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INTEGRATED NUTRIENT MANAGEMENT FOR GROWTH, YIELD AND PROFITABILITY OF BROCCOLI

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Abstract

A field experiment on broccoli taking the hybrid variety 'Green Magic' was conducted with seven treatments [T_1 = 100% recommended dose of inorganic fertilizer(100-35-60-18-2-1.2 kg/ha of N-P-K-S-Zn-B+Cowdung (CD) @5 t/ha), T_2 = 50% inorganic fertilizer recommended dose + Mustard Oil Cake(MOC) @ 1.5 t/ha, T_3 = 50% inorganic fertilizer of recommended dose + CD @ 10 t/ha, T_4 = 50% inorganic fertilizer of recommended dose + Poultry Manure (PM) @ 6 t/ha, T_5 = 25% inorganic fertilizer of recommended dose + MOC @ 3 t/ha, T_6 = 25% inorganic fertilizer of recommended dose + CD @ 15 t/ha, T_7 = 25% inorganic fertilizer of recommended dose + PM @ 12 t/ha] at the Horticultural Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur during the period from September 2015 to February 2016. The aim of the study was to standardize the organic manure and inorganic fertilizers of broccoli for proper growth and yield. The experiment was laid out in a Randomized Complete Block Deign with three replications. All the parameters studied were significantly influenced by different treatments. The maximum plant height (62.20 cm) and canopy spread (64.67 cm), maximum number of leaves/plant (30.23) and average size of leaves (738.1 cm^2) and length of terminal head (15.57 cm) were found in T_5 which was statistically similar with T_7. The diameter of stems (3.87 cm), terminal head diameter (16.17 cm), terminal head weight/plant (424.6 g), number of lateral heads/plant (4.86), weight of lateral heads/plant (155.5 g), yield/plot (11.60 kg/$6m^2$), yield (19.34 t/ha) were found the highest in T_7 which was statistically similar with T_5. Gross return and net return were the highest in $T_7$and benefit cost ratio (BCR) was also maximum (3.64) in T_7.

Keywords: Organic fertilizer, Inorganic fertilizer, Growth, Yield and Broccoli.

Introduction

Broccoli (*Brassica oleracea*var. *italica* L.) is one of the non-traditional and relatively new cole crops in Bangladesh, belonging to the family Brassicaceae and it is grown in cool winter season in Bangladesh as an annual crop (Swarup, 2012).

Broccoli responds greatly to major essential elements like N, P, and K in respect of its growth and yield (Mital *et al.*, 1975; Singh *et al.*, 1976; Thompson and

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Kelly, 1988) and storage life. Nutrients may be applied through two sources *viz.*, organic and inorganic. Increased use of chemical fertilizers in crop field causes health hazards, and create problem to the environment by polluting water, air and soil. The continuous use of chemical fertilizers also badly affects the soil texture and structure. Decreased organic matter content of soil hampers soil microbial activity. Soils of Bangladesh contain 0.056 to1.638% organic matter (Akter *et al*., 2012). Now a days gradual decrease of soil organic matter and reduced yield of crop are alarming issues to the farmers. Organic manure plays direct role in plant growth as a source of all necessary macro and micronutrients in available forms during mineralization and improves physical and chemical properties of soils (Chaterjee *et al*., 2005, Kumar*et al.*, 2013, Attigah *et al.*, 2013).

Cow dung, poultry manure and mustard oil cake are available in the country, which are the good source of all the essential nutrients. Use of these manures also improves the organic matter status of soil. A judicious application of organic and inorganic fertilizers might be helpful to obtain a good economic return from a crop, as well as from the subsequent crop, and to maintain good soil health (Abou El- Magd *et al.*, 2006).

The production technology of broccoli has not yet been standardized in Bangladesh. Available information is scanty regarding the effect of organic manure with inorganic fertilizers on the growth and yield of broccoli. The present study was undertaken to investigate vegetative growth and yield performance of broccoli under different doses of organic manure and inorganic fertilizer and to find out the best combinations of them for sustainable crop productivity.

