IMPACT OF BIO-ORGANIC FERTILIZER ON CAULIFLOWER (*BRASSICA OLERACEA* VAR. BOTRYTIS) GROWTH AND SOIL QUALITY

Leah C. Tuan

Associate Professor, Department of Agricultural Sciences, College of Agriculture, Fisheries, and Natural Resources, University of Eastern Philippines, University Town, Northern Samar, Philippines
(Email: leahtuanc@gmail.com)

Abstract

Utilization of carabao manure and carabao manure tea as a sustainable approach on nutrient management for cauliflower production was studied to determine the effect of carabao manure and carabao manure tea on the growth of cauliflower and effects on soil quality. Carabao manure preparations included dried carabao manure, administered at 1.0 kg and 1.5 kg levels per pot and manure tea.

The application of carabao manure as an organic bio fertilizer was found to have highly influenced the growth of cauliflowers, evident on the different growth parameters evaluated.

Soil quality, in terms of the physical, chemical, and presence of microorganisms was significantly improved with the incorporation of carabao manure. Soil analysis showed that soils added with different levels of dried carabao manure registered proportional result. NPK was comparatively higher in soil added with 1.5 kg/pot dried carabao manure than those with 1.0 kg/pot and in the untreated soil.

Carabao manure, a farm waste product, an untapped resource, has been proven to be an effective, safe and an economical bio-organic fertilizer. A commodity capable of becoming a promising industry; a lowly resource, but if given enough attention can "turn dust into gold" and effect significant changes in the lives of many sorts.

Keywords: Bio-Organic Fertilizer, Carabao Manure, Carabao Manure Tea

1. Introduction

Inorganic fertilizers are conventionally used to improve soil fertility and plant production. Chemical fertilizers provide nutrients in forms that are readily available to crops, thus rapidly enhancing crop growth and yields. However, as these fertilizers do not increase the soil organic matter content, they do not greatly improve many of the soil properties essential for ensuring soil health (Chen, 2018, Stewart et al., 2005). Non-conventional organic fertilizers from animal wastes such as swine manure, carabao manure and caramanure tea though readily and abundantly available in the backyard, remained untapped for crop production especially vegetable production including cauliflower.

Organic manure can serve as alternative option to mineral fertilizers (Gupta et al., 1988; Naeem et al., 2006) for improving soil structure (Dauda et al., 2008) and microbial biomass (Suresh et al., 2004). Organic manures such as carabao manure and improve the soil structure, aeration, slow-release nutrient which support root development leading to higher

yield and better quality of plants. These are readily available in the backyard but remained untapped for crop production especially vegetables including cauliflower. Therefore, utilization of locally produced manures in vegetable production may increase crop yields and income with less use of chemical fertilizer. The aim of this study was to determine the impact of bio-organic fertilizers on cauliflower growth and soil quality.

2. Methodology

Preparation of Bio-organic Fertilizer from Animal Manure

Carabao manure was collected and air-dried until it was totally dried. Carabao manure (CM) as a bio-fertilizer was processed in two ways: dried (DCM) and manure tea (CMT).

Dried Carabao Manure (DCM) Preparation

This was done by mixing desired amount of DCM with 20% Carbonized Rice Hull (CRH) to improve its porosity. The mixture was added with garden soil at a ratio of 1:2, i.e., 1.0 kg DCM + 2.0 kg garden soil/pot. This bio fertilizer was applied as basal fertilizer and as top dress at a given frequency of application on cauliflower plants.

Carabao Manure Tea Preparation

A sack full of partially dried carabao manure was placed in a plastic sack to make a tea bag. The tea bag was submerged in a 200-liter drum by placing weight, a stone, on top of it. Uncontaminated ground water was poured over the tea bag leaving a 20% air gap. The drum was covered with clean sack and tea bag was soaked for one week, after which, the tea manure was ready for use.

Application of Animal Manure as Bio Organic fertilizer

a. Dried Carabao Manure (DCM) Application

Dried carabao manure (DCM) was prepared in two levels: 33 and 50 t/ha converted into 1.0 kg (DCM-1) and 1.5 kg (DCM-1.5), respectively. Application of DCM was done once for DCM-1 and twice for DCM-1.5. First application (before planting) was administered at 33 t/ha or 1.0 kg DCM/ plant. Second application (only for DCM-1.5), was done at 17 t/ha or 500 g DCM-1.5 per plant as top dress, 10 days after the first application.

b. Carabao Manure Tea (CMT) Application

Carabao manure tea (CMT) was applied at a rate of 50 ml (undiluted) to each pot as soil drench immediately before planting. Diluted manure tea (mixed with equal amount of ground water) was applied to the plants in all the treatments at a rate of 100 ml during the second week and 200 ml per week thereafter. This was applied directly to the soil to provide micronutrients and energy for increased microbial activity.

