's why it needs voluminous amount.

Vermicompost tea (VCT) is one of the sources of organic plant supplements (OPS) as alternative to chemical fertilizer and as liquid nutrient fertilizer in low-input agricultural system. According to Litterick et al. (2004, cited by Selvaraj, 2011) VCT are water extracts of vermicomposted materials made for their beneficial effects on plants. Moreover, it is a specific type of compost tea derived from soaking or brewing vermicompost in water (<http://www.extension.umn.edu>). The extracted liquid has microorganisms suppresses the soil borne disease which serve as protectors from or control plant diseases which increase production, and nutrient content of vegetables and fruits (Jack and Thies, 2006; Lowenfels, et al. 2006 cited by <http://www.extension.umn.edu>; and <http://yelmworms.com/compost-tea/>).

Vermicompost is readily available in the locality and some farmers are producing their own in which they could make VCT following the ratio by the Mariano Marcos State University and Agricultural Training Institute (2013). The



nutrients in VCT are readily available for plant uptake. VCT contains beneficial microorganisms that control or reduce diseases (Balfanz, *et. al.*, 2010), it has plant growth regulators which influence nutrient availability (Arancon, *et al.*, 2003), produce nutrient (<http://yelmworms.com/compost-tea/>), nutritional quality of the plant is enhanced (<https://www.blackdiamondvermicompost.com/compost-tea/>), and promote plant growth (Pant, *et al.*, 2012). The frequency application is necessary to determine how economical it is and at the same time if the growth and yield performance of the crop could be improved.

The following hypotheses were tested: test crop perform similarly in terms of growth performance; application frequency of vermicompost tea significantly affects leaf color of okra and; inorganic fertilizer and vermicompost are comparable with each other in terms of yield. The study was conducted to: a) determine the productivity of okra using application frequency of vermicompost tea; b) determine the best application frequency of vermicompost tea that contribute high yield of okra and; c) determine the production economics of growing okra using vermicompost tea.

II. MATERIALS AND METHODS

The study was conducted 18°3'47" north latitude and 120°32'56" east latitude or 23° northeast of the University Main Library, City of Batac, Ilocos Norte, Philippines. The area is usually planted with various vegetables during the wet and dry seasons. The study has shallow tube well as a source of water for irrigation.

Table 1 shows the physical and chemical properties of the soil in the experimental area. The area has medium soil texture and there was an increase in soil pH, available phosphorus (P), exchangeable potassium (K) and organic matter content after the conduct of the study. The soil pH value was ranged from 7.40 to 7.60 classified as strongly alkaline.

Figure 1 shows the agro-climatic data from the month of October to December 2015 gathered from the MMSU-PAGASA-PCARRD Agro-meteorological Station, Batac City. The total amount of rainfall recorded was 304.2 mm with high amount observed at 20 DAP or at early vegetative stage of okra. The rainfall was caused by a typhoon that also brought strong winds (191.7 km/day). At early vegetative stage (17 to 21 DAP), plant was not exposed to drought due to favorable amount of rainfall that contributed to good growth. Due to sufficient rainfall the temperature and relative humidity were respectively lower and higher. Afterwards, no amount of rain was observed up to 74 DAP but at 75 DAP there was minimal amount of rainfall recorded.

Strong winds were observed again at 16 and 19 DAP and up to 58 and 79 DAP ranging from 105 to 192 km/day. More than the normal speed of 7.2 km/hr affected the plant's development causing an increase of transpiration, sterility due to the loss of pollens, disease spores dispersal and plant form. If there is a high transpiration of plants they will easily wilt, hence faster senescence. However, no incidence of lodging was noted.

The strong winds contributed to lower relative humidity and temperature values at the reproductive stage. No plant damage was observed during this condition. However, lower wind speed resulted to normal relative humidity and fluctuating value of temperature due to erratic wind speed. The relative humidity was ranged from 58 to 97%, while the temperature was 26.6 to 27°C and the wind speed was 18.1 to 34.2 km/day. High relative humidity (97%) was observed at 22 DAP; while low relative humidity (58%) was observed at 80 DAP. High temperature (27°C) was recorded at 10 DAP and the lowest (26.7°C) at 85 DAP.

Research Design

The experiment was laid out in Randomized Complete Block Design (RCBD) with five treatments and replicated thrice. A total land area of 276 m² was used in the study. The area was divided into three blocks and each block was subdivided into five plots measuring 3m x 4m (12 m²) each plot. Every block had 1.0 m apart and 0.50 m between plots.

Variables of the Study

Vermicompost tea and inorganic fertilizer (complete fertilizer and urea) were used in this study. Vermicompost tea was sprayed at different frequencies (1, 2, and 3 times a week) application. While inorganic fertilizer was applied following the recommended rate for okra which is 19g/hill 14-14-14 as basal fertilizer. The plants were applied with 10 g/hill 46-0-0 (urea) at 30 days after emergence (DAE) as side dress.

