Environment and Ecology 42 (3A) : 1194—1200, July—September 2024
Article DOI: https://doi.org/10.60151/envec/IXAR8456
ISSN 0970-0420

Effect of Different Sources of Concentrated Organic Inputs and Bio-Fertilizers on Growth, Yield and Quality of Broccoli cv Calabrese

Johnson Naorem, A. Sarkar, Chhail Bihari, N.K. Adhikary, S.P. Kanaujia, C.S. Maiti, T. Karak, S. Shil

Received 16 September 2023, Accepted 13 June 2024, Published on 5 August 2024

ABSTRACT

Broccoli, scientifically known as *Brassica oleracea* L. var. *italica*, is an important cool-season vegetable crops belonging to the family Brassicaceae or Cruciferae. Organic broccoli farming is an eco-friendly approach that ensures sustainable agricultural practices for consistent and resilient production by improving resistance against various pests and environmental challenges. Two consecutive years of field experiment was conducted during the *rabi* seasons of 2017-2018 and 2019-2020 comprising of twenty-one treatments with different sources of concentrated organic inputs along with bio-fertilizers by cultivar calabrese laid out in two factorial Randomized Block Design replicated by three times. The treatment combinations were consisted of seven different organic inputs viz. T_1- neem cake @ 1 t ha^{-1}, T_2-mustard cake @ 1 t ha^{-1}, T_3- neem cake @ 0.75 t ha^{-1}, T_4- mustard cake @ 0.75 t ha^{-1}, T_5- neem cake @ 0.5 t ha^{-1}, T_6- mustard cake @ 0.5 t ha^{-1} and T_7-control and three different level of biofertilizers viz. B_1- azotobactor @ 2 kg ha^{-1}, B_2- azospirillum @ 2 kg ha^{-1} and B_3- PSB @ 2 kg ha^{-1}. The exponential and significant improvement in plant height (31.68 cm), dry matter content (32.26%), gross head weight (615.18 g), net head weight (304.26 g) and projected yield (8.44 t ha^{-1}) were influenced by integrated application of mustard cake @ 1t ha^{-1} with azospirillum @ 2 kg ha^{-1}. The plant applied in different doses of mustard cake along with azospirillum responded better performance in most of the biochemical aspects viz. TSS (3.92 to 4.09^{o} Brix), vit-C (99.71 to 101.77 mg 100 g^{-1} pulp) and crude protein (2.23 to 2.43%). Mustad cake @ 1t ha^{-1} along with azospirillium @ 2 kg ha^{-1} clearly demonstrated more accumulation of N (2.12%), P (1.20%) and K (1.78%) content in plant tissue and significantly improved the head quality.

Keywords Broccoli, Biofertilizer, Organic inputs, Quality, Yield.

Johnson Naorem[1], A. Sarkar[2], Chhail Bihari[3], N.K. Adhikary[4], S.P. Kanaujla[5], C.S. Maiti[6], T. Karak[7], S. Shil[8]

[1, 3]PhD Scholar, [2]Asst Professor,
[4]Scientist (AICRP on Ve Crops), [5, 6, 7]Professor
[8]Subject Matter Specialist (SMS)
[1, 2, 3, 4, 5, 6]Department of Horticulture, School of Agricultural Sciences, Medziphema Campus, Nagaland University, Nagaland 797106, India

[7]Department of Soil Science, SAS, Nagaland University, Nagaland 797106, India

[8]SMS (Horticulture), KVK, Khowai, Tripura 799207, India

Email: asarkar@nagalanduniversity.ac.in
*Corresponding author

INTRODUCTION

Broccoli (*Brassica oleracea* L. var. *italica*) is a cole crop bearing chromosome number 2n = 18 and be-