Soil and Organic Fertilizer Analysis

The soil medium (garden soil) including dried carabao manure and carabao manure tea was submitted to PCA, Central Office for chemical and physical nutrient analysis and presence of macro and micro nutrients.

At the end of the experiment, fresh soil samples taken from pots in different treatments were also submitted for laboratory test to determine the abundance of microorganisms and the N, P, and K retained in the soil.

3. Results And Discussion

Effects on Growth

Data on growth parameters such as plant height, number of leaves, length of leaves, width of leaves, leaf area, leaf weight, leaf length, root weight and weight of whole plant are presented in Table 1.

Plant Height (cm)

Plant height differed significantly as influenced by the application of different levels of Dried Carabao Manure (DCM). Plants applied with DCM-1 or M1 were tallest, 39.83 cm followed by plants applied with DCM-1.5 or M2, 38.35 cm. Plants were shortest in pots without DCM. No significant difference, were observed between M1 and M2. The increase in plant height as a result of carabao manure bio-organic fertilizer application may be attributed to the presence of available nutrients sufficient enough to promote plant growth. El-Tantawy (2009) and El-Magd, et, al (2016), observed accelerated growth of the plants applied with organic manure.

Number of leaves at harvest

Although the number of leaves produced per plant varied according to DCM application, variation was not significant. The application of different levels of DCM to the plants did not have significant influence on the number of leaves of the cauliflowers at harvest. The production of almost the same number of leaves with or without the application of different levels of DCM and indicates that the cauliflower variety used in the study can adapt to local conditions even in soils with low fertility level. This observation is true in almost all vegetable (Brassica) researches in the area where the control (without fertilizer application) plants were able to develop considerable number of leaves but of different length, breadth and weight subject to available nutrients in the soil (Tuan, 2002).

Leaf Length at Harvest (cm)

Different levels of DCM significantly influenced the length of cauliflower leaves. Longest leaves were found in M1 and M2; shortest leaves were noted in M0. A significant difference was observed in leaf length among the DCM levels. Findings of the study revealed that cauliflower plants applied with DCM yielded longer leaves compared with plants without DCM. Higher rate of DCM produced bigger and longer leaves. This may be due to the available form of nitrogen preferably ammonium in the carabao manure tea (CMT) administered as supplement to the plants on a weekly interval. This implies that DCM added with CMT provided adequate nutrients to the cauliflowers in terms of leaf production. This confirms the findings of Fayed (2010) who claimed that CMT significantly increased the vegetative parameters of the Roghini olive trees. In addition, El-tantawy (2009) also found out that farmyard compost tea increased the height and leaf area of potato plant.

Leaf Width at Harvest (cm)

DCM rates significantly influenced the width of cauliflower leaves. Plants applied with DCM-1 and DCM-1.5 produced the widest leaves while those applied with CMT only had the narrowest leaves. The production of wider leaves in cauliflowers is necessary to support flower/curd formation. Results of this study revealed that formation of bigger and wider leaves is directly related to the application of DCM supplemented with CMT as sources of nutrient. The effect of DCM and CMT on plant growth may be related to the important role of the three macro nutrients (NPK) as manifested in the growth of cauliflowers. These nutrients play vital role in plant physiological processes especially photosynthesis. DCM and CMT contain these three vital nutrients and other micronutrients that were readily utilized by the plants upon application. CMT contains instant plant nutrients and is suitable for short duration vegetable crops. Gross et al. (2008), reported that ammonium is the major form of nitrogen present in the extract solutions from all manure types and that the nitrogen released after 14-day extraction by the different methods from the different manures ranged between 50% and 85%. Alo and Tuan (2015) obtained almost similar result in cauliflower applied with chicken dung.

Leaf Area at harvest (cm^2)

The application of DCM significantly influenced the leaf area of cauliflower plants. Highest leaf area was recorded among plants applied with DCM-1,654.26 cm^2 and those with DCM-1.5, 632.84 cm^2. Lowest leaf area was observed in the control plants (M0), with 403.71cm^2. No significant difference in leaf area was observed between M1 and M2.

