International Journal of Agricultural Technology 2023 Vol. 19(3):1097-1106
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Hot pepper (*Capsicum frutescens* l.) production as influenced by different organic sources of nutrients

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Magallon, W. N. and Cabahug, A. G. (2023). Hot pepper (*Capsicum frutescens* l.) production as influenced by different organic sources of nutrients. International Journal of Agricultural Technology 19(3):1097-1106.

Abstract The effect of different locally available organic sources of nutrients in hot pepper production was investigated. Results showed that organic nutrient sources used in the study could meet the needs of hot pepper production and can be used as an alternative option for organic farmers. The effects of various treatments on hot pepper growth and yield were significantly influenced. The findings improved growth and yield performance; by Vermicompost (T4) application at 10 t ha^{-1} (P=<0.01), resulting in the best overall behavior in all of the plants; Growth performance, the number of days to flower, fruit yield, total yield per treatment, projected yield per hectare, and the highest net income of 623,710.5 Pesos with 702.46 ROI and followed by combustion ash fertilizer (T2) and goat manure (T3) over control treatments were applied at 10 t ha^{-1} which was an excellent alternative source of organic fertilizers with 589.60 ROI and 499.00 ROI, respectively. Applying vermicompost, combustion ash fertilizer and goat manure at 10 t ha^{-1} are shown to be the best for hot pepper production.

Keywords: Combustion ash, Goat manure, Hot pepper, Organic production, Vermicompost

Introduction

Organic farming is one of the world's most rapidly expanding agricultural sectors. Despite only 1% of global agricultural land, organic is one of the most recognized food labels. Most people in developed countries consume organic food today (Seufert *et al*., 2017). Organic food consumption may lower the risk of allergies, being overweight, and being obese. In addition, epidemiological studies have shown that certain pesticides negatively affect children's cognitive development (Mie *et al*., 2017). Because health is a person's most valuable asset, most people would buy organic food to stay healthy(Srinieng and Thapa, 2018).

Organic fertilizer is an alternative method of providing crop nutrients to reduce high inorganic fertilization rates, protect the environment, and lower

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farmers' production costs (Chatzistathis *et al*., 2021). However, Farmers in developing countries prefer chemical fertilizers over organic fertilizers. Primarily, they fear losing income if they use organic fertilizers instead of chemical fertilizers(Wang *et al*., 2018).

On the other hand, *Capsicum* is an economically significant, globally consumed vegetable and spice crop (Kim *et al.*, 2014). Given its phytochemical, the crop has a promising future from its nutritional, medicinal, and economic worth (Esguerra and Absulio, 2016; Saleh *et al*., 2018; Batiha *et al*., 2020). Hot pepper fruits, also known as Chili, have been used as food vegetables, flavouring ingredients, natural colourants, and in traditional medicines since ancient times. Furthermore, Chili contains significant amounts of pigments (such as chlorophyll, anthocyanin, and lutein) with potential health benefits, including vitamins, minerals, flavonoids, carotenoids, and capsaicinoids. Capsaicin is the main active compound responsible for these species' pungent taste and has been shown to have health benefit (Hernández-Pérez *et al*., 2020). Researchers found the therapeutic effect of C. frutescens leaf and fruit extract (Hegde *et al*., 2014; Tamayo *et al*., 2014) with antioxidant properties(Antonious, 2018). In addition, Hot pepper consumption reduces micronutrient deficiency (Dekebo, 2020).

The current emphasis on agricultural practices and the pursuit of healthy food is increasing as organically grown foods continue to be prevalent in developed and developing worlds. The production and use of hot peppers are becoming more popular, especially in the Philippines. The recent price ranges from 150-700 pesos per kilogram, attracting more farmers to venture. Some farmers in the study area grow hot peppers for personal and commercial purposes, with the issues mentioned in organic farming and the benefits of hot pepper production. The purpose of this research was to establish organic hot pepper production using locally available materials as organic fertilizers, which would provide solutions to productivity and food safety constraints, as well as the high cost of synthetic agricultural inputs, while determining crop performance and, in particular, improving yield and fruit quality.

Materials and methods

The study was conducted at the Crop Science Experimental area of JHCSC-Dumingag Campus, Dapiwak, Dumingag, Zamboanga del Sur, Philippines, which has GPS coordinates of 8°11'19.29"N 123°17'32.05"E at an elevation of about 503.6 above sea level.