Materials and Methods

An experiment on integrated nutrient management of broccoli was conducted at the Horticultural Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Gazipur during the period from September 2015 to February 2016. The variety of broccoli used in this experiment was Green Magic, a hybrid, which was produced by Sakata Co. Ltd., Japan. The seeds were collected from Siddique Bazar of Dhaka. The experiment comprised of seven treatments [T_1 = 100% Recommended Dose of Fertilizer (RDF) (100-35-60-18-2-1.2 kg/ha of N-P-K-S-Zn-B+Cowdung (CD) @ 5 t/ha), T_2 = 50% RDF + Mustard Oil Cake (MOC) @ 1.5 t/ha, T_3 = 50% RDF + CD @ 10 t/ha, T_4 = 50% RDF + Poultry Manure (PM) @ 6 t/ha, T_5 = 25% RDF + MOC @ 3 t/ha, T_6 = 25% RDF + CD @ 15 t/ha, T_7 = 25% RDF + PM @ 12 t/ha]. As per treatment of the experiment, organic manures *viz.*, cowdung, mustard oil cake and poultry manure and inorganic fertilizers viz., N in the form of urea, P in the form of triple super phosphate (TSP), K in the form of muriate of potash (MoP), S in the form of gypsum, Zn in the form of zinc sulphate and B in the form of boric acid were applied to the field. Well decomposed CD, MOC & PM and TSP were incorporated in the soil during final land preparation. Gypsum, Ziinc

sulphate and Boric acid were incorporate in the soil during bed preparation. Urea and MoP were applied in three instalments; the first instalment was applied 15 days after transplanting (DAT), second and third instalments were top dressed at 30 and 45 DAT. The average monthly maximum and minimum temperature, relative humidity and monthly total rainfall during the crop growing period were collected from the meteorological station of BSMRAU and are presented in Appendix-3.

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Unit plot size was 2.4 m × 2.5 m and 55 days old seedlings were transplanted on 22 November 2015 maintaining plant spacing of 50 cm × 60 cm. Intercultural operations such as weeding, mulching with straw and irrigation were done as per requirement. Data were recorded from 10 randomly selected plants of each plot on plant height (cm), number of leaves/plant, canopy spread (cm), stem diameter (mm), head initiation (days), leaf size (cm^2), terminal head length (cm), terminal head diameter (cm), terminal head weight/plant (g), number of lateral heads/plant, lateral head weight/plant (g), yield per plot (kg/ha) and yield (t/ha). The data were statistically analyzed using MSTATC software program. Means were separated using Least Significant Difference (LSD) test at 5% level of probability (Gomes and Gomes, 1984). Economic analysis was done in order to compare the profitability of the treatment combination and BCR was calculated using the following formula.

$$\text{BCR} = \frac{\text{Gross return (Tk/ha)}}{\text{Total cost of production}}$$

Results and Discussion

Plant height

Plant height was recorded at 15, 30, and 45 DAT and at harvest. The plant height at different DAT was significantly influenced by different treatments (Table 1). At 15 DAT the tallest plant (31.30 cm) was recorded in T_7 which was identical with T_5 (31.03 cm) and T_6 (30.33 cm). The plants of T_2showed the lowest plant height (22.13 cm). At 30 DAT, maximum plant height was recorded from T_5 (52.33cm) closely followed by T_7 (52.10 cm) and the lowest was recorded from T_2 (37.70cm). At 45 DAT, T_5 produced the highest plant height (59.40cm) which was statistically similar with T_7 (58.87cm) and T_6 (56.67cm) and T_2gave the lowest plant height. At harvest, the tallest plant was recorded in T_5 (62.20 cm) which was identical with T_7 (62.07 cm), T_6 (60.87 cm), T_1 (58.93 cm) and T_3 (58.20 cm). The plants of T_2 gave the lowest plant height (53.07 cm). The increased plant height might be due to nitrogen both in inorganic and organic form which enhanced the plant height up to 92% over the control. These results are in complete agreement with those obtained by Rakesh *et al.* (2006) who

showed that organic manure along with mineral fertilizers increased vegetative growth including plant height of broccoli.

