International Journal of Agriculture and Environmental Research

ISSN: 2455-6939

Volume: 08, Issue: 03 "May-June 2022"

EFFECT OF LOCALLY AVAILABLE ORGANIC FERTILIZERS ON GROWTH AND YIELD OF CAULIFLOWER AND SOIL NUTRIENT COMPOSITION (*Brassica oleracea* Var. *Snow Mystique*)

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DOI: https://doi.org/10.51193/IJAER.2022.8308

Received: 08 Jun. 2022 / Accepted: 14 Jun. 2022 / Published: 28 Jun. 2022

ABSTRACT

Cauliflower production in Bhutan is one of the cash crops generating Nu.31 million in 2016, however, it is a crop requiring heavy fertilization. However, synthetic fertilization was reported to degrade the soil and its productivity in the long run by numerous scientists all over the world. Therefore, this study was conducted to evaluate the efficacy of locally available organic fertilizers on growth and yield of cauliflower and its soil nutrient constituent. The study included six different treatments namely T1 (Control), T2 (Vermicompost), T3 (Bio-slurry), T4 (FYM), T5 (Jholmol) and T6 (Bhur OM). The study revealed that application of locally available organic fertilizers had a statistically significant effect (P value = 0.0003) on the yield of cauliflower. The highest yield was obtained from T2 (25.77 tons/ha) which was 8.30 % more compared to the lowest yield from T1 (14.33 tons/ha). Growth parameters like plant height, plant width, curd length, curd width, curd height and number of leaves were not significantly affected by the application of organic fertilizers; however, except for plant height and number of leaves, T1 performed the lowest in other growth parameters. A statistically significant effect in soil nutrient composition was observed on applying different organic fertilizers. T6 and T5 had high major soil nutrient content such as organic matter, available phosphorus and available potassium but it was observed that their yield was low as compared to other treatments. This could be linked to nutrient unavailability due to high C:N ratio in T6 (21) and T5 (23). In general, the result of the

ISSN: 2455-6939

Volume: 08, Issue: 03 "May-June 2022"

study revealed that the application of organic fertilizers in cauliflower had a positive effect on its yield, growth parameters and soil quality.

Keywords: Cauliflower, cauliflower growth and yield, efficacy, locally available organic fertilizers, soil nutrient composition

1.0 INTRODUCTION

Cauliflower (*Brassica oleracea*), belonging to crucifer family is cultivated widely around the world due to its richness in health promoting water soluble vitamins like thiamin, riboflavin, niacin, biotin, pantothenic acid, folate, vitamin B_6, vitamin C and fat soluble vitamins like alpha-carotene, beta-carotene, beta-cryptoxanthin, vitamin E and other minerals like Na, K, Ca, Mg, P, Fe, Cu, Zn, CL, Mn, I and Se (Roe et al., 2013). In Bhutan, cauliflower production was introduced in 1966 (DoA, 2019) and it contributed to 17% (1445.57 MT) of total cole crops (8,378.75 MT) produced in 2019 (Renewable Natural Resources Statistics Division (RSD), 2019). It is one of the cash crops generating Nu. 31 Million in 2016 (IMS, 2017). However, cauliflower, as reported by Pawar & Barkule, (2017) is a heavy feeder of mineral nutrients and removes large amounts of macronutrients from soil. And the only source of macronutrients is from applying either synthetic fertilizers or organic fertilizers but synthetic fertilizers, as reported by (Massah & Azadegan, 2016) degrade the quality of soil due to formation, accumulation and concentration of mineral salts of fertilizers leading to soil compaction and degradation in the long-term. In Bhutan, synthetic fertilizer usage was estimated at 11.9 kg/acre in 2016 (NSSC, 2020) and a total of 3244.65 MT of fertilizers were procured and supplied across the country in 2018 (DoA, 2018) which is a concern for a nation driving to become 100% organic nation.

Organic fertilizers, on the other hand, play an important role in regulating plant growth, potential nutrient input, and microbial decomposition activity (Cai et al., 2019). Organic fertilizers also play a vital role in improving the physical, chemical and biological properties of the soil and also improve the structure, texture, and water holding capacity of soil (Chandra, 2005). However, no concrete studies were conducted in the country on the effectiveness of locally available organic fertilizers in cauliflower production, thus, this study was conducted to evaluate the effect of various locally available organic fertilizers on the growth and yield of cauliflower and its soil nutrient composition.