longs to the family Cruciferae. The name broccoli has been derived from the Italian word 'brocco' means shoot and the word sprouting broccoli refers to the development of young flower buds which have been used as vegetables. It is also known as hari gobhi in Hindi. It contains little amount of sodium, low calories and fat, good source of calcium, high vit-C, vit-A and vit-B_2. The important elements in broccoli inflorescence (flowers) are called glucosinolates and sulforaphane which are therapeutic values and acts as anticarcinogenic. The production of broccoli with the application of organic inputs could serve as an alternative to mineral fertilizers (Farahzety and Aishah 2013) as well as to improve the soil structure and microbiological biomass. Organic fertilizers, including cow manure, chicken litter and sheep manure may be used for crop production as a substitute for synthetic fertilizers (Xie *et al.* 2018). The increase in use of fertilizers no doubt enhances the production of commodities remarkably, but it has a long-term detrimental impact on soil health. The use of chemical fertilizers alone increases the crop yields in the initial stage but adversely affects sustainability at the later stage in bulk density of soil, water holding capacity, humic substances, microbial activities and optimum range of hormone concentration (Gupta *et al*. 2019). Nutrient loss in the ecosystem is minimized and input costs are also lowered by organic production since plants absorb nutrients effectively. Bio-fertilizers play a multifunctional role as nutrient solubilizers, soil stabilizers, soil conditioner, hormone secretion and assistance of other beneficial microorganisms synergistically in soil (Mohapatra *et al.* 2013). In a sustainable agriculture system, organic fertilizers not only supply plant nutrients but also improve soil organic matter contents (Yaldiz *et al.* 2017). Farmer's unconscious and non-judicial application of chemical fertilizer especially nitrogenous fertilizers in agriculture field may cause nitrate accumulation that are detrimental and hazardous for environment (Yoldas *et al.* 2017).

MATERIALS AND METHODS

The experiment was carried out at the instructional cum research farm, Department of Horticulture, SAS, Nagaland University, Medziphema campus during 2017-18 and 2019-20. The experimental plot was located at the foothill of Nagaland with an altitude of 304.8 m MSL with a geographical location of 25°45'43" N latitude and 93°53'04" E longitudes and represents sub-humid, sub-tropical climate with moderate temperature. The temperature range between 12ºC during winter and 32ºC during summer and average annual rainfall ranges from 200 cm to 270 cm. The soil pH was 4.75 with organic carbon of 1.74% and atmospheric humidity in between 62 and 95%. The experiment was laid out in factorial Randomized Block Design (RBD) with twenty-one treatments replicated by three times. The treatment combinations with cv calabrese were consisted of seven different organic inputs viz. T_1- neem cake @ 1 t ha^{-1}, T_2-mustard cake @ 1 t ha^{-1}, T_3- neem cake @ 0.75 t ha^{-1}, T_4- mustard cake @ 0.75 t ha^{-1}, T_5- neem cake @ 0.5 t ha^{-1}, T_6- mustard cake @ 0.5 t ha^{-1} and T_7-control and three different level of biofertilizers viz. B_1- azotobactor @ 2 kg ha^{-1}, B_2- azospirillum @ 2 kg ha^{-1} and B_3- PSB @ 2 kg ha^{-1}. The nursery bed was raised under low-cost poly house. The bed was raised at 15 cm above ground level to avoid waterlog conditions and seeds were sown in line with a 4-5 cm distance in a bed of 1m × 1m at a depth of 1 cm and intermittent irrigation were applied. Prepared seedlings were transplanted in well-prepared plots of 1.8 m × 1.8 m size at a spacing of 60 × 45 cm. Recommended dose of organic inputs and biofertilizers were applied in field fifteen days before transplanting of seedlings. The observations were recorded in respect of growth, yield and yield-attributing characters. On the other hands, biochemical attributes (TSS, vit-C, crude protein and chlorophyll content of leaves) were also observed. Total soluble solids (TSS) were determined with the help of hand refractometer calibrated in ^{0}Brix at 20ºC with necessary correction factor. Ascorbic acid (vit-C) was estimated using 2, 6-dichlorophenol indophenols dye titration method following the standard procedure of AOAC (1995). Crude protein was determined by adopting standard procedure of nitrogen estimation of pulp (kjeldahl method) and worked out using the formula: % crude protein= % nitrogen content × 6.25. The nutrient contents in plant tissue were determined by adopting standard procedures of Jackson (1973). Two years pooled data were collected from five plants randomly selected from each unit plot and the mean data of each character statistically analyzed by adopting analysis of variance

and the treatment variance was tested against error mean square by applying Fischer Snedecore 'F' test of probability at 0.5% level of significance (Panse and Sukhatme 1989).

