



Research Article

Enhancing Growth and Yield of Broccoli (*Brassica oleracea* var. *italica*) by Applying Cowdung and MicronutrientsMst. Ayesha Siddika¹, Most. Alataf-Un-Nahar², Afrin Sultana¹ and Md. Rezaul Karim^{1✉}¹Department of Horticulture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh²Bangladesh Institute of Research and Training on Applied Nutrition (BIRTAN), Regional Station, Netrokona

ARTICLE INFO	ABSTRACT
<p>Article history Received: 29 August 2023 Accepted: 13 December 2023 Published: 31 December 2023</p> <p>Keywords Cowdung, Boron, Zinc, Yield, Broccoli</p> <p>Correspondence Md. Rezaul Karim ✉: mrkarim1996@yahoo.com</p> <p>OPEN ACCESS</p>	<p>Similar to other crops, balanced fertilization is one of the key elements of growing broccoli with a good yield. The study was carried out at the Horticulture Farm of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh to study the impact of different levels cowdung (C) and micronutrients (M) on the growth and yield of broccoli. The two-factor experiment consisted of three levels of cowdung viz., C0 (no cowdung), C1 (cowdung @ 7 t/ha), C2 (cowdung @ 10 t/ha) and three different doses of micronutrients viz., M0 (no micronutrients), M1 (B @ 1 kg/ha + Zn @ 2 kg/ha), M2 (B @ 1.5 kg/ha + Zn @ 2.5 kg/ha). The experiment was laid out in randomized complete block design with three replications. Results revealed that significant variations recorded for most of the parameters studied due to the application of cowdung and micronutrients. At 60 DAT, the highest plant height (58.79 cm) with maximum number of leaves (19.48) was observed in C2 treatment. In case of micronutrients all these characters maximized in M2 treatment and minimized in M0 treatment. At 60 DAT, plant height (61.90 cm) and number of leaves per plant (20.55) were recorded highest in the combination of C2M2 and lowest in C0M0 treatment combination. The highest yield (10.99 t/ha) was found when cowdung applied @ 10 t/ha and the lowest yield (7.44 t/ha) was found from the control treatment. Micronutrients (B and Zn) had also significant influence on yield. The highest yield (10.32 t/ha) was found from the application of micronutrients (1.5kg B/ha + 2.5 kg Zn/ha) and the lowest yield (8.21 t/ha) was found from the control treatment. The combined effects of cowdung and micronutrients were statistically significant. The combination of cowdung 10 t/ha and micronutrients (B @1.5 kg/ha + Zn @ 2.5 kg/ha) gave the highest yield (12.20 t/ha) and the lowest yield (7.00t/ha) was received from no cowdung and no micronutrients. The results of the experiment recommended that cowdung 10 t/ha and micronutrients (B @1.5 kg/ha + Zn @ 2.5 kg/ha) could be recommended for increasing broccoli yield.</p>
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Introduction

Broccoli (*Brassica oleracea* L. var. *italica*) belongs to the Brassicaceae family and is famous as a cole crop (Sardar et al., 2022). Broccoli is an edible green plant in the cabbage family whose large flowering head and stalk is eaten as a vegetable (Mishra et al., 2020). It is considered as a high value vegetable due to its relative importance to human health and economic values for farmers involved in its production (Jibrin and Anton, 2019). It has anti carcinogenic properties and has been found useful for number of other diseases (Singh et al., 2017). Broccoli is a rich source of many vitamins, antioxidants, and minerals important to reduce the chances of cancer problems (Thamburaj and Singh, 2003; Goncalves et al., 2011).

Nutritional value, quality and yield of any crop are affected by many factors such as genotype (species, cultivar), soil fertility, soil structure and environmental conditions (Cartea et al., 2008). Like other crops, plant nutrition is one of the key principles for getting high yield of broccoli. Currently, soil organic matter depletion and crop yield reduction are alarming issues to the farmers (Kayesh et al., 2019). Undoubtedly, for optimum plant growth and production, the essential nutrients must be readily available in sufficient amounts and balanced proportion in soil. Nutrients may be applied through two sources: organic and inorganic. 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 (Chatterjee et al., 2005, Kumar et al., 2013; Attigah et al., 2013; Nahar

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et al., 2015; Tasmim et al., 2023). Organic fertilizers are better for the environment since they have higher cation exchange capacity, a lower bulk density, higher water holding capacity, and more nutrients. It also improves microflora activities (Basak et al., 2022). Cowdung is available in the country, which is a good source of different nutrients. Its use also improves the organic matter status of the soil. Besides organic fertilizer, inorganic fertilizer also boosts plants' vegetative growth, yield, and quality. It is well known that plants need various inorganic nutrients in addition to carbon dioxide (CO₂) and water for their growth and production (Rahman et al., 2021).