Treatments

- Treatment 1— No fertilizer application
- Treatment 2— Once a week
- Treatment 3— Twice a week
- Treatment 4— Thrice a week
- Treatment 5— Inorganic fertilizer (290-106-106 kg of NPK per hectare)

Cultural Management Practices

Land Preparation

The area (276 m²) was prepared by land clearing to remove all weeds and plant debris. Two times rotavation with weekly interval was followed with the use of tractor rotavator. Four days after the second rotavation, furrows were prepared at a distance of 0.50 meter apart using carabao-drawn plow.

Preparation of Planting Materials

Smooth green variety of okra was used. Okra seeds were soaked in tap water for 24h prior to sowing.

Planting and Transplanting

The seeds of okra (smooth green) were sown directly at 1 to 2 seeds per hill spaced at 0.50 m between hills and 0.50 m between rows. Replanting was done at 10 days after sowing (DAS) when the seedlings are capable for transplanting to complete the population per plot.

Water Management

Okra is tolerant to drought, however, it needs watering if the soil is very dry. Furrow irrigation was done when the soil is very dry because the study area has sandy loam textural class.

Process in Making Vermicompost Tea

Vermicompost was purchased from the university and bagged in clean sack. Two kg of vermicompost to 10 liters of water (1:10) was used based on the recommended rate of



compost tea by MMSU and ATI (2013). Vermicompost was brewed for 72 hours using the brewery of the university. The tea was transferred into a clean container after brewing and stored in a dry place and without exposure to direct sunlight. Vermicompost tea can contain the three basic plant nutrients: nitrogen in the form of nitrate or ammonium (NO_3^- and NH_4^+); phosphorus (P); and potassium (K) (Balfanz, *et al.*, 2010).

Nutrient Management

The nutrient management was according to treatments. For the plants applied with inorganic fertilizer, complete fertilizer (19g/hill) was applied basally whereas urea (10g/hill) was applied as side dress at 30 days after emergence (DAE). A total of 2.74 kg 14-14-14 and 1.40 kg 46-0-0 was applied under plot with inorganic fertilizer. The application frequency for VCT was dependent on the treatments. Through foliar application, VCT was sprayed late in the afternoon to avoid burning effect on the leaves. The concentration used was 15 mL of VCT and one L of water (MMSU and ATI, 2013).

Pest Management

Growth of weeds. Weeds compete with the plants in water absorption, space and light. Hand weeding was done when weeds occurred in between rows.

Insect pest and disease incidence. There was minimal infestation of insect pests and disease infection was recorded. Chemical pesticide was not used.

Harvesting

The plants were harvested according to the maturity indices of okra. Okra was harvested when the fruit is bright green and the pods are fleshy. The sample plants each treatment was harvested and placed in plastic bags separately with proper labeling. Harvesting was done every other day to avoid the over maturity of fruits.

Data Gathering Procedures

Number of Fruits per Hill and Number of Fruits per Kilogram

The numbers of harvested fruits per hill from random 10 sample plants were recorded. On the other hand, the number of harvested fruits per kilogram was counted every harvesting. The fruits are in marketable state wherein insect and disease-free, free from bruises, no mechanical damage, and have a shiny bright color.

Percent Marketable Fruits

After harvesting, the fruits were classified according to their marketability. Marketable fruits were classified as follows: insect and disease-free, free from bruises, no mechanical damage, and have a shiny bright color. Whereas the unmarketable fruits were classified as: presence of insect damage, curled fruits and evident bruises. This was recorded by getting the average from the first to the last priming. It was calculated as follows:

$$\% \text{ Marketable Fruits} = \frac{\text{Weight of marketable fruits (kg)}}{\text{Total weight of harvested fruits (kg)}}$$

Fruit Length and Diameter

The length and diameter of the fruit was measured using a ruler and vernier caliper, respectively, from the 10 sample fruits every treatment from the first to the last priming.

Yield per Hectare

This was recorded by getting the yield taken from the harvest area (6 m²) from the first to the last priming. The yield per hectare was calculated as follows:

$$\text{Yield per Hectare} = \frac{\text{Yield per plot (kg)} \times 10000(\text{m}^2)}{1000\text{kg per ton} \times \text{area harvested (m}^2)}$$

Statistical Analysis

Primary data gathered from the experiment was used as the basis of analysis using STAR program and recommendation. The data gathered was summarized and analyzed statistically using the one way analysis of variance (ANOVA) for the Randomized Complete Block Design (RCBD). Where F-test showed significant results, treatment mean differences were further tested using the Tukey's Honest Significant Difference (HSD).