RESULTS AND DISCUSSION

Growth attributes

Plant height

The different organic inputs and inoculation of various bio-fertilizers significantly increased the plant height of broccoli over control (Table 1). The maximum plant height (30.01 cm) was recorded with mustard cake @ 1 t ha^{-1} (T_2) which was superior to all other concentrated organic inputs. *Azospirillum* @ 2 kg ha^{-1} recorded maximum plant height (28.78 cm) which was superior to the rest of the biofertilizers. The interaction of different organic inputs and various bio-fertilizers showed a significant impact on plant height. The combined application of mustard cake @1 t ha^{-1} and azospirillum @ 2 kg ha^{-1} (T_2B_2) recorded maximum plant height (31.68 cm) which was superior to all other treatment combinations. *Azospirillum* aids in increased plant growth due to their nitrogen-fixing capacity and they also help in synthesis of growth-promoting substances like IAA and GA. Organic fertilizers released all types of micro and macronutrients that invariably improved soil physical properties and availability of soil nutrients as a consequence in broccoli plant height to a greater extent. The findings are also in consonance with Singh *et al.* (2018) in broccoli.

Dry matter content of plant

The highest dry matter content in the plant (28.86%) was recorded with mustard cake @ 1 t ha^{-1} (T_2) which was superior to all other concentrated organic inputs (Table 1). *Azospirillum* @ 2 kg ha^{-1} recorded maximum dry matter content (27.34 %) which was superior to the rest of the biofertilizers. The interaction between different concentrated organic inputs and various bio-fertilizers showed a significant impact on plant dry matter content. The highest dry matter content in the plant (32.26%) was recorded in treatment combination of mustard cake @ 1 t ha^{-1} + azospirillum @ 2 kg ha^{-1} (T_2B_2) which was followed by mustard cake @ 1 t ha^{-1} + PSB @ 2 kg ha^{-1} (30.24 %). The improvement in the dry matter may be because of better availability and uptake of nitrogen which might have led to a balanced C/N ratio and increased activity of plant metabolism. The above findings are in conformity with Mehta and Sirari (2018).

Yield and yield attributes

Gross head weight

The maximum gross head weight (560.20 g) was recorded with mustard cake @ 1 t ha^{-1} (T_2), which was superior to all other concentrated organic inputs

Table 1. Influence of concentrated organic inputs and biofertilizers on plant height and dry matter content of broccoli. T_1: Neem cake @ 1 t ha^{-1}, T_2: Mustard cake @1 t ha^{-1}, T_3: Neem cake @ 0.75 t ha^{-1}, T_4: Mustard cake @ 0.75 t ha^{-1}, T_5: Neem cake @ 0.50 t ha^{-1}, T_6: Mustard cake @ 0.50 t ha^{-1} and T_7: Control, B_1: Azotobactor @ 2 kg ha^{-1}, B_2: *Azospirillum* @ 2 kg ha^{-1} and B_3: PSB @ 2 kg ha^{-1}.

Treatments	Plant height (cm)				Dry matter of plant (%)			
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
T_1	29.33	29.32	28.70	29.12	26.25	27.42	25.36	26.34
T_2	29.60	31.68	28.75	30.01	22.01	32.26	30.24	28.86
T_3	28.31	28.93	27.98	28.41	25.11	26.11	23.06	24.76
T_4	28.85	30.63	27.79	29.09	28.68	29.69	28.22	28.17
T_5	27.69	28.17	27.59	27.82	24.06	25.38	22.01	23.82
T_6	29.89	29.07	29.91	28.28	27.46	28.43	27.55	27.81
T_7	21.99	23.69	21.27	22.32	20.06	22.07	19.44	20.52
Mean	27.95	28.78	27.00		24.80	27.34	25.13	
CD ($p<0.05$)	T			0.59				0.90
	B			0.39				0.68
	T × B			1.02				1.46

Table 2. Influence of concentrated organic inputs and biofertilizers on yield and yield attributes of broccoli.