Figure 1. An image showing the experimental area taken from Google Earth Pro

The experimental area was laid out using Randomized Complete Block Design (RCBD), with four treatments replicated four times. The treatments are the different organic sources of nutrients applied at 10 tons/ha as follows: treatment 1 was-control, treatment 2 was- combustion ash fertilizer, treatment 3 was- goat manure, and treatment 4 was- vermicompost. Each experimental unit had a dimension of 3 x 4 m with a total experimental area of 357 square meters.

The experimental area was cleared by ploughing thoroughly at a depth of 15 cm using a tractor-drawn implement. Ploughing and harrowing were done twice in two weeks intervals to pulverize the soil and allow the weed seeds to germinate and be controlled. The organic fertilizers such as goat manure and vermicompost were applied basally two weeks before transplanting. The combustion ash fertilizer a commercially available fertilizer in the philippines marketed by William Sy. It is Japan technology it is purely chicken manure processed into ash. This fertilizer was applied four times as indicated below: first application, five days before planting, second application during the flowering stage, fruiting stage, and last application during first harvest.

Mulching was done using a plastic sheet to suppress growing weeds and to maintain soil moisture. Hot pepper (Siling Labuyo) seedlings were transplanted to the experimental area one month after germination. One seedling was transplanted to each hill at a distance of 40 cm x 30 cm. Replanting the missing hills was done one week after transplanting the extra seedlings. Proper care and management were employed during the entire growth and development of the plants. Regular watering of the plants was done to maintain soil moisture. Weeds were uprooted to prevent nutrient competition of the plants.

Harvesting was done when the fruits were in the mature green stage or attained full size, waxy, and shiny. The fruits were harvested by twisting the fruit upward or by cutting the peduncle with a sharp knife. The harvested fruits were classified according to size and ripeness.

The data were analyzed using the Software Statistical Tool for Agricultural Research (STAR Computer Software). The mean comparison was made using Least Significance Difference (LSD).

Results

The temperature and humidity were taken and recorded during the study. The highest relative humidity was recorded on the first week of August at 3 pm, with an average of 30.0%, while the rest of the months were low.
The highest temperature was recorded at noon on the third week of August with an average of 29.7^{0}C, while the rest of the months were low. As to the rainfall reading, the highest rainfall was recorded in September with 535 mm.

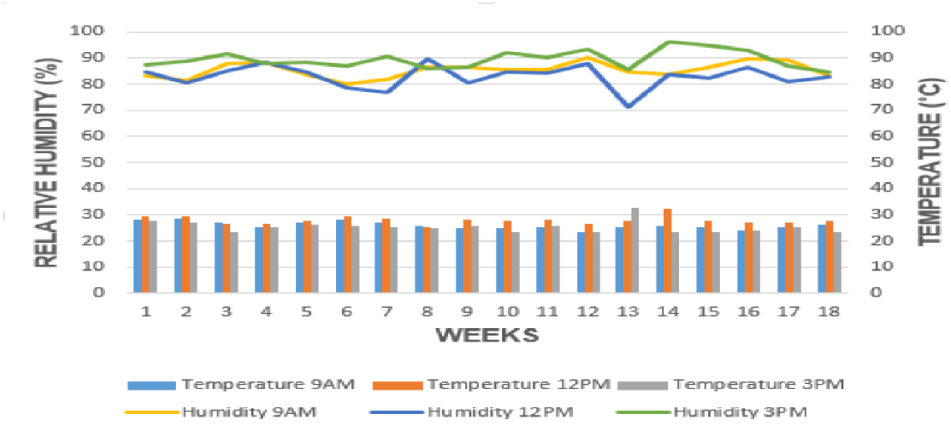

Figure 2. Agro-meteorological (temperature and relative humidity) data during the conduct of the study

The laboratory analysis of soil samples and vermicompost, combustion ash, and goat manure is shown in Table 1. The soil in the research area is strongly acidic with pH 5. 57 and low in organic matter with 2. 58%, nitrogen with 0.129%, and available phosphorus with 7.10 ppm. However, there is high exchangeable potassium with 749 ppm. The vermicompost analysis with pH 6.40, Organic matter with 32%, Nitrogen with 1.60%, available phosphorus with 2.35 ppm, exchangeable potassium with 1.30 ppm. Combustion ash fertilizer has its pH 13.33 and high available of phosphorus and potassium with 23 and 16 ppm, respectively. The goat manure is strongly alkaline (pH 8.75),

and contained 1.9% nitrogen, 2.81% available phosphorus, and 3.61% potassium(Magallon and Cabahug, 2022).