Production Economics

The economics of production per hectare was evaluated using the cost and return analysis. Economics variables included net income, production cost kg⁻¹ fruits and return of investment (ROI). The costs of labor and materials were considered during the conduct of the study as basis in the computation of cost and return.

The following formula was used:

$$\text{Gross Income (GI)} = \text{Yield} \times \text{Price/kg}$$

$$\text{Net Income} = \text{GI} - \text{Total Production Cost (TPC)}$$

$$\text{Production cost kg}^{-1} \text{ fruits} = \text{TPC} / \text{Yield}$$

$$\text{Return on investment} = \text{Net Income} / \text{TPC} \times 100$$

III. RESULTS AND DISCUSSION

Number of Fruits per Hill

The application frequency of VCT did not significantly affect the number of fruits per hill (Table 2). The number of fruits per hill was ranged from 29 to 34 fruits. This means that irrespective of the source of nutrients, the plants produced a comparable number of fruits per hill. In contrast with the study of Selvaraj (2011) on tomato that high concentration VCT resulted in significantly more fruit per branch.

Number of Fruits per Kilogram

Statistically, there was no significant effect on the number of fruits per kilogram irrespective of treatments used (Table 2). But numerically the plant with no fertilizer (95 fruits) had the highest number of fruits per kilo compared to other treatments and it has lighter weight per fruit. Among application frequency of VCT to plants applied twice a week (94 fruits) had the highest number of fruits per kilogram. Further increase up to three times application did not increase the number of fruits. This means that fruits on this application frequency are heavier than the others.

Percent Marketable Fruits

Statistically, there was significant ($P < 0.05$) difference of the treatments on % marketable fruits (Table 2). VCT and inorganic fertilizer were significantly higher than no fertilizer. Therefore, VCT had the same effect with inorganic fertilizer which produced comparable percent marketable fruits. Numerically, as the application frequency of VCT increases the percent marketable fruits also increased.

Fruit Length and Diameter



The application frequency of VCT showed no significant effect on fruit length and diameter of okra (Table 3). There was an increasing trend of fruit length and diameter if VCT is applied up to twice a week but declined if the application is thrice a week. Among treatments those applied with inorganic fertilizer produced longer fruits while twice a week application of VCT produced a wider (13.49 cm) fruit diameter. No fertilizer application produced shorter fruits and diameter.

Yield per Hectare

The application frequency of VCT significantly ($P < 0.05$) affected the yield per hectare (Table 3). Plants with twice a week application of VCT and inorganic fertilizer had comparable yield. The former was comparable to once and thrice a week application. Plants with inorganic fertilizer and twice a week application of VCT significantly outyielded the plants with no fertilizer.

On the other hand, there was a declined yield of okra if the application frequency of vermicompost tea is up to thrice a week. VCT provided good and increased yield of plants (Pant, et al., 2011; Ingham, 2003, cited by Selvaraj; 2011 Meghvansi et al., 2012; and Pant, et al.).

Cost and Return Analysis

The high yield of plants applied with inorganic fertilizer did not contribute to the higher return of investment (ROI)

as indicated in Table 4. Among application frequency of vermicompost tea three times application had the highest ROI of 43.46 % even if it has the lowest yield. The said frequency application had the highest cost in producing okra fruits per kilogram. High production cost of inorganic fertilizer was due to material input specifically fertilizer materials and polyethylene bag. This means that the yield does not compensate for the high cost of inorganic fertilizer. However, no fertilizer application to plants had the lowest ROI and production cost kg^{-1} fruits.

IV. CONCLUSION

Based on the results, it can be concluded that the application frequency of vermicompost tea significantly affected the percent marketable fruits and fruit yield per hectare. High yield is attained if vermicompost tea is applied twice a week because if it is more than this frequency, the yield does not increase. Thrice a week application of vermicompost tea is more profitable than the others even though twice a week application has the highest yield among them, but does not compensate the costs.

Table 1. Physical and chemical properties of soil in the experiment area before and after the conduct of the study, 2015 DS.

SOIL PROPERTIES	BEFORE EXPERIMENT	AFTER EXPERIMENT				
		T1	T2	T3	T4	T5
pH	7.40	7.60	7.47	7.53	7.53	7.40
Organic matter (%)	1.16	1.29	1.69	1.60	1.62	1.33
Available P (ppm)	10.41	14.18	20.43	17.40	20.28	87.33
Exchangeable K (ppm)	342.51	376.60	403.07	409.69	396.45	378.25
Texture	Medium	Medium	Medium	Medium	Medium	Medium

Provincial Agriculture Office, Soils Laboratory, Laoag City, Ilocos Norte. T1- no fertilizer, T2- Once a week, T3- Twice a week, T4- Thrice a week and T5- Inorganic fertilizer.