The variation in leaf area observed among treatments was bigger in plants applied with DCM than those in control plants. This means that DCM had sufficient nutrients. Nourishment received by the plants enabled the production of bigger and wider leaves; a plant requirement that allows optimum light interception and distribution for efficient physiologic process such as photosynthesis and carbohydrate transport (El-Sawy et al., 200; el-Dissoky, 2008) which contribute to the formation of reproductive parts in cauliflower. Fageria, et al (2009) cited that for foliar fertilization to be more effective, it may be necessary to have more than one application depending on the severity of nutrient deficiency. In addition, nutrient concentration and day temperature should be optimal to avoid leaf burning and fertilizer source should be soluble in water.

Leaf Weight at Harvest (g)

Different rates of DCM had significant influence on the weight of cauliflower leaves per plant. Average leaf weight per plant was heaviest in M1, 381.39 g, and M2, 375.55 g, but no significant difference was observed between them. Lightest leaves were observed in plants not applied with DCM-1 (M1B0), 213.09 g. Gross et al., 2008, mentioned that organic fertilizers have the property to enhance soil aggregation, soil aeration, and water holding capacity; factors which offer good environmental condition to broccoli plants.

Root Length at Harvest (cm)

Root lengths also varied significantly as influenced by the application of different rates of DCM. Longest roots were observed in plants applied with DCM-1.5, 27.99 cm followed by plants applied with DCM-1, 25.87 cm. Shortest roots were recorded in plants without DCM, 24.16 cm. Longer roots observed in plants applied with organic fertilizer can be explained by the manure's effect in improving the soil structure and soil aeration which supported root development. The results also suggested that the observed response was largely due to increased availability of N and P, which consequently enhanced root growth. It can be noted that carabao manure is rich in N and P and further enhanced with the application of manure tea. Similar results were reported by Wright et al, 1995, who observed that maximum root growth and rooting depth of barley crop were higher in treatments which received animal manures relative to where manure was not applied.

Root Weight at Harvest (g)

Average root weight at harvest varied significantly as influenced by the different treatments. Root weight as influenced by the application of different rates of DCM likewise varied significantly. Heaviest roots were those of the plants applied with DCM-1, 27.24g; shortest in plants untreated with the manure, M0, 24.16 g. Root weight between M1 and M2 was not significant.

Heavier roots observed among the fertilized treatments especially those which received higher rates of carabao manure is indicative of the sufficient and readily available form of utilizable nutrient in the soil. More roots allowed higher rates of absorption of soil nutrients which have increased their capability to explore nutrients under stressed conditions. It is deemed that manure took time to release nutrients to nourish the plants. However, the beneficial effect of organic manure on yield may be due to an increase in organic matter rate that caused generation of carbon dioxide during compost decomposition (Wilkinson, 1979) and improvement of the soil structure conditions, enabling the plants to have good root development by improving the aeration of the soil (Arisha et al., 2003). Galo (1993) pointed out that, bulky organic manure has a capability to improve the aeration and moisture relationship of the soil. He further stressed that colloidal humus increases the water holding capacity of the soil and improves the structure and tilt of clay soil. Almeida (1991) also supported that among the organic fertilizers used in vegetable production, livestock manures stand out due to their positive effects on soil conditioning and nutrient availability, especially N.

Weight of Whole Plant at Harvest

Weight of whole plants differed significantly as influenced by the application of DCM. Average weight of whole plants applied with DCM-1, 235.83 g and DCM-1.5, 221.20 g had statistically the same except on plants without DCM, 139.12 g. Weight of whole plant comprises all plant parts including the roots. The results of the study relative to the weight of the whole plant almost follow similar pattern with the other growth parameters evaluated such as the vegetative parts (leaf length, width and leaf area) and underground parts (root length and weight). In all these parameters, the results pointed out that the application of

carabao manure supplemented with manure tea had the tremendous effect in the growth of vegetative plant parts manifested by the healthy condition of the plants. In general, these treatments showed better performance in terms of leaf length, leaf width, leaf area including root length and weight ultimately producing heavier whole plant weight.

Effects on Soil Quality

Soil and fertilizer analysis was done prior to the conduct of the experiment to determine the nutrient level including the physical and chemical condition of the soil medium used in the study. Table 2 shows the nutrient composition of garden soil and garden soil-carbonized rice hull (CRH) medium used in the study. Based on the result of the analysis, the garden soil used fairly contained the macro (N, P and K) nutrient and pH of 6.1 to 6.5 suitable for cauliflower production.