Table 1. Effect of organic manure and inorganic fertilizerson plant height and number of leaves/plant of broccoli at different growth stage

Treatment combination	Plant height (cm) at DAT				Leaves per plant at DAT			
	15	30	45	At harvest	15	30	45	60
T_1	27.77	43.97	53.87	58.93	11.57	16.37	21.33	27.40
T_2	22.13	37.70	49.00	53.07	10.53	13.53	18.70	22.00
T_3	27.03	41.03	52.53	58.20	11.30	15.50	20.73	27.57
T_4	22.87	38.90	51.20	54.27	10.60	14.27	19.53	23.87
T_5	31.03	52.33	59.40	62.20	13.07	18.70	25.07	30.23
T_6	30.33	48.10	56.67	60.87	11.73	17.27	23.47	28.87
T_7	31.30	52.10	58.87	62.07	12.63	18.00	24.87	29.73
$LSD_{0.05}$	2.80	3.70	4.74	5.22	0.979	2.51	2.94	2.34
Level of significance	**	**	**	**	**	**	**	**
CV (%)	5.75	4.65	4.90	5.01	4.73	8.72	7.54	4.86

** Significant at 1% level of probability, DAT= Days after transplanting.

T_1 = 100% RDF @5 t/ha, T_2 = 50% RDF + MOC @ 1.5 t/ha, T_3 = 50% RDF + CD @ 10 t/ha, T_4 = 50% RDF + PM @ 6 t/ha, T_5 = 25% RDF + MOC @ 3 t/ha, T_6 = 25% RDF + CD @ 15 t/ha, T_7 = 25% RDF + PM @ 12 t/ha.

Number of leaves/plant

The number of leaves per plant at different growth stages was significantly influenced by different treatments (Table 1). Number of leaves per plant was recorded at 15, 30, 45 and 60 DAT. At 15 DAT, the highest number of leaves per plant(13.07) was recorded in T_5which was identical with T_7 (12.63). The plants of T_2gave the lowest number of leaves per plant(10.53). At 30 DAT, the highest number of leaves per plant(18.70) was recorded in T_5closely followed by T_7 (18.00) and T_6 (17.27)and the lowest was obtained from T_2 (13.53). Number of leaves/plant at 45 DAT showed similar trend of 30 DAT. At 60 DAT, maximum number of leaves per plant(30.23) was recorded in T_5 which was identical with T_7 (29.73) and T_6 (28.87). The plants of T_2produced the lowest number of leaves(22.00). Rakesh *et al.* (2006) reported that organic manure plus mineral fertilizer enhanced the vegetative growth of broccoli plants.

Stem diameter

The diameter of stem was measured at the point where the terminal head was cut off. The diameter of stem was significantly influenced by different treatments

(Table 2). Stem diameter was recorded at60 DAT. The maximum diameter (3.87 cm) was recorded in T_7 which was statistically similar with T_5 (3.86 cm) and T_6 (3.72 cm). The minimum stem diameter (3.26 cm) was noted in T_2. The diameter of stem was found maximum might be due to enjoying optimum nutrients at early stage (Rabby, 2008).

Table 2. Effect of organic manure and inorganic fertilizer on canopy spread, stem diameter and head initiationof broccoli

Treatment combination	Stem diameter (cm)	Head initiation (Days)		
		1st	50%	100%
T_1	3.55	37.67	45.00	52.33
T_2	3.26	35.33	41.00	50.00
T_3	3.49	38.33	45.00	52.33
T_4	3.30	35.33	43.00	51.00
T_5	3.86	42.33	46.33	54.33
T_6	3.72	41.00	46.00	53.00
T_7	3.87	41.67	46.33	53.67
$LSD_{0.05}$	0.333	4.89	3.54	2.63
Level of significance	**	*	*	*
CV (%)	5.21	7.10	4.46	2.83

** Significant at 1% level of probability, DAT=Days after transplanting.

T_1 = 100% RDF @5 t/ha, T_2 = 50% RDF + MOC @ 1.5 t/ha , T_3 = 50% RDF + CD @ 10 t/ha, T_4 = 50% RDF + PM @ 6 t/ha, T_5 = 25% RDF + MOC @ 3 t/ha, T_6 = 25% RDF + CD @ 15 t/ha, T_7 = 25% RDF + PM @ 12 t/ha.

Head initiation

Significant influence of different treatments on head initiation of broccoli was observed (Table 2). The plants under T_5 took the longest time (42.33 days) for first head initiation which was statistically similar with T_7 (41.67 days), T_6 (41.00 days), T_3 and T_1, while the plants of $T_2$and T_4required minimum time (35.33 days). The plants under T_5 and T_7 took the maximum time (46.33 days) for 50% head initiation which was statistically similar with T_6, T_1, T_3 and T_4. On the other hand T_2 took the lowest time (41.00 days) for 50% head initiation. Again T_5 took the maximum time (54.33 days) for 100% head initiation which was statistically similar with T_7 (53.67 days), T_6 (53.00 days), T_1 and T_3 and T_2 took the lowest time (50.00 days) for 100% head initiation. This finding was supported by the results of Thakur *et al.* (1991) and Balyan *et al.* (1988).