Treatments	Gross head weight (g)				Net head weight (g)				Projected yield ha^{-1} (t)			
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
T_1	440.16	494.14	404.99	446.43	223.29	234.44	182.87	213.53	6.19	6.49	5.07	5.92
T_2	560.11	615.18	505.31	560.20	252.95	304.26	202.94	253.38	7.01	8.44	5.63	7.03
T_3	380.10	415.18	365.23	386.84	188.86	204.48	179.78	191.04	5.22	5.66	4.99	5.29
T_4	510.34	545.19	475.10	510.21	232.90	274.39	202.07	236.45	6.45	7.59	5.60	6.54
T_5	330.17	345.07	315.25	330.16	178.69	184.37	169.94	177.66	4.96	5.11	4.70	4.92
T_6	485.14	475.46	445.64	468.75	212.74	244.24	191.87	216.28	5.88	6.78	5.31	5.99
T_7	280.89	297.73	279.81	286.14	124.81	137.76	120.50	127.69	3.45	3.81	3.34	3.53
Mean	426.70	455.42	398.76		202.03	226.28	178.57		5.59	6.27	4.95	
CD												
($p<0.05$)	T			11.13				7.45				0.33
	B			7.28				4.38				0.22
	T × B			19.27				12.91				0.57

(Table 2). *Azospirillum* @ 2 kg ha^{-1} (B_2) recorded maximum gross head weight (455.42 g) which was superior to the rest of the biofertilizers. The interaction of different concentrated organic inputs and bio-fertilizers showed a significant impact on gross head weight. The combined application of mustard cake @ 1 t ha^{-1} and *Azospirillum* @ 2 kg ha^{-1} (T_2B_2) recorded maximum gross head weight (615.18 g). Mustard oil cakes are a very good source of magnesium, sulfur, manganese and zinc along with other trace elements that helps in better vegetative growth resulting in maximum gross head weight. The findings are also in consonance with Angadi *et al.* (2017) in brinjal.

Net head weight

The maximum net head weight (253.38 g) was recorded with mustard cake 1 t ha^{-1}(T_2) which was found superior to all other concentrated organic inputs (Table 2). *Azospirillum* @ 2 kg ha^{-1} (B_2) recorded maximum net head weight (226.27 g). The interaction of different concentrated organic inputs and various bio-fertilizers showed a significant impact on net head weight. The treatment combination of mustard cake @ 1 t ha^{-1} and azospirillum @ 2 kg ha^{-1} (T_2B_2) recorded maximum net head weight (304.26 g). The effective utilization of nutrients for increased metabolism and synthesis of carbohydrates, thereby, resulted in increased vegetative growth and subsequent partitioning and translocation of photosynthates from the leaf (source) to the head, which ultimately influenced the net head weight. Similar findings are also reported by Dipika *et al.* (2014) in broccoli.

Projected yield

The highest projected yield per hectare (7.03 t ha^{-1})

Table 3. Influence of concentrated organic inputs and biofertilizers on quality attributes of broccoli.

Treatments	TSS (ºBrix)				Vitamin-C (mg 100 g^{-1})				Crude protein in head (%)			
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
T_1	3.19	3.31	3.10	3.20	98.07	98.91	97.35	98.11	2.06	2.08	2.02	2.05
T_2	3.99	4.09	3.89	3.99	100.02	101.77	100.04	100.61	2.22	2.43	2.08	2.24
T_3	3.08	3.21	2.99	3.09	96.92	97.94	95.94	96.93	1.84	1.98	1.92	1.91
T_4	3.91	4.01	3.79	3.89	98.98	100.76	98.96	99.56	2.12	2.33	1.98	2.14
T_5	2.98	3.10	2.91	3.00	95.83	96.91	94.85	95.86	1.86	1.88	1.82	1.85
T_6	3.90	3.92	3.70	3.84	98.03	99.71	97.99	98.58	2.02	2.23	1.88	2.04
T_7	3.14	3.19	3.11	3.14	90.16	91.08	88.60	89.95	1.46	1.53	1.42	1.47
Mean	3.47	3.53	3.35		96.86	98.15	96.25		1.94	2.07	1.87	
CD												
($p<0.05$)	T			0.14	T			2.33				0.06
	B			0.09	B			1.53				0.04
	T × B			NS	T × B			1.02				0.10