Table 1. Soil chemical properties prior to planting, vermicompost, combustion ash, and goat manure

Treatments	pH	Organic Matter (%)	Nitrogen (%)	Available P (ppm)	Exchange-able K (ppm)	CEC	Ca (meq/100g)
Soil Analysis:	5.57	2.58	0.129	7.10	749	19.34	2.20
Interpretation:	Strongly acidic	Very low	Very low	Low	Very high		
Vermicompost	6.40	32	1.60	2.35	1.30		5.03
Combustion ash fertilizer	13.33			23	16		22
Goat Manure Analysis	8.75		1.97	2.81	3.61		

The height of plants from 15th to 75th day after transplanting and number of days from transplanting to flowering are presented in Table 2. The result shows that treatment 4 (vermicompost) consistently obtained the highest height with 18.23 cm, 37.98 cm, 76.33 cm, 86.88 cm, and 88.75 cm, respectively, followed by treatment 2 (combustion ash fertilizer) with 14. 60 cm, 34. 40 cm, 74.00 cm, 84.15 cm and 84. 95 cm from 15th day to 75th day after transplanting. And treatment 3 (goat manure)13.45 cm, 32.68 cm, 70.48 cm, 80.23 cm and 80.93 cm. treatment 1 (control) obtained the lowest height.

As to the number of days from transplanting to the flowering stage, treatment 4 (vermicompost) was the first to bear flowers with 30.38 days, followed by treatment 2 (combustion ash fertilizer) with 32.38 days, treatment 3 (goat manure) with 33.63 days, and treatment 1 (control) with 35 days. Statistically, the results for both parameters are highly significant, which implies that the application of different sources of organic nutrients affects plant height and the flowering of hot pepper.

The yield and yield components of hot pepper as affected by the application of different organic sources of nutrients are presented in Table 3. Regarding the yield of fruits per plant per harvest, treatment 4 (vermicompost) consistently obtained the highest yield from the first to the fifth harvest with 0.52kg, 0.63kg, 0.47kg, 0.77kg, and 0.51kg, respectively. Treatment 2 (combustion ash fertilizer) was followed, which obtained 0.48kg, 0.54kg, 0.44kg, 0.74, and 0.46kg from the first to the fifth harvest. Treatment 3 (goat manure) obtained 0.26kg, 0.51kg, 0.32kg, 0.70kg, and 0.43kg and treatment 1 (control) obtained relatively the lowest yield compared to all treatments. As to

the yield per treatment, treatment 4 (vermicompost) yielded the highest with 14.25kg, followed by treatment 2 (combustion ash fertilizer) with 12.92 kg, treatment 3 (goat manure) with 10.50kg, and treatment 1 (control) with 4.63 kg.

For the projected yield per hectare, treatment 4 (vermicompost) obtained the highest production of 11.88 tons, followed by treatment 2 (combustion ash fertilizer) with 10.78 tons, treatment 3 (goat manure) with 8.75 tons, and treatment 1 (control) with 3.86 tons.

Treatment 4 (vermicompost) obtained the highest result regarding height measurement, the number of days from transplanting to flowering, yield and yield components per treatment, and projected yield per hectare.

Table 2. The height of the plants from the 15th to the 75th day after transplanting and the number of days from transplanting to flowering

Treatments	Height of plants after transplanting					Number of days from transplanting to flowering
	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT	
Т1 - Control	10.23[b]	30.10[b]	47.83[b]	48.08[b]	49.73[b]	35.00[a]
Т2 – Combustion ash fertilizer	14.60[b]	34.40[ab]	74.00[a]	84.15[a]	84.95[a]	32.38[c]
Т3 – Goat manure	13.45[b]	32.68[b]	70.48[a]	80.23[a]	80.93[a]	33.63[b]
Т4 –Vermicompost	18.23[a]	37.98[a]	76.33[a]	86.88[a]	88.75[a]	30.38[d]
F-tests	**	*	**	**	**	**
C.V. %	4.17	9.14	5.93	8.38	8.08	1.97

means having the same letter are not significantly different from each other. * - significant at a 5% level of significance ** - significant at a 1% level of significance

Table 3. Yield and yield components of hot pepper as affected by the application of different sources of organic nutrients

