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RESEARCH ARTICLE

STUDY ON THE GROWTH, YIELD AND SOIL NUTRIENT STATUS OF BROCCOLI (*BRASSICA OLERACEAE* VAR. *ITALICA*) UNDER ORGANIC NUTRIENT MANAGEMENT

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ABSTRACT

The study was conducted in farmers' field at Manohora, Bhaktapur during 2012-13 to study the effect of different organic manures on growth and yield of broccoli var. Centauro and on soil nutrient status. There were seven treatments replicated thrice laid out in Randomized Block Design. Treatments applied were FYM @ 20 ton/ha (T₁), Compost @ 6.66 ton/ha (T₂), Vermicompost @ 4 ton/ha (T₃), Poultry manure @ 2 ton/ha (T₄), FYM+PM @ (10 ton FYM + 1 ton PM)/ha (T₅), FYM+VC @ (10 ton FYM + 2 ton VC)/ha (T₆) and control (T₇). The treatments were applied as basal application of fertilizer in this experiment. The result revealed significant differences in yield per plant, yield per plot, and yield per hectare among treatments. The highest yield per plant (803.33 gm/plant), yield per plot (9.64 kg/plot) and yield per ha (24.1 ton/ha) was observed in treatment T₄ whereas lowest yield was recorded from T₇. It was found that there were significant differences in plant height and canopy area between the treatments. However, tallest plant height (46.83 cm) and highest canopy area (47.62 cm) was recorded from T₄ and the lowest value in both from T₇. Number of green leaves per plant was significantly influenced by the applied manures. Maximum number of green leaves (10.25) was recorded in T₅. Applied treatments influenced significantly in soil nutrient status after harvesting the crop. Maximum pH value (7.15) and maximum OM % (3.99 %) in soil after harvesting the crop was obtained in T₁. Similarly, the highest available nitrogen, phosphorous and potassium was obtained from plots treated with poultry manure.

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INTRODUCTION

Broccoli (*Brassica oleracea* var. *Italica*), a member of crucifer family and is one of the important vegetable crop of Nepal that is gaining popularity among farmers and consumers which is somewhat similar to cauliflower but the central head or inflorescence develops a longer stem than that of cauliflower and leaves are more ragged. It is also known as multiple harvesting crops which is used as culinary purpose, pickles and also in the form of salad. It is one of the most nutritious cole crops and contains vitamin A (130 times and 22 times higher than cauliflower and cabbage, respectively), thiamin, riboflavin, niacin, vitamin C and minerals like Ca, P, K and Fe. In the global context, cauliflower and broccoli is estimated to be cultivated in 120.426 million ha resulting the production of 21.2668 million tons with average yield of 17.65 tons/ha (FAOSTAT, 2014). Total area under broccoli production in Nepal is 2138 ha with 26729 metric tons of total production and productivity of 12.5 t/ha (MOAD, 2013). Organic and inorganic sources of fertilizer play an important role in increasing agriculture production.

The use of chemical fertilizer in Nepal started in the early sixties. Presently chemical fertilizers are the major source of nutrient but escalating cost, coupled with increasing demand of fertilizer and depleting soil health necessitates the safe and efficient use of organics in crop production. There is a paucity of information on the use of organic fertilizers for vegetable production. The study was made to assess the effects of different sources of organic fertilizers on growth and yield of broccoli and soil nutrient status so that it would be helpful to enhance and maintain the soil organic status for obtaining a sustainable crop yield.

MATERIALS AND METHODS

The experiment was conducted at Manohora, Bhaktapur district of Nepal during the period from October 2012 to February 2013 to study the growth, yield and soil nutrient status of broccoli under organic nutrient management. The experimental variety was Centauro which is suitable in these agro-climatic conditions and has good yield. Collected soil samples (0-15 cm) were analyzed to classify soil texture by Hydrometer method (Bouyoucos, 1927) and other parameters by (Hunter, 1984) method. The experimental soil was low in fertility