Accordingly, nutrient analysis result shown in Table 3, confirms the presence of macro and micro nutrient both in carabao manure and manure tea. This is in accord with the findings of M.M. Abou El- Magd, A.M, El-Bassiony and Z.F. Fawzy (2006) on their claim that organic manure plays a direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization, improving the physical and physiological properties of soils.

It could be noted that carabao manure contains sufficient amount of boron. Boron (B) is vital to plant health in forming and strengthening cell walls especially in the reproductive process. It was further stressed that while boron is an important nutrient on its own, it also has a positive impact on the uptake of potassium and phosphorus in many plants. http://www.cropnutrition.com/borons-importance-in-plant-dev...

Soil samples were also taken after the termination of the study, and submitted for soil analysis to determine the nutrients retained/available in the soil after cropping period. The analysis revealed substantial levels of N, P and K in the soil were still available (Table 4). This finding supports the claim of Gale *et al*., (2006), that only 10% to 50% of the total nitrogen in solid manure/compost was available for plant uptake within the season of application and this fraction decreases with the extent of decomposition. Further, nutrients contained in manures are released more slowly and are stored for a longer time in the soil ensuring longer residual effects, improved root development and higher crop yields (Sharma and Mittra, 1991; Abou El Magd *et al*., 2005). It not only maintains soil fertility but also conserves soil moisture (Yadav et al. 2014) and increases the availability and absorption of the essential nutrient elements, such as Fe2+, Mg2+ and NH4+ cations, which are necessary for enzyme activation and chloroplast and chlorophyll formation (Elhindi 2012). Aside from the macro and micronutrients recovered from the soil samples, voluminous amount of micro-organisms were also recorded. These beneficial microorganisms help improve aeration, soil structure and porosity.

The substantial amount of nutrients and microorganisms recovered in the soil after the study proves that organic farming is a sustainable production system that has no adverse effects on the natural resources and the environment. (Gale et al. 2006; Suresh et al., 2004).

Table 1. Growth parameters of cauliflower (*Brassica oleracea* var. Botrytis) applied with Bio-organic fertilizer.

Treatments	Mean*							
	Plant Height	Number of Leaves	Leaf Length	Leaf Width	Leaf Area	Leaf Weight	Root Length	Weight of Whole Plant
Control	35.05[b]	16.18	15.32[c]	9.18[b]	134.57[b]	71.03[b]	24.16[b]	19.87[b]
Carabao manure1 (3t/ha)								
+ CMT	39.83[a]	17.06	19.55[b]	11.38[a]	218.09[a]	125.18[ab]	26.47[a]	27.24[a]
Carabao manure2 (10t/ha)								
+ CMT	38.35[a]	17.06	21.02[a]	11.83[a]	210.95[a]	127.31[a]	25.87[ab]	25.58[a]

**Means followed by the same letters are not significant at 5% LSD.*

Table 2. Biological/microbial content of the soil and organic fertilizer after taken before transplanting and after harvest of cauliflower in UEP, Catarman, Northern Samar, Philippines

BIOLOGICAL/MICROBIAL PROPERTIES	Before Transplanting		After Harvest		
	Carabao Manure	Manure Tea	MO	M1	M2
Salmonella	Negative	Negative	Negative	Negative	Negative
E. coli	Negative	Negative	Negative	Negative	Negative
Aerobic Plate Count (cfu/g)	7.8×10^6	1.0×10^6	2.0×10^7	1.1×10^8	1.0×10^7
Total Coliform (MPN/g)	3.6	240.0	1.5×10^4	1.1×10^4	2.1×10^4
Fecal Coliform (MPN/g)	<3.0	93.00	9.2	3.0	43.00
Yeast and Molds Count (cfu/g)	7.0×10^4	25 estimated	6.0×10^3	9.7×10^3	1.6×103^3

Source: Philippines Coconut Authority (PCA) Plant and Soil Analysis Laboratory. Quezon City, Philippines.