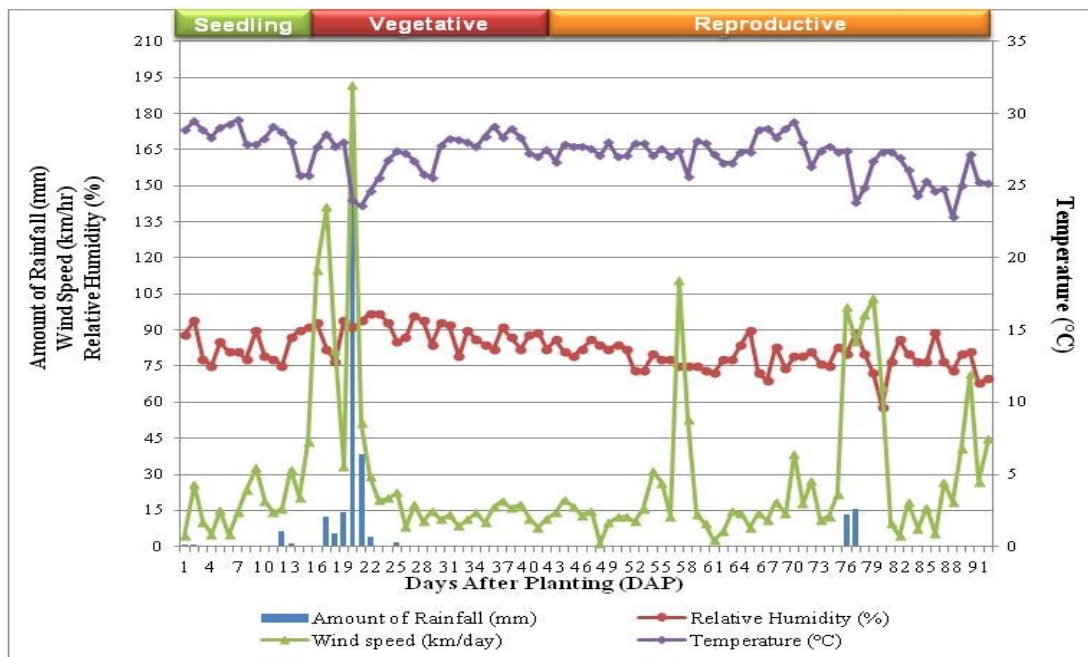


Fig. 1. Agro-climatic data on amount of rainfall (mm), wind speed (km/day), relative humidity (%), and temperature in growing of okra from October 1, 2015 to December 31, 2015.



Table 2. Number of fruits per hill, number of fruits per kilogram and percent marketable of okra as affected by application frequency of vermicompost tea, 2015 DS.

TREATMENT	NUMBER OF FRUITS PER HILL	NUMBER OF FRUITS PER KILOGRAM	PERCENT (%) MARKETABLE
	ns	ns	*
No Fertilizer	29.00	95.00	81.18b
Once a week	33.00	92.00	90.50a
Twice a week	34.00	94.00	92.56a
Thrice a week	34.00	91.00	93.44a
Inorganic Fertilizer	34.00	92.00	91.78a
CV(%)	13.29	2.50	4.37

Means marked with the same letter within each group in a column are not significantly different at 5% level using Tukey's Honest Significant Difference (HSD).

Table 3. Fruit length and diameter and yield per hectare of okra as affected by application frequency of vermicompost tea, 2015 DS.

TREATMENT	FRUIT LENGTH (cm)	FRUIT DIAMETER (cm)	YIELD PER HECTARE (t/ha)
	ns	ns	*
No Fertilizer	12.05	1.16	10.51c
Once a week	12.86	1.25	12.44bc
Twice a week	13.45	1.31	13.40ab
Thrice a week	13.03	1.27	12.40bc
Inorganic Fertilizer	13.49	1.28	15.40a
CV (%)	5.00	4.58	9.73

Means marked with the same letter within each group in a column are not significantly different at 5% level using Tukey's Honest Significant Difference (HSD).

Table 4. Cost and return of okra as affected by application frequency of vermicompost tea, 2015 DS.

TREATMENT	YIELD PER HA	TCP (Php)	NI PER HA (Php)	PRODUCTION COST KG ⁻¹ FRUIT	ROI (%)
No Fertilizer	10.51	78,971	236,329	7.51	33.42
Once a week	12.44	96,392	276,408	7.75	34.87
Twice a week	13.40	110,826	291,174	8.27	38.06
Thrice a week	12.40	112,686	259,314	9.09	43.46
Inorganic Fertilizer	15.40	121,456	340,444	7.89	35.68

HA- hectare
TCP- total cost of production
NI- net income
ROI- return on investment
Php- Philippine peso
Price per kg of fruits- Php25.00

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