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having pH 6.34 and silt loam texture. The soil had organic matter 1.604 % total nitrogen of 316.10 kg/ha, total phosphorus 86.21 kg/ha and total potassium 162.60 kg/ha. There were FYM @ 20 ton/ha (T₁), Compost @ 6.66 ton/ha (T₂), Vermicompost @ 4 ton/ha (T₃), Poultry manure @ 2 ton/ha (T₄), FYM+PM @ (10 ton FYM + 1 ton PM)/ha (T₅), FYM+VC @ (10 ton FYM + 2 ton VC)/ha (T₆) and control (T₇). Urea, Diammonium Phosphate and Murite of Potash were used as the source of fertilizer in the rate of NPK: 100:60:50 kg/ha (Shakya, 2011). The size of each plot was 5 m x 2 m and plant spacing was 60 cm x 45 cm. The intercultural operation, weeding, pest management and irrigation were done when necessary. Data of broccoli were recorded in randomly from 5 plants per plot. The growth parameters (plant height, number of leaves per plant, canopy spread), yield parameters (head weight, yield per plot and yield per hectare) and available soil nutrient status (N, P, K) were observed during the experiment. The statistical analysis of the data was carried out as per the method described by Cochran and Cox, 1963. The treatment effect was tested at 5% level of significance.

RESULTS AND DISCUSSION

Growth parameters

Plant height

The data related to plant height as influenced by various organic manures is depicted in table 1. Application of different organic manures exhibited a significant influence on the height of broccoli plants. Plant height ranged from 37.33 cm to 46.83 cm. The tallest plant height was observed in poultry manure @ 2 ton/ha (T₄) with 46.83 and lowest in Control (T₇) with 37.33 cm. The maximum percent increase in plant height as compared to T₇ (Control) was observed in T₄ (25.44%) followed by T₃ (23.86%). This increase may be due to availability of nutrients throughout the crop growth and its higher uptake by the crop apart from the favorable effect of soil physical, chemical and biological properties. The application of poultry manure would have helped in the better or enhanced metabolic activity through the supply of important micronutrients in the early growth phase which in turn must have encouraged the overall growth. These results are in conformity with the finding of (Duhon et al., 2001).

Canopy area

Application of different organic manures exhibited a significant influence on plant canopy of broccoli plants (Table 1). Plant canopy ranged from 36.55 cm to 47.62 cm. Maximum plant canopy (47.62cm) was recorded from T₄ (poultry manure) which is statistically at par with T₁, T₃ and T₅. The minimum plant canopy (36.55 cm) was recorded from T₇ (control). The maximum percent increase in plant canopy as compared to T₇ was observed in T₄ (30.28%) followed by T₃ (24.02%). The result showed that the application of poultry manure @ 2 ton/ha increased the plant canopy area with the maximum value. The application of poultry manure would have helped in the better or enhanced metabolic activity through the supply of important macro and micronutrients in the early growth phase which in turn must have encouraged the overall growth.

Manure plays a direct role in plant growth as a source of all necessary macro and micro nutrients. Similar trends were coincided with those as reported by (Abou El-Magd et al., 2005).

Number of green leaves per plant

The number of green leaves/plant showed significant variation by the applications of different organic manures (Table 1). The maximum number of green leaves were recorded in T₅ (Poultry manure + FYM) and the value was 10.25 and it is statistically at par with T₃. The minimum number of green leaves (8.91) was recorded in T₇ (control). The data indicates that the numbers of green leaves were higher in plots treated with PM and FYM. This might be due to the fact that application of FYM and PM provided adequate N which is associated with high photosynthetic activity and vigorous vegetative growth. Combination of FYM and PM significantly increased the number of green leaves. Similar results were obtained by (Kabir, 1998) and (Azad, 2000) in cabbage.

Yield parameters

Head weight

All manures gave a significant synergistic effect for the yield parameter i.e., marketable head weight of broccoli compared to control (Table 1). The best treatment of broccoli yield component was recorded using poultry manure @ 2 ton/ha (T₄). The lowest head weight was obtained from control (T₇). The highest marketable head weight obtained was 803.33 gm/plant and the lowest head weight obtained was 412.66 gm/plant. The higher yield is attributed to increased canopy area/ leaf area. Higher the leaf area higher will be the photosynthetic surface, higher the photosynthetic surface and higher will be the photosynthetic accumulation hence resulting in higher yield (Shashidhara, 2000). This might be caused because poultry manure contains high amount of nitrogen and nitrogen enhance photosynthesis, cell division and cell enlargement. Similar trend of result was reported by (Reddy and Padmaja, 2005). This finding is at par with (Ifikhar and Qasim, 2003) showed that poultry manure increased total available N, P and K contents. Sufficient quantity of essential nutrients in poultry manure was determined (Blum, et al., 2003) and also (Budhar, et al., 1991) showed the highest yield of rice was with the application of poultry manure.