2.0 MATERIALS AND METHODS

2.1. Study Area

ISSN: 2455-6939

Volume: 08, Issue: 03 "May-June 2022"

This study was conducted in the research field at National Center for Organic Agriculture (NCOA), Yusipang, Bhutan. The site is located at 27°27’40’’ N and 89°42’31’’ E and at an altitude of 2700 masl. The site falls under the cool temperate zone of the agro ecological zones of Bhutan and receives annual rainfall between 650-850 mm (Gyamtsho, 1996).

2.2. Experimental Design and Setup

The experiment was laid out using randomized complete block design (RCBD). It included six treatments with three replications. Treatment details are as listed in (Table 1.). The study area was well plowed and brought to fine tilth. Plot sizes of 6m x 6m x 0.2m were raised and organic fertilizers (Treatments) of 10 kgs per bed were applied and mixed properly with soil. Healthy cauliflower seedlings (Snow Mystique) of 4-5 leaf stage were transplanted with a planting distance of 50 cm between rows and 40 cm between plants as advised by (DoA, 2019). The cauliflower seedlings were raised using poly-tunnels in the month of October, 2020. Plants in each plot were adjusted such that 25 plants were accommodated in a plot and 10 plants were randomly selected and tagged for observation.

Table 1: Treatment details

Sl. No.	Treatments	Quantity	Symbol
1	Control	N/A	T1
2	Vermicompost	@ 10kgs/plot	T2
3	Bio-slurry	@ 10kgs/plot	T3
4	Farm Yard Manure (FYM)	@ 10kgs/plot	T4
5	Jholmol	@ 10kgs/plot	T5
6	Bhur Organic Manure (Bhur OM)	@ 10kgs/plot	T6

2.3. Data Collection and Analysis

Growth parameters such as height of the plant (cm), width of the plant (cm), number of leaves per plant, length of the curd (cm), width the of curd (cm), height the of curd (cm), weight of the curd (gm) and yield per plot (gm/plot) were measured on attaining the maturity stage. Post trial soil samples were collected using an auger (0-20 cm depth) following random sampling method and submitted for analysis at the Soil and Plant Analytical Laboratory (SPAL) program of National Soil Services Center (NSSC), Department of Agriculture, Ministry of Agriculture and

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Forests, Bhutan to determine soil parameters such as pH, organic matter content (%), C:N ratio, available phosphorus (mg/kg), available potassium (mg/kg), total exchangeable bases (meq/100g) and cation exchange capacity (meq/100g). The means of the data were tested for the homogeneity of variances using Bartlett Test and then subjected to one way ANOVA followed by Tuckey's HSD Post Hoc Test at a significance of P value ≤0.05 in R-Studio version 4.0.5. tosee the differences among means. The visual representation of yield and growth data was done using the chart feature in google sheet.

3.0 RESULTS AND DISCUSSION

3.1. Crop Yield

A significant variation was observed in means of crop yield per hectare (ton) between control plot and plots applied with organic fertilizers (as shown in Table 2.). T2 (Vermicompost) produced the highest cauliflower yield with 25.77 tons per hectare which is 8.85 % more than T1 (Control), while T3 (Bio-slurry), T4 (FYM), T5 (Jholmol) and T6 (Bhur OM) produced 8.30 %, 6.53 %, 4.13 % and 5.65 % respectively more than T1. Whereas T1, produced the lowest yield with 14.33 tons per hectare (Figure 1.). Similar result was achieved by researchers Blouin et al., (2019) where vermi-compost was found to increase plant yield by 26 % and concluded that application of vermicompost can be an efficient resource to increase crop yield in agriculture. Adekiya et al., (2020) also found that organic manures improved yield of okra compared to that of NPK fertilizer.