Table 4. Influence of concentrated organic inputs and biofertilizers on N, P and K content in broccoli head.

Treatments	Nitrogen (%)				Phosphorus (%)				Potassium (%)			
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
T_1	2.00	2.00	1.98	1.99	1.07	1.10	1.04	1.07	1.67	1.67	1.61	1.65
T_2	2.10	2.12	2.08	2.10	1.16	1.20	1.12	1.16	1.72	1.78	1.69	1.73
T_3	1.96	1.98	1.95	1.96	1.03	1.04	0.99	1.02	1.62	1.64	1.58	1.61
T_4	2.08	2.10	2.06	2.08	1.13	1.16	1.08	1.13	1.69	1.74	1.66	1.69
T_5	1.96	1.98	1.95	1.93	0.99	1.00	0.95	0.98	1.59	1.61	1.55	1.58
T_6	2.08	2.10	2.06	2.06	1.09	1.13	1.04	1.08	1.66	1.71	1.65	1.67
T_7	2.08	2.04	1.81	1.81	0.79	0.85	0.73	0.79	1.49	1.51	1.45	1.48
Mean	1.99	2.01	1.97		1.04	1.07	0.99		1.63	1.66	1.60	
CD ($p<0.05$)	T			0.05				0.04				0.04
	B			0.03				0.02				0.02
	T × B			NS				NS				NS

was recorded with mustard cake @ 1 t ha^{-1} (T_2) trailed by mustard cake @ 0.75 t ha^{-1} (6.54 t ha^{-1}), which was superior to most of the other concentrated organic inputs (Table 2). *Azospirillum* @ 2 kg ha^{-1} recorded the highest projected yield per hectare (6.27 t ha^{-1}) but which was statistically at par with azotobacter @ 2 kg ha^{-1} (5.59 t ha^{-1}). The interaction of different concentrated organic inputs and bio-fertilizers showed good impact on projected yield per hectare. The treatment combination of mustard cake @ 1 t ha^{-1} and azospirillum @ 2 kg ha^{-1} (T_2B_2) recorded the highest projected yield per hectare (8.44 t ha^{-1}), but it was statistically at par with mustard cake @ 0.75 t ha^{-1} and azospirillum @ 2 kg ha^{-1} (7.59 t ha^{-1}). Mustard cake powder is rich source of nitrogen, phosphorus, and potassium (NPK). Mustard cake proteins are considered as potential source of plant protein. So, an application of this organic fertilizer provides a complete package of nutrients for soil. The increased vegetative growth and subsequent partitioning and translocation of photosynthates from the leaf (source) to the different parts of the plants, ultimately influenced the vegetative and yield parameters thus resulting in higher projected yield per hectare.

Quality attributes

Total soluble solids

Maximum total soluble solids content in the head (3.99 ^{0}Brix and 3.53 ^{0}Brix) was recorded with neem cake @ 1 t ha^{-1} (T_2) and azospirillum @ 2 kg ha^{-1}(B_2) respectively (Table 3). The interaction of different concentrated organic inputs and bio-fertilizers showed good impact on the total soluble solids content in the head. The maximum total soluble solids content (4.09^{0}Brix) was reported from the treatment combination of mustard cake @ 1 t ha^{-1} and azospirillum @ 2 kg ha^{-1} (T_2B_2) followed by mustard cake @ 0.75 t ha^{-1} and azospirillum @ 2 kg ha^{-1} (4.01^{0}Brix). Integrated application of organic manures with the biofertilizers which might have helped in better uptake of major nutrients including micronutrients.