Yield per plot

There was a significant effect of various level of fertility on head weight of broccoli per plot (Table 01). With respect to treatments, the maximum yield per plot was obtained from T₄ (Poultry manure @ 2 ton/ha) i.e., 9.64 kg/plot. The minimum yield per plot was recorded in T₇ (Control) and the yield was 4.96 kg/plot. The maximum percent increase in yield per plot as compared to T₇ (control) was observed in T₄ (19.2%) followed by T₃ (8.2%). The higher yield is attributed to increased canopy area/ leaf area. Higher the leaf area higher will be the photosynthetic surface, higher the photosynthetic surface and higher will be the photosynthetic accumulation hence resulting in higher yield (Shashidhara, 2000).

Table 1. Effect of different organic sources of nutrient on the growth and yield of broccoli

Treatments	Plant height (cm)	Canopy area (cm)	No. of leaves	Head weight (gm/plant)	Yield (Kg/plot)	Yield Ton/ha)
T ₁ (FYM)	41.5	43.29	9.41	620	7.44	18.6
T ₂ (Compost)	38.79	38.93	9	464.33	5.572	13.93
T ₃ (Vermicompost)	46.24	45.33	9.75	755	9.065	22.65
T ₄ (Poultry Manure)	46.83	47.62	9.33	803.33	9.64	24.1
T ₅ (FYM+PM)	44	43.12	10.25	632.33	7.58	18.97
T ₆ (FYM+Vermicompost)	39.54	38.12	9.08	491.66	5.9	14.75
T ₇ (Control)	37.33	36.55	8.91	413.66	4.96	12.41
CD (0.05)	8.0698	8.5290	0.5917	17.1305	0.2058	0.5139

Table 2. Effect of organic manures on soil chemical properties and macro nutrient status

Treatments	pH	OM %	N Kg/ha	K ₂ O Kg/ha	P ₂ O ₅ Kg/ha
T ₁ (FYM)	7.15	3.99	328.39	192.43	104.73
T ₂ (Compost)	6.60	2.936	339.08	176.43	119.18
T ₃ (Vermicompost)	6.85	3.27	347.343	198.41	125.24
T ₄ (Poultry manure)	6.58	3.11	369.30	220.30	132.1
T ₅ (FYM + Poultry manure)	6.62	2.46	355.91	186.05	111.95
T ₆ (FYM + Vermicompost)	6.75	2.21	332.54	171.63	103.90
T ₇ (Control)	6.51	1.75	320.33	167.06	90.11
CD (0.05)	0.1019	0.2449	1.8170	15.0945	3.3006

The same reports are recorded by other investigators such as (Abou El-Magd *et al.*, 2005).

Soil chemical properties

Soil pH

The data related to soil pH value as influenced by treatments are depicted in Table 2. There was a significant effect on soil pH value after the harvest of broccoli. The pH value of all different treated soil was found to be slightly acidic to neutral. The initial pH value of soil before applying any treatments was 6.34. Therefore compared to it, after harvesting the crop, the pH value of T₁ (FYM @20 ton/ha) was found higher than other treatment with 7.15 and minimum pH value was recorded in T₇ (Control) i.e., 6.51. The observation showed that the optimum pH was recorded wherever FYM was applied. Soil pH significantly affects the availability of the most of the elements, ions which are important to plants and also for microbial growth. In this experiment, pH of all soil was found to be slightly acidic to neutral. Plant nutrients like nitrogen, phosphorous, potassium, sulfur etc are less available in acidic soil, however, their availability is more in neutral soil. There is almost availability of all micro and macro nutrients in soil with neutral soil. The low pH value in soil treated with inorganic fertilizers than with organic fertilizers was also observed by (Maskey and Bhattarai, 1994). So, the result of soil pH analysis was satisfactory.