Treatment	Average fruit yield/plant/harvest (kg)					Total Yield/treatment (kg)	Projected yield (tons/ha)
	1st	2nd	3rd	4th	5th		
T_1 - Control	0.22[b]	0.26[c]	0.19[c]	0.36[c]	0.22[c]	4.63[c]	3.86[c]
T_2- Combustion ash fertilizer	0.48[a]	0.54[b]	0.44[a]	0.74[ab]	0.46[ab]	12.92[ab]	10.78[ab]
T_3- Goat manure	0.26[b]	0.51[b]	0.32[b]	0.70[b]	0.43[b]	10.50[b]	8.75[b]
T_4- Vermicompost	0.52[a]	0.63[a]	0.47[a]	0.77[a]	0.51[a]	14.25[a]	11.88[a]
F-Test	**	**	**	**	**	**	**
C.V. %	9.06	7.96	7.17	6.23	8.14	15.38	15.37

This means having the same letter are not significantly different from each other. ** - significant at a 1% level of significance

The cost and return analysis of the study is shown in table 4. For the total expenses incurred, treatment 2 (combustion ash fertilizer) had the highest expenses of ₱93,849.50, followed by treatment 4 (vermicompost) with ₱88,789.50, treatment 3 (goat manure) with ₱87,645.50, and treatment 1 (control) with ₱83,069.50. As to the profit per hectare, treatment 4 (vermicompost) had the highest net profit of ₱623,710.50, followed by treatment 2 (combustion ash fertilizer) with ₱553,332.10, treatment 3 (goat manure) with ₱437,354.50, and treatment 1 (control) with ₱148,180.70. In terms of return on investment, treatment 4 (vermicompost) obtained the highest ROI of 702.46%, followed by treatment 2 (combustion ash fertilizer) with 589.60%, treatment 3 (goat manure) at 499.00%, and the lowest obtained by treatment 1 (control).

Table 4. Cost and return analysis (₱)

Item	T_1 Control	T_2 Combustion ash fertilizer	T_3 Goat manure	T_4 Vermicompost
Yield (kg)	3,854.17	10,786.36	8,750.00	11,875.00
Unit price (Php)	60.00	60.00	60.00	60.00
Gross income	231,250.20	647,181.60	525,000.00	712,500.00
Total expenses	83,069.50	93,849.50	87,645.50	88,789.50
Net income	148,180.70	553,332.10	437,354.50	623,710.5
ROI %	178.38	589.60	499.00	702.46

Discussion

The study was carried out to ascertain the effects of different organic sources of nutrients on the growth and yield performance of hot pepper production and to assess the profitability of growing hot pepper.

The different sources of nutrients, combustion ash fertilizer (T2), goat manure (T3), and vermicompost (T4) significantly affect the agronomic characteristics (P=<0.05) and yield and yield components of hot pepper in all measuring periods (P=<0.01). Specifically, during the growth of hot pepper, applied with vermicompost (T4) obtained consistently the highest in terms of heights which implies that application of vermicompost as organic fertilizer affects the vegetative stage of the plants (Aminifard, 2021; Khanal, 2018).

The number of days from transplanting to flowering revealed significant results (P=<0.01). Treatment 4 (vermicompost) application was the earliest to bear flowers at 30.38 days, followed by treatment 2 (combustion ash fertilizer) at 32.38 days, treatment 3 (goat manure) at 33.63 days, and treatment 1 (control) at 35 days from transplanting (Kumar *et al*., 2016).

Treatment 4 (vermicompost) applied 10 (t ha^{-}1) excelled over the other treatments in terms of yield of fruits per plant, the average weight of fruits per treatment per harvest, total yield per treatment, and projected yield per hectare (P=<0.01) which is consistent to the study of Joshi *et al*., (2015) on different solanaceous crops that described vermicompost as the best organic fertilizer and a biocontrol agent, making it more environmentally friendly than chemical fertilizers and a great soil amendment.

The application of vermicompost at the rate of 10 tons per hectare (Treatment 4) improved hot pepper's growth and yield components, its net income, and return on investment (ROI) of 702.46%. Followed by combustion ash fertilizer (Cempa *et al*., 2022; Komiyama *et al*., 2013) and goat manure (Okon, 2020; Owoade *et al*., 2019) which can also be used as alternative sources of organic fertilizers applied 10 tons/ha to hot pepper production. Further study may be conducted on other solanaceous crops.

Acknowledgements

The researchers would like to thank everyone who contributed to the success of the study.

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(Received: 2 September 2022, accepted: 30 April 2023)