In addition, micronutrients are essential elements for normal plant growth, development and productivity of plants as they play important roles in the meristematic development, chlorophyll formation, photosynthesis and transpiration as well as tannin and phenolic compound development (Tripathi et al., 2015). However, suitable and balance combination of macro and micro nutrients are not only essential for plant growth and production, but also good for environment (Singh et al., 2015). Therefore, sufficient application of mineral nutrition especially Zn and B are imperative to increase crop productivity (RiveraMartin et al., 2020; Sardar et al., 2021; Sultana et al., 2023). Moreover, Zn is involved in the regulation of plant hormones especially indole acetic acid which improves plant growth. The production of reactive oxygen species (ROS) is controlled by applying Zn. This micronutrient could protect the membrane from oxidative damage under abiotic stresses (Fatemi et al., 2020). Boron also plays very important role in physiological and biochemical processes, because it is one of the most important plant micronutrient (Ain et al., 2021). Different physiological disorders i.e. hollow stem, sword leaves, browning of heads, and hollow stems occur due to boron deficient conditions (Ali et al., 2019).

Micronutrients are to be necessarily taken up by the plants from soil or supplemented through foliar application improves vegetative growth and yield of crop (Sidhu et al., 2019). Foliar applications of nutrients like molybdenum, zinc, copper and boron are advantageous compare to soil application, as it furnishes rapid availability of nutrients, enhances immediate uptake of applied nutrients, rule out problem of soil fixation, supplement when immediate response needed and last but not the least, provide nutrients that may not be readily available for root uptake (Singh et al., 2018). Foliar application can be considered as one of the easier and effective methods, to deliver the needed nutrients to plants in adequate concentrations and improve plant nutritional status as

well as increase the crop yield and its quality (Smolen, 2012).

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). There is a good scope of broccoli cultivation in Bangladesh for increasing vegetable diversification and to meet vegetable demand of the country's people. Broccoli production is still limited because of poor management of nutrient applications. The nutritional stress is increasing with the passage of time because of low soil fertility and numerous stresses occur in the root zone of plants which reduce the uptake of minerals (Sardar et al., 2022). Therefore, the present study was designed to evaluate the impact of cowdung and micronutrients application on growth and yield of broccoli.

Materials and Methods

Soil and climate of the experimental site

The research was conducted at the Horticulture Farm of the Department of Horticulture Bangladesh Agricultural University (BAU), Mymensingh. The experimental field belongs to the Old Brahmaputra Floodplain beneath the AEZ 9 having non-calcareous dark gray floodplain soil. The texture of the soil of the research plot was silty-loam with a pH of 5.5-6.8. The microclimate of the experimental area is sub-tropical in nature and the seasonal condition comprising of moderate temperature and a scanty rainfall and plenty of sunshine prevailing during rabi season (October to March).

Planting materials and treatments of the experiment

The variety of broccoli used in this experiment was Tasaki. It is a Hybrid variety which was produced by Sakata Seed Corporation, Japan. The seeds of the variety were purchased from Bangladesh Krishi Beej Bitan, Shere-Bangla Road; Agargaon; Dhaka. There were two factors with three replications in this experiment such as Factor A: three levels of cowdung C0: control (No cowdung), C1: Cowdung @ 7 t/ha, C2: Cowdung @ 10 t/ha and Factor B: three levels of micronutrients M0: control (No Micronutrients), M1: B @ 1 kg/ha + Zn @ 2 kg/ha and M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha.

Design and layout of the experiment

The two-factor experiment was laid out in the randomized complete block design (RCBD) with three replications. Total number of treatment combinations in this trial was 9. The total number of plots was 27 and each replication was consisted of 9-unit plots. The size of each unit plot was 3 m x 1.8 m and total area of the experimental plot was 145.8 m².

Land preparation and raising of seedlings

The land was ploughed by power tiller followed by laddering to attain a good tilth. The weeds, stubbles and crop residues were dispelled. Trimming of the corners and levies was done by spade and using wooden hammer all the large clods were broken into small pieces. Organic and inorganic fertilizer was applied to the field following the treatments of the experiment. Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were applied at the rate of 260.87, 100 and 133.33 kg/ha, respectively as the source of nitrogen, phosphorus and potassium (Ahmed et al., 2018). Well decomposed cowdung and TSP were incorporated into the soil during final land preparation. Urea and MoP were applied in three equal installments at 15, 30 and 45 DAT.

The seedlings were raised at the Horticulture Farm, BAU, Mymensingh, under special care in two seedbeds of 3 m x 1 m in size. Ten grams (10 g) of seeds were sown in each seedbed. After sowing, the seeds were covered with finished light soil. At the end of germination, shading was provided by polythene tunnel to protect the young seedlings from scorching sunshine and heavy rainfall. Light watering, weeding and mulching were done when necessary to provide seedlings with good or ideal conditions for better growth.

Transplanting

Healthy and uniform sized 25 days old seedlings were transplanted maintaining 60 cm line to line distance and 50 cm plant to plant distance. Transplanting was done in the afternoon and after that, the seedlings were watered immediately. The young transplants were shaded by banana leaf sheath during daytime to protect them from scorching sunshine up to 3 days. A number of seedlings were also planted in the border of the experimental plots for gap filling.

Harvesting

Harvesting of the broccoli was not possible on a certain or particular date because curd initiation as well as curd maturation period in different plants were not uniform. Only the compact mature curds were harvested with 2-4 