Organic matter content

Organic matter content in soil after harvest of crop was influenced significantly due to various fertility levels. The data related to organic matter content in soil as influenced by treatments are depicted in Table 2. The initial organic matter content in soil before applying any treatments was 1.604%. Therefore comparison to it and after harvesting of crop, the maximum organic matter content in soil was recorded in T₁ (FYM @ 20 ton/ha) i.e., 3.99% organic matter was recorded and the minimum organic matter content i.e., 1.75% was

recorded in T₇ (Control). The higher organic matter content in FYM treated soil is due to the application of FYM in an experiment during the study period. The higher organic matter content in the field where FYM and biofertilizers were used than that of other farmland was also determined by (Maskey and Bhattarai, 1994).

Soil macro nutrient

Significant effect of various fertility levels on the available nitrogen, phosphorous and potassium content in soil was found after the harvest of Broccoli. The data related to available nitrogen content in soil as influenced by various treatments are depicted in Table 2.

Available nitrogen

The initial available nitrogen content in soil before applying any treatments was 316.10 kg/ha. Therefore, comparison to it after harvesting of crop, the total available nitrogen content was found higher in T₄ (Poultry manure @ 2 ton/ha) than any other treatments and the minimum value was recorded from T₇ (control). The maximum value recorded was 369.30 kg/ha in T₄. The minimum value recorded was 320.33 kg/ha available nitrogen in T₇. Poultry manure contains higher percentage of nitrogen than other manures used. In case of chemical fertilizers due to leaching and volatilization there are more chances of losses of nitrogen. In the same way, mineralization of chemical fertilizers is faster than that of manures. Organic manure holds the nutrients and retained from losses. Higher value of total nitrogen in poultry manure treated soil is due to the slow but continuous releases of nitrogen from poultry manure. Similar result was found by (Jaishy *et al.*, 2000) while studying the nitrogen content by using bio-fertilizers and chemical fertilizers.

Available potassium

The initial available potassium content in soil before applying any treatments was 162.60 kg/ha. Therefore, comparison to it

after harvesting of crop, the mean value of available potassium was found higher in T₄ (poultry manure @ 2 ton/ha) i.e., 220.30 kg/ha K₂O and the minimum value was recorded in T₇ (control) i.e. 167.06 Kg/ha K₂O. As the data revealed that maximum available potassium content in soil was observed in plot treated with poultry manure, it might be due to enhancement in potassium availability by shifting the equilibrium among the forms of potassium from relatively exchangeable potassium to soluble potassium forms in the soil. The requirement of potassium content is quite essential for the proper growth and development of crops. The crop root takes up K⁺ actively from the soil. The soil parent material and use of fertilizers affect the potassium content of soil.

Available phosphorous

The initial available phosphorous content in soil before applying any treatments was 86.21 kg/ha. Therefore comparison to it, after harvesting of crop, the maximum value of available phosphorous was found in T₄ (Poultry manure @ 2 ton/ha) and the value recorded was 132.1 Kg/ha. The minimum value was recorded in T₇ with mean value of 90.11 kg/ha. Manure amendments are an excellent source of phosphorus (P₂O₅) for crop production; however, animal manures differ in P availability. Poultry manure (PM) contains more stable mineral-associated P than many manures and may act as a longer-term P source when used in crop production.

Conclusion

On the basis of evaluation of the observations recorded during the experimentation, it was found that plant height and canopy area were highest with the application of poultry manure @ 2 ton/ha than application of other manures. Also, the application of Poultry manure @ 2 ton /ha gave the maximum value for yield contributing parameter of broccoli as well as gave the significantly highest available nitrogen, potassium and phosphorous content value in soil after harvesting the crop. The pH value and OM % was more with the application of FYM @ 20 ton/ha. Therefore it can be concluded that, poultry manure @ 2 ton/ha, FYM @ 20 ton/ha and combination of poultry manure and FYM can be regarded as very good source of nutrients for growing organic broccoli. Since organic broccoli products are expected to be healthy for human and may be more profitable than those from conventional production system, further studies are needed to determine the optimal rate of organic for proper growth and production of broccoli.

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