Leaf size (cm^2)

Leaves size was recorded at 60 DAT. The size of leaves varied significantly due to the influence of different treatments (Table 3). The maximum leaf size (738.10 cm^2) was found in T_5which was identical with T_6 (732.90 cm^2) and T_7 (729.40 cm^2) whereas the minimum (660.70 cm^2) was in T_2.

Table 3. Effect of organic manure and inorganic fertilizer on leaf size, head diameter, head length and number of lateral headsof broccoli

Treatment combination	Leaf size (cm^2)	Terminal head diameter (cm)	Terminal head length(cm)	Number of lateral heads/plant
T_1	692.20	14.13	14.33	4.13
T_2	660.70	12.87	13.47	3.07
T_3	681.10	14.20	13.83	3.60
T_4	667.50	13.40	13.67	3.33
T_5	738.10	16.17	15.57	4.46
T_6	732.90	15.60	14.90	4.46
T_7	729.40	16.17	15.40	4.86
$LSD_{0.05}$	41.78	1.66	1.50	0.318
Level of significance	**	**	*	**
CV (%)	3.35	6.37	5.85	4.45

** Significant at 1% level of probability, DAT=Days after transplanting.

T_1 = 100% RDF @5 t/ha, T_2 = 50% RDF + MOC @ 1.5 t/ha , T_3 = 50% RDF + CD @ 10 t/ha, T_4 = 50% RDF + PM @ 6 t/ha, T_5 = 25% RDF + MOC @ 3 t/ha, T_6 = 25% RDF + CD @ 15 t/ha, T_7 = 25% RDF + PM @ 12 t/ha.

Days required for terminal head harvest

Days required for terminal head harvest varied significantly due to the influence of different treatments (Fig 1). T_7 took the highest time (38 days) followed by T_6 (37 days) for 1st harvest and the lowest time was required in T_3 (33.33 days). For 50% head harvest, T_6 took the maximum time (50.00 days) closely followed by T_7 (49.67 days) and the minimum time was T_1 (44.00 days). On the other hand, for final harvest T_7 took the maximum time (57.33 days) while T_1 took the lowest time (49.67 days). This finding was supported by the results of Thakur *et al.* (1991) for cauliflower who reported that the increasing rate of N delayed head maturity. Balyan *et al.* (1988) also reported similar results in cauliflower.

Diameter and length of terminal head

Diameter and length of terminal head were significantly influenced by different treatments (Table 3). Maximum diameter was recorded in T_5 and T_7 (16.17 cm) which was identical with T_6(15.60 cm) and the minimum diameter (12.87 cm)

was in T_2. The maximum length (15.57 cm) of terminal head was recorded in T_5 which was statistically similar to T_7 (15.40 cm), T_6(14.90 cm) and T_1(14.33 cm).On the contrary minimum length (13.47 cm) was found in T_2.

Number of lateral heads/plant

There was a significant variation in number of lateral heads produced by the plants under different treatments (Tables 3). The maximum number of lateral heads (4.86) was recorded in T_7 with the minimum (3.071) of lateral heads was recorded in T_2.Similar trend has also been reported by Bankder and Mukhopadhyay (1980).

Weight of terminal head

Weight of terminal head varied significantly due to the influence of different organic manures and inorganic fertilizers (Table 4). The plants of T_7 produced the maximum terminal head weight (424.60g) which was statistically similar to T_5 (422.30 g) and T_6 (413.50 g) while T_2produced the lowest (328.90 g). This result is in agreement with Kandil and Gad (2009) who concluded that using organic manure along with inorganic fertilizers gave a significant promotive effect on plant growth, head yield, chemical constituents and mineral composition of broccoli. Similar results were also reported by Chaterjee *et al.* (2005), Mellgren (2008) and Yoldas and Esiyok (2004) in broccoli.