Table 2. Chemical and physical properties of the organic fertilizers used in the experiment in UEP, Catarman, Northern Samar, Philippines

CHARACTER/PROPERTIES	Carabao Manure	Carabao Manure Tea (CMT)
Nitrogen (N), Total, %	0.363 ± 0.019	<LLD (0.014)
Phosphorus (P_2O_5), Total, %	0.394 ± 0.008	<LLD (0.005)
Potassium (K_2O), Total, %	0.757 ± 0.032	<LLD (0.125)
Calcium (Ca), Total, %	1.853 ± 0.015	0.016 ± 0.005
Magnesium (Mg), Total, %	0.519 ± 0.020	0.004 ± 0.0001
Sulfur (S), Total, %	0.232 ± 0.012	<LLD (0.003)
Chlorine (Cl), Total, %	-	0.009 ± 0.002
Organic Matter (OM), Total, %	18.225 ± 0.370	-
Organic Carbon (OC), Total, %	7.958 ± 0.284	-
Boron (B), Total, mg-kg^{-1} (ppm)	14.286 ± 1.0	-
Iron (Fe), Total, %, (mg-kg^{-1} (ppm)	2.670 ± 0.209	1.6 ± 0.033

Copper (Cu), Total, %, (mg-kg^{-1} (ppm)	0.003 ± 0.0001	2.4 ± 0.052
Manganese (Mn), Total, %, (mg-kg^{-1} (ppm))	0.039 ± 0.002	<LLD (0.001)
Zinc (Zn), Total, %, (mg-kg^{-1} (ppm))	0.017 ± 0.002	<LLD (0.003)
Moisture, %, as received	7.358 ± 0.025	-
pH, 1:9 H_2O, as received	5.8 ± 0.050	-
C: N Ratio	22:1	-

Source: Philippines Coconut Authority (PCA) Plant and Soil Analysis Laboratory. Quezon City, Philippines.

Table 3. Available Nitrogen (N), Phosphorus (P) and Potassium (K) in the Soil after the Harvest of Cauliflower Plants in UEP, Catarman, Northern Samar, Philippines

LEVEL OF CARABAO MANURE	Nitrogen (N) Total, %	Phosphorus (P) Available, mg-kg^{-1} (ppm)	Potassium (K) Exchangeable, meq/100g
Control	0.466 ± 0.007	277.7	0.943 ± 0.067
Carabao Manure1 (3t/ha) + CMT	0.549 ± 0.001	419.1	2.193 ± 0.139
Carabao Manure2 (10t/ha) + CMT	0.552 ± 0.002	424.8	1.902 ± 0.074

Source: Philippines Coconut Authority (PCA) Plant and Soil Analysis Laboratory. Quezon City, Philippines.

4. Summary, Conlusion And Recommendations

Summary

The application of carabao manure as an organic bio fertilizer was found to have highly influenced the growth and yield of cauliflowers, evident on the different growth and yield parameters evaluated, i.e., plant height, length and width of leaves, leaf area and weight at harvest, root weight and weight of whole plant. The findings indicate that carabao manure contained adequate nutrients to ensure normal growth and development of cauliflowers.

Carabao manure, dried and processed as manure tea was found to be effective in improving soil quality evidently manifested by the positive reaction of the growth of cauliflowers. Soil added with dried manure and manure tea was capable of enriching the soil with the major plant nutrients and beneficial microorganisms.

Soil quality was significantly improved with the incorporation of the bio-organic fertilizer in terms of the physical, chemical and presence of microorganisms. Soil analysis showed that soils added with different levels of dried carabao manure registered proportional result. NPK contents varied according to proportion as follows comparatively higher in soil added with 1.5 kg dried carabao manure.

Conclusions

Carabao manure, a farm waste product, is rich in plant nutrients and beneficial microorganisms, is a potential bio-organic fertilizer. Carabao manure being rich in macro and micro nutrients and beneficial microorganisms based on the soil analysis, significantly helped improve the physical and chemical quality of the soil; Carabao manure as an organic fertilizer

can bring a good number of benefits aligned with sustainability issues on economic feasibility, environment impact and social soundness.

Finally, with the positive effects on the growth of cauliflower observed through the utilization of carabao manure and carabao manure tea as a bio-organic fertilizer prove the suitability of DCM supplemented with CMT as major sources of nutrients for the production of healthy cauliflowers.

Recommendations

Based on the results of the study, the following recommendations are made:

1. Advocate and promote the utilization of carabao manure and carabao manure tea as bio-organic fertilizer being a safe and economical yet highly effective bio-organic fertilizer to increase farm productivity.
2. Design a carabao manure processing facility to ensure safe handling and packaging of the product.

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