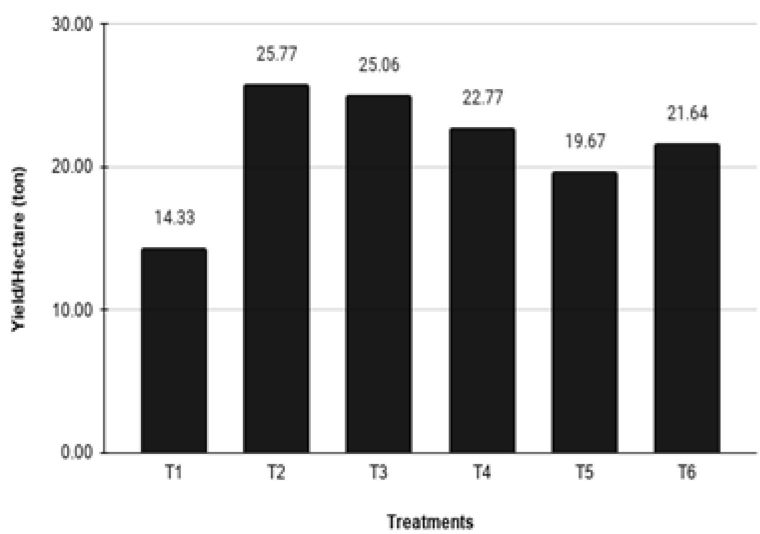

Figure 1

International Journal of Agriculture and Environmental Research

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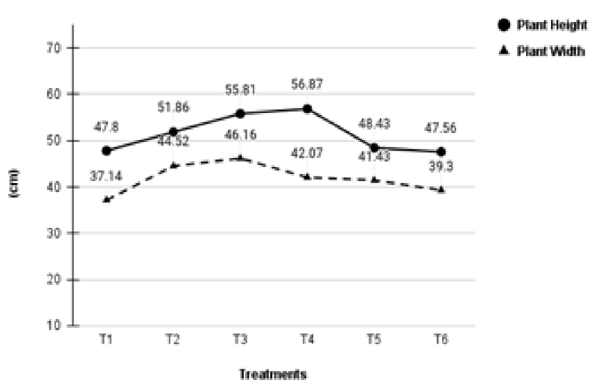
Table 2: Effect of different treatments on cauliflower yield

Sl. No.:	Treatments	Yield per Hectare (ton)
1	T1 (Control)	14.33 e
2	T2 (Vermicompost)	25.77 a
3	T3 (Bio-slurry)	25.06ab
4	T4 (Farm Yard Manure)	22.77 bc
5	T5 (Jholmol)	19.66 bde
6	T6 (Bhur Organic Matter)	21.63bcd
	P value	0.0003
	CV (%)	20.00

Means with the same alphabets within the column are not significantly different as tested by Tuckey's HSD Post Hoc Test. CV = Coefficient of Variation.

3.2. Growth Parameters

It was found that there was no statistically significant effect of different treatments on growth parameters such as curd height, curd length, curd weight, number of leaves, plant height and plant width. However, except for plant height and number of leaves, T1, was found to produce the lowest mean in plant width (37.14 cm), curd height (8.73 cm), curd width (8.41 cm) and curd length (9.31cm). Plant height was recorded highest in T4 (56.87 cm) and lowest in T6 (47.56 cm) while the width of the plant was recorded highest in T3 (46.16 cm). Curd height was found highest in T3 (10.03 cm) while curd width was noted highest in T4 (12.23 cm). Curd length was observed maximum in T4 (12.64 cm) whereas number of leaves was recorded highest in T2 and T3 with 14 numbers and lowest in T1, T4, T5 and T6 with 13 numbers (Figure 2 and 3).



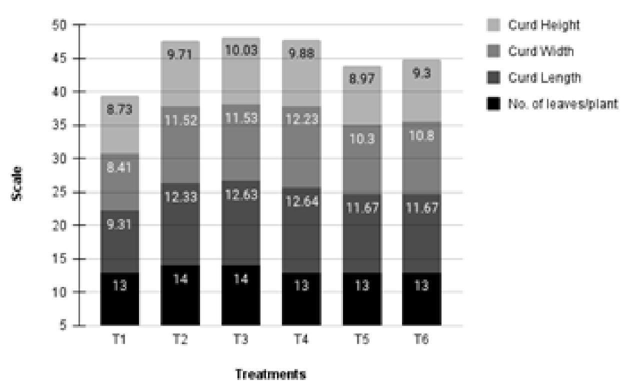


Table 3: Effect of different treatments on soil chemical composition

Treatments	pH(H_2O)	OM (%)	C:N Ratio	Av.P (mg/kg) (Bray)	Av.K (mg/kg) ($CaCl_2$)	TEB (meq/100g)	CEC (meq/100g)
T1	5.82 [e]	2.75 [d]	10.00 [e]	16.94 [e]	196.85 [e]	8.75 [b]	16.47 [a]
T2	6.24 [c]	2.92 [d]	12.14 [d]	27.01 [c]	221.19 [c]	9.02 [ab]	6.89 [e]
T3	6.35 [b]	3.27 [c]	12.67 [d]	35.32 [a]	196.95 [e]	11.08 [a]	7.34 [d]
T4	6.07 [d]	3.27 [c]	13.57 [c]	25.86 [d]	199.70 [d]	10.81 [ab]	13.27 [b]
T5	6.41 [ab]	3.96 [a]	23.00 [b]	34.74 [a]	394.48 [a]	10.84 [ab]	11.17 [c]
T6	6.44 [a]	3.61 [b]	21.00 [a]	30.13 [b]	308.84 [b]	9.78 [ab]	11.26 [c]
P value	2.80e-12	4.88e-16	2.20e-16	2.20e-16	2.20e-16	0.016	2.20e-16
CV (%)	7.07	13.37	34.3	23.96	32.24	9.96	32.54