Table 4.Effect of organic manure and inorganic fertilizer on terminal headweight, lateral headweight, head weight per plant, yield per plot and yieldof broccoli

Treatment combination	Terminal head weight (g)	Lateral head weight (g)	Head weight per plant (g)	Yield per plot(kg)	Yield(t/ha)
T_1	374.4	137.5	511.93	10.58	17.64
T_2	328.9	120.2	449.10	8.98	14.97
T_3	372.7	134.5	507.27	10.14	16.91
T_4	339.8	125.8	452.27	9.31	15.51
T_5	422.3	155.1	577.43	11.55	19.19
T_6	413.5	153.9	567.47	11.35	18.92
T_7	424.6	155.5	579.40	11.60	19.34
$LSD_{0.05}$	34.78	13.83	9.85	1.04	1.96
Level of significance	**	**	**		
CV%	5.11	5.54	5.21	5.57	6.29

** Significant at 1% level of probability, DAT=Days after transplanting.

T_1 = 100% RDF @5 t/ha, T_2 = 50% RDF + MOC @ 1.5 t/ha , T_3 = 50% RDF + CD @ 10 t/ha, T_4 = 50% RDF + PM @ 6 t/ha, T_5 = 25% RDF + MOC @ 3 t/ha, T_6 = 25% RDF + CD @ 15 t/ha, T_7 = 25% RDF + PM @ 12 t/ha.

Lateral head weight

Significant variation was revealed regarding lateral head weight due to the influence of different treatments (Table 4). The highest lateral head weight was found in T_7 (155.50 g) which was identical with T_5 (155.10 g) and T_6 (153.90 g). The lowest lateral head weight (120.20 g) was obtained from T_2. This phenomenon might be due to continuous release of essential nutrient elements from different manures and fertilizers used. Treatment that nourished the plants properly gave the highest weight of lateral head/plant (Rabby, 2008).

Head weight per plant

The head weight/plant of broccoli varied significantly due to different treatments (Table 4). The head yield ranged from 449.10 to 579.40 g/plant. The highest head weight/plant (579.40 g) wasrecorded in T_7 which was identical with T_5 (577.43 g). The lowest head weight/plant (449.10 g) was found in T_2.

Yield per plot

The head yield/plot of broccoli were significantly influenced by different treatments (Table 4). The maximum head yield per plot was recorded in T_7 (11.60 kg) which was statistically similar to T_5 (11.55 kg) and T_6 (11.35 kg). On the other hand, the lowest head yield per plot (8.98 kg) was obtained from T_2. These results indicated that yields per plot can be enhanced with the application of organic manure and inorganic fertilization. This result is in agreement with Kandil and Gad (2009).

Table 5. Economic analysis of production as influenced by different organic manure and inorganic fertilizers

Treatment combination	Marketable Yield/ha (t/ha)	Total cost of production/ha (Tk)	Gross return/ha (Tk)	Net return/ha (Tk)	Benefit Cost Ratio (BCR)
T_1	17.64	125297	441000.00	315703.00	3.52
T_2	14.97	158919	374250.00	215331.00	2.35
T_3	16.91	130053	422750.00	292697.00	3.25
T_4	15.51	115553	387750.00	272197.00	3.35
T_5	19.19	223160	479750.00	256590.00	2.15
T_6	18.92	146630	473000.00	326370.00	3.23
T_7	19.34	132924	483500.00	350576.00	3.64

T_1 = 100% RDF @5 t/ha, T_2 = 50% RDF + MOC @ 1.5 t/ha , T_3 = 50% RDF + CD @ 10 t/ha, T_4 = 50% RDF + PM @ 6 t/ha, T_5 = 25% RDF + MOC @ 3 t/ha, T_6 = 25% RDF + CD @ 15 t/ha, T_7 = 25% RDF + PM @ 12 t/ha.