Vitamin-C content

The highest vitamin-C content (100.61 mg 100 g^{-1}) was recorded with mustard cake @ 1 t ha^{-1} (T_2), but it was statistically at par with mustard cake @ 0.75 t ha^{-1} (99.56 mg 100 g^{-1}) (Table 3). *Azospirillum* @ 2 kg ha^{-1} (B_2) recorded the highest vitamin-C content (98.15 mg 100 g^{-1}). The interaction of different concentrated organic inputs and bio-fertilizers showed good impact on vitamin-C content. The treatment combination of mustard cake @ 1 t ha^{-1} and azospirillum @ 2 kg ha^{-1}(T_2B_2) recorded the highest ascorbic acid content (101.77 mg 100 g^{-1}), but it was statistically at par with mustard cake @ 0.75 t ha^{-1} + azospirillum @ 2 kg ha^{-1} (100.76 mg 100 g^{-1}). The increase of vitamin-C content in leaves with added biofertilizers along with organic manure might be due to its efficacy to fix atmospheric nitrogen and enhancing carbohydrate synthesis which ultimately results in ascorbic acid content. Another reason for increased ascorbic acid

due to the application of azotobacter and azospirillium because it has a positive effect on the enzyme reaction and formation of metabolites for carbohydrates and proteins synthesis which leads to increases in vitamin-C content. Similar findings are also reported by Meena *et al.* (2014) in tomato using organic manures and biofertilizers.

Crude protein content in the head

The maximum crude protein content in the head (2.24 %) was recorded with mustard cake @ 1 t ha^{-1}, but it was statistically at par with mustard cake @ 0.75 t ha^{-1} (2.14%) (Table 1). It is evident that azospirillum @ 2 kg ha^{-1} (B_2) recorded the highest crude protein content (2.07 %), but it was statistically at par with azotobacter @ 2 kg ha^{-1} (1.94%). The highest crude protein content (2.43%) was noticed by mustard cake @ 1 t ha^{-1} and azospirillum @ 2 kg ha^{-1} (T_2B_2) which was statistically at par with mustard cake @ 0.75 t ha^{-1} + azospirillum @ 2 kg ha^{-1} (2.33%). The enhancement in crude protein content might be the reason for seedling inoculation in azospirillum since it increases P and N uptake in plant system, enhancement of other mineral absorption and production of phytohormones such as IAA and gibberellins.

Nutrient content

Nitrogen, phosphorus and potassium content

The maximum nitrogen, phosphorus and potassium content (2.10, 1.16 and1.73% respectively) was recorded with mustard cake @ 1 t ha^{-1} (Table 4). *Azospirillum* @ 2 kg ha^{-1} (B_2) was recorded the highest nitrogen, phosphorus and potassium content (2.01, 1.07 and 1.66%, respectively). There was no significant difference between the treatment combination, but mustard cake @ 1 t ha^{-1} and azospirillum @ 2 kg ha^{-1} (T_2B_2) reported maximum nitrogen, phosphorus and potassium content (2.12, 1.20 and 1.78% respectively) in tissue. Bio-fertilizers have been identified as a good supplement to increase soil fertility and crop production in sustainable farming. The use of bio-fertilizers results in the highest biomass and increased nutrient content as well as nutrient uptake by plants (Chandan *et al.* 2018). The increase in phosphorus content might be due to the increased availability of soil phosphorus because of the solubilizing effect of organic acids, which are produced from decomposing organic manures (Herencia *et al.* 2011). Potassium is known that microorganisms can solubilize minerals in the rock and can provide a continuous supply of potassium for plant growth.

CONCLUSION

The integration of concentrated organic manures and biofertilizers helps in enhancing crop production and productivity maintaining the soil health and fertility. From the present investigation, it is concluded that the maximum plant growth, higher yield and quality of broccoli cv calabrese in the hill ecosystem was obtained from mustard cake @ 1t ha^{-1} + azospirillum @ 2 kg ha^{-1} and were found to be supremacy.