Values with the same alphabets within the column are not significantly different as tested by Tuckey's HSD Post Hoc Test. CV = Coefficient of Variation. OM = Organic Matter, C:N = Carbon: Nitrogen, Av.P = Available Phosphorus, Av. K = Available Potassium, T.E.B. = Total Exchangeable Bases, CEC = Cation Exchange Capacity, BS = Base Saturation

Soil chemical composition data shown in Table 3. revealed that there was a statistically significant effect of different organic fertilizers on soil nutrient composition. Soil pH was found to be increased in the plots where organic fertilizers were applied. Highest pH was found in T6 (pH = 6.44) and lowest in T1 (pH = 5.82). The soil pH range of the treatments fall under moderately acidic range (5.6 - 6.5) of the rating tabulated by Motsara & Roy, (2008), where they mentioned that most of the essential nutrients are available to plant in this range. Organic matter content also increased in the plots where organic fertilizers were applied. Organic matter (OM) content was found maximum in T5 (3.96 %) and minimum in T1 (2.75%) but, OM content decreased with decrease in soil pH and this could be due to decrease in microbial activity with decrease in soil pH. Sullivan et al., (2019) noted that decomposition of soil organic matter via microbial activity is faster when pH is neutral and slower when pH is acidic.

C: N ratio was noted highest in T5 (23.00) and lowest in T1 (10.00). Available phosphorus was recorded maximum in T3 (35.32 kg/mg) and minimum in T1 (16.94 kg/mg) while available potassium was observed maximum in T5 (394.48 kg/mg) and minimum in T1 (196.85 kg/mg). Total Exchangeable Bases (TEB) was noted maximum in T3 (11.08 meq/100g) and minimum in T1 (8.75 meq/100g). Cation exchange was noted highest in T1 (16.47 meq/100g) and lowest in T3 (7.34 meq/100g).

ISSN: 2455-6939

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Although major soil nutrients such as OM, available phosphorus and available potassium were recorded high in T6 (Bhur Organic Matter) and T5 (Jholmol), it was found that their yield, plant height, plant width, curd length, curd width, curd height and number of leaves were low as compared to that of T2 (Vermicompost), T3 (Bio-slurry) and T4 (FYM). This could be attributed to the presence of high C: N ratio in T6 (21.00) and T5 (23.00) where higher C:N ratio was linked to poorer nutrient availability as explained by (Magdoff, 2009). Brust, (2019) also pointed out that when an organic substrate has a C: N ratio between 1 and 15, rapid mineralization of nutrients takes place, which is available for plant uptake.

Application of organic fertilizers such as vermicompost was as good as applying chemical fertilizers and can be a good alternative to chemical fertilization Farahzety & Aishah, (2013). Furthermore, application of organic fertilizers showed potential impact in restoring soil fertility of the depleted sandy soils, as application of manure for three seasons increased soil nutrient composition such as OM, available P, pH, bases, and improved Ca and Zn concentrations in maize shoots in the greenhouse (Zingore et al., 2008).

In addition, Cai et al., (2019) also observed that application of manure strongly and positively affected crop yields by increasing Soil Organic Carbon (SOC) storage, soil nutrients, and soil pH. Han et al., (2016) also concluded that organic fertilizers increased soil pH, the concentrations of nitrogen, phosphorus, and major cations.

4. CONCLUSION

The application of organic fertilizers was found to have a positive effect on the growth and yield of cauliflower. Out of all the organic fertilizers assessed, vermi-compost performed well by producing a total yield of 25.77 tons of cauliflower per hectare. Organic fertilizer application also improved soil nutrient constituents by raising pH, organic matter and other major nutrients such as phosphorus and potassium. Thus, use of various organic fertilizers as an alternative for inorganic fertilizers can be a good option to the cauliflower growers.

However, there is the need to do an in depth long term study on effectiveness of locally available organic fertilizers in sustainable cauliflower production with emphasis on cost of production and nutritional content to prove the advantages of organic cauliflower production.

ACKNOWLEDGEMENT

The authors would like to thank the management of National Organic for Agriculture Center (NCOA), Yusipang for providing us with the research field and manpower in conducting this study and for also sourcing the cauliflower seeds.

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