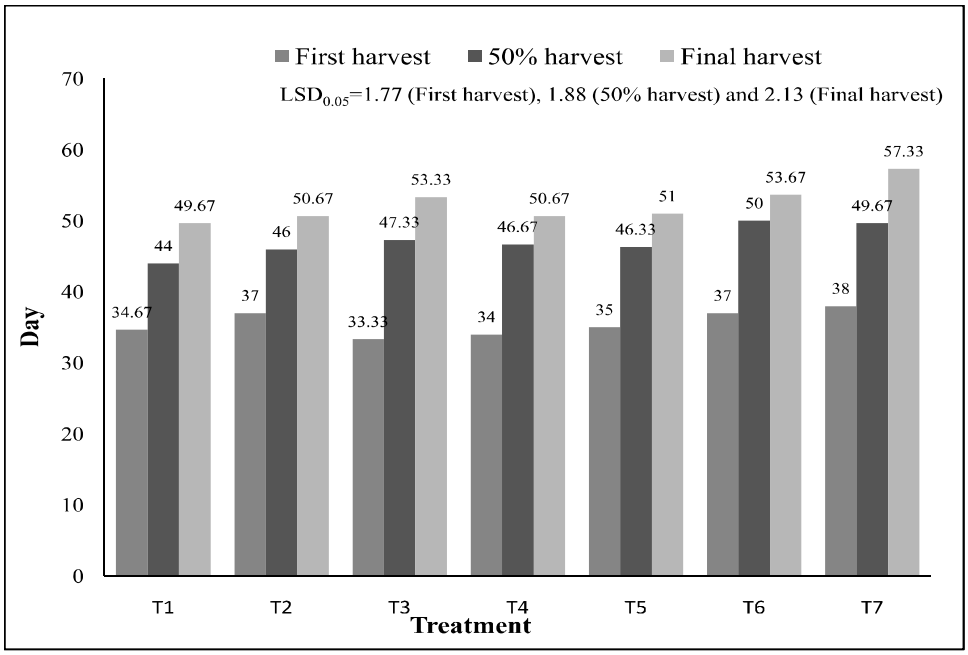

Fig. 1. Effect of organic manure and inorganic fertilizers on days required for head harvest.

T_1 = 100% RDF @5 t/ha, T_2 = 50% RDF + MOC @ 1.5 t/ha , T_3 = 50% RDF + CD @ 10 t/ha, T_4 = 50% RDF + PM @ 6 t/ha, T_5 = 25% RDF + MOC @ 3 t/ha, T_6 = 25% RDF + CD @ 15 t/ha, T_7 = 25% RDF + PM @ 12 t/ha

Yield per hectare

Yield per hectare was also significantly influenced by different treatment combination (Table 4). The highest head yield per hectare (19.34 t/ha) was recorded from T_7 which was identical with T_5 (19.19 t/ha), T_6 (18.92 t/ha) and T_1 (17.64 t/ha) while the lowest head yield of 14.97 t/ha was recorded in T_2.Similar results were reported by Chaterjee *et al.* (2005).

Economic analysis

The production cost of broccoli varied due to different organic manure and inorganic fertilizers (Table 5). Cost of production was higher in other approaches compared to recommended approach. Production cost was the highest (Tk. 223160/ha) in T_5followed by T_2 (Tk. 158919/ha) and it was the lowest (Tk. 115553/ha) in T_4. The maximum gross return (Tk. 483500.00/ha) and net return (Tk. 350576.00/ha) were found in T_7 while the minimum in T_2 (Tk. 374250.00/ha and 215331.00/ha, respectively). The highest benefit cost ratio (3.64) was found in T_7 followed by T_1 (3.52) while it was the lowest in T_5 (2.15).

Conclusion

Based on the results of the present study,it can be concluded that the treatment T_7= (25% RDF + PM@12 t/ha) performed the best regarding diameter of stem, terminal headdiameter, length of terminal head, terminal headweight per plant, no. of lateral heads per plant, weight of lateral heads per plant, yield per plot and yield per hectare (t/ha). Thistreatment was statistically similar to T_5 (25% RDF + MOC @ 3 t/ha).Gross return and net return was the highest in T_7 and benefit cost ratio was also the maximum (3.64) in the same treatment. Hence, 25% RDF + PM @ 12 t/ha may be the recommended for sustainable broccoli production.

References

Abou El- Magd, M.M., A.M, El-Bassiony and Z.F. Fawzy. 2006. Effect of Organic Manure with or Without Chemical Fertilizers on Growth, Yield and Quality of Some Varieties of Broccoli Plants. *JApplied Sci Res.* **2**(10): 791-798.

Akter, S., S. Noor, M. Rahman, S. Sultana and S. K. Nandi. 2012. Effect of orgnaic manure and chemical fertilizer on the yield of broccoli. *Bangladesh Hort.* **24**(1&2): 59-64.

Attigah, A.S., Asiedu, E.K., Agyarko, K. and Dapaah, H.K. 2013. Growth and yield of okra (Abelmoschus esculentus L.) as affected by organic and inorganic fertilizers. ARPN: *J. Agri. Biol. Sci.* **8**(12):766-770.