REFERENCES

Angadi V, Rai PK, Bara BM (2017) Effect of organic manures and biofertilizers on plant growth, seed yield and seedling characteristics in tomato (*Lycopersicon esculentum* Mill.). *Journal of Pharmacognosy and Phytochemistry* 6 (3): 807—810.

AOAC (1995) Official Method of Analysis. Association of official analytical chemist, Washington DC, USA, 14th edn.

Chandan SK, Singh SK, Pandey A, Singh P, Prabha S (2018) Effect of integrated nutrient management on growth, yield and nutrient uptake by Indian mustard (*Brassica juncea* L). *Annals of Plant Soil Research* 20: 31—36.

Dipika M, Ranjit C, Nimbalkar K (2014) Effect of vermicompost and inorganic fertilizers on growth, yield and quality of sprouting broccoli (*Brassica oleracea* L. var. *italica* plenck). *International Journal of Bio-resource and Stress Management* 5 (4) : 507—512. https://doi.org/10.5958/0976-4038.2014.00606.X.

Farahzety AM, Aishah HS (2013) Effects of organic fertilizers on performance of cauliflower (*Brassica oleracea* var. *botrytis*) grown under protected structure. *Journal of Tropical Agriculture and Food Science* 41 (1) : 15—25.

Gupta R, Swami S, Rai AP (2019) Impact of integrated application of vermicompost, farmyard manure and chemical fertilizers on okra (*Abelmoschus esculentus* L.) performance and soil biochemical properties. *International Journal of Chemical Studies* 7 : 1714—1718.

Herencia JF, Garcia-Galavis PA, Ruiz Dorando JA, Maqueda C (2011) Comparison of nutritional quality of the crops grown in an organic and conventional fertilized soil. *Scientia Horticulture* 129 (4) : 882—888. https://doi.org/10.1016/j.scienta.2011.04.008.

Jackson ML (1973) Soil chemical analysis. Prentice Hall of India. Pvt Ltd New Delhi.

Meena RK, Sanjay K, Sutanu M, Devendra K, Manoj K (2014)

Effect of organic manures and biofertilizers on growth, flowering, yield and quality of tomato cv Pusa Sheetal. *International Journal of Agricultural Science* 10 (1) : 329—332.

Mehta CM, Sirari K (2018) Comparative study of aerobic and anaerobic composting for better understanding of organic waste management : A mini review. *Plant Archives* 18 (1) : 44—48.

Mohapatra SK, Munsi PS, Mahapatra PN (2013) Effect of integrated nutrient management on growth, yield and economics of broccoli *(Brassica oleracea* L. var. *italica* plenck.). *Vegetable Science* 40 (1) : 69—72. https://doi.org/10.61180/

Panse VG, Sukhatme PV (1989) Statistical methods for agricultural workers. ICAR, New Delhi.

Singh G, Sarvanan S, Kerketta A, Rajesh J (2018) Effect of organic manures and inorganic fertilizers on plant growth, yield and flower bud quality of broccoli (*Brassica oleracea* var. *italica*) cv green magic. *International Journal of Pure and Applied Bioscience* 6 (5) : 1338—1342. http://dx.doi.org/10.18782/2320-7126.

Xie WY, Shen Q, Zhao FJ (2018) Antibiotics and antibiotic resistance from animal manures to soil: A review. *European Journal of Soil Science* 69 (1) : 181—195. https://doi.org/10.1111/ejss.12494.

Yaldiz G, Arici YK, Yilmaz G (2017) Phytochemical analysis, antioxidant and antibacterial activities of four Lamiaceae species cultivated in barnyard manure. *Journal of Agricultural Science* 23 (1) : 95—108.

Yoldas F, Ceylan S, Mordogan N, Ongun AR (2017) Effects of organic chicken manure on nitrate accumulation and nutrient element content of broccoli. *Acta Biologica Turcica* 30 (4) : 169—173.