Balyan, D. S., B. S. Dhankar, D. S. Ruhul and K. P. Singh. 1988. Growth and yield of cauliflower variety Snowball-16 as influenced by nitrogen, phosphorus and zinc. Haryana. *J. Hort. Sci.* **17:** 247-254.

Bankder, G. J, and A, Mukhopadhay. 1980. Response of *Polianthes tuberose* L. to high doses of mineral nutrition. *S. Indian Hort.* **33:** 214-216.

Chaterjee, B., P. Ghanti, U. Thapa and P. Tripathy. 2005. Effect of organic nutrition in sprout broccoli (*Brassica aleraceae* var. *italica*), *Vegetable Science*. **33** (1): 51-54.

Gomez, K. A. and A. A. Gomez. 1984. Statistical Procedures for Agricultural Research. John Wiley and Sons Publication. New York. Pp. 202-215.

Kandil, H. and N. Gad. 2009. Effects of inorganic and organic fertilizers on growth and production of brocoli (*Brassica oleracea* L.). Factoti si Procese Pedogenetice din Zona Temperata 8 S. noua (2009) 61-69.

Kumar, M., B.Das, K.K. Prasad, and P. Kumar. 2013. Effect of integrated nutrient management on growth and yield of broccoli (Brassica oleracea var. italica) under Jharkhand conditions. *Veg. Sci*., **40**(1): 117-120.

Mellgren, R. 2008. Effect of irrigation and nitrogen treatments on yield, quality, plant nitrogen uptake and soil nitrogen status and the evaluation of sap test, SPAD chlorophyll meter and Dualex to monitor nitrogen status in broccoli. Master thesis in the Horticultural Science Programme. Agriculture and Agri-Food Canada's L'Acadie research substation.

Mital, R.K., T. Singh., M. Bhugat and K. P. Maheshwari. 1975. Response of broccoli to nitrogen and row spacing. *Indian J. Agronomy*. **20**(3): 278-279.

Rabby, F. M., 2008. Study on growth, yield and quality of broccoli (*Brassica aleracea* var. *italica* L) under organic farming, an unpublished MS thesis, Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Salna, Gazipur -1706.

Rakesh, S., S. N. S. Chaurasia and S. N. Singh. 2006. Response of nitrogen sources and spacing on growth and yield of broccoli (*Brassica aleracea* var. *italica plenck*), *Vegetable Sci.* **33**(2): 198- 200.

Singh, R. D, S. N. Tiwari, B. B. Singh and J. N. Seth. 1976. Effect of nitrogen and potash on growth and curd yield of cauliflower variety Snowball-16. *Prog. Hort.* **7**(4): 31-34.

Swarup, V. 2012. Vegetable science and technology in India. Kalayani Publishers, New Delhi, Pp. 370-371.

Thakur, O. P., P. P. Sharma and K. K. Singh. 1991. Effect of nitrogen and phosphorus with and without boron on head yield and stalk-rot incidence in cauliflower. *Vegetable Sc.* **18:** 115-121.

Thompson, H.C. and W.C.Kelly. 1988. Vegetable crops. Fifth edition, Tata Mc Graw Hill Book Co. New York, Tornoto, London. P: 307.

Yoldas, F. and D. Esiyok. 2004. Effects of plant spacing, sowing and planting date on yield and some quality parameters of broccoli. Ege University, Turkey. **41**(2): 37-48.

Appendix 1a. Physical properties of soil of the experimental field (0-15 cm)

Physical Properties	Content
Sand(%)	21.2
Silt (%)	51.4
Clay(%)	27.4
Bulk density(g/cm^3)	1.36
Particle density(g/cm^3)	2.65
Soil porosity (%)	51.32
Textural class	Silt loam

Appendix 1b. Chemical properties of soil of the experimental field (0-15 cm)

Chemical Properties	Analytical value	Critical value	Optimum value
P^H	6.1	-	-
Organic Carbon (%)	0.82	-	-
Total N (%)	0.118	0.075	3.0
Available phosphorus (ppm)	14.185	14.0	60.0
Exchangeable Potassium (meq/100g)	0.475	0.2	1.5
Exchangeable Calcium (meq/100g)	8.5	2.0	18.0
Exchangeable Magnesium (meq/100g)	2.035	0.8	9.0
Available Sulphur (ppm)	15.23	14.0	60.0

CEC (meq/100g) =20.55

Appendix 2. Nutrient content (%) of cowdung, mustard oil cake and poultry manure

Organic manure	Nutrient content (%)		
	N	P	K
Cowdung	0.45	0.15	0.45
Mustard oil cake	4.8	1.6	1.2
Poultry manure	1.89	0.55	0.73

Appendix 3. Monthly record of temperature, relative humidity and rainfall during the period from September, 2015 to February, 2016

Year	Month	**Air temperature (^{o}C)			**Relative humidity (%)	*Rainfall (mm)
		Maximum	Minimum	Average		
2015	September	33.03	26.56	29.80	86.60	253.18
	October	32.91	23.38	28.15	85.74	22.05
	November	30.45	18.31	24.38	85.33	0.00
	December	25.96	13.93	19.95	88.61	0.00
2016	January	24.24	12.82	18.53	85.03	12.98
	February	27.14	14.92	21.03	75.96	3.89

* Monthly total

** Monthly average

Source: Weather Records of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur-1706, Bangladesh.

Appendix 4. Date of head initiation and head harvest of broccoli

Treatment	Date of head initiation			Date of head harvest		
	1st head initiation	50% head initiation	100% head initiation	1st head initiation	50% head initiation	100% head initiation
T_1	30/12/2015	07/01/2016	14/01/2016	03/02/2016	13/02/2016	18/02/2016
T_2	28/12/2015	03/01/2016	18/01/2016	03/02/2016	16/02/2016	20/02/2016
T_3	31/12/2015	07/01/2016	14/01/2016	02/02/2016	16/02/2016	22/02/2016
T_4	28/12/2015	05/01/2016	13/01/2016	01/02/2016	13/02/2016	19/02/2016
T_5	04/01/2016	08/01/2016	16/01/2016	02/02 2016	13/02/2016	20/02/2016
T_6	03/01/2016	08/01/2016	15/01/2016	09/02/2016	28/01/2016	02/03/2016
T_7	03/01/2016	08/01/2016	15/01/2016	09/02/2016	20/02/2016	28/02/2016

Appendix 5. Analysis of Costof production Input cost (Tk/ha)

Treatment Combination	Labour cost	Ploughin gCost	Seed cost	Bambooand chati	Irrigation cost	Metallicsubstance	Insecticidesand fungicides	CD	MOC cost	PM cost	Urea cost	TSP cost	MoP cost	Gypsum cost	$ZnSO_4$ cost	Boric acid cost	Total cost
T_1	45000	10000	3500	10000	9000	1000	3500	7500	0	0	3488	2100	1500	2500	296	96	99480
T_2	45000	10000	3500	10000	9000	1000	3500	0	51000	0	1744	1050	750	1250	148	48	127990
T_3	46400	10000	3500	10000	9000	1000	3500	15000	0	0	1744	1050	750	1250	148	48	103390
T_4	41600	10000	3500	10000	9000	1000	3500	0	0	7200	1744	1050	750	1250	148	48	90790
T_5	42400	10000	3500	10000	9000	1000	3500	0	102000	0	872	525	325	625	74	24	183845
T_6	56400	10000	3500	10000	9000	1000	3500	22500	0	0	872	525	325	625	74	24	118345
T_7	52400	10000	3500	10000	9000	1000	3500	0	0	14400	872	525	325	625	74	24	106245

Overhead cost (Tk/ha)

Treatment Combination	Cost of lease of land for6 months(11%of value of land Tk.200000/year)	Miscellaneous cost (Tk.5%of the input cost)	Interest on running capital for 6 months (Tk.11%of cost/year)	Total of overhead cost	Total cost of production [Input cost +Overhead cost]
T_1	11000	4974	9843	25817	125297
T_2	11000	6400	13529	30929	158919
T_3	11000	5170	10493	26663	130053
T_4	11000	4546	9217	24763	115553
T_5	11000	9192	19123	39315	223160
T_6	11000	5917	11368	28285	146630
T_7	11000	5312	10367	26679	132924

T_1 = 100% RDF @5 t/ha, T_2 = 50% RDF + MOC @ 1.5 t/ha, T_3 = 50% RDF + CD @ 10 t/ha, T_4 = 50% RDF + PM @ 6 t/ha, T_5 = 25% RDF + MOC @ 3 t/ha, T_6 = 25% RDF + CD @ 15 t/ha, T_7 = 25% RDF + PM @ 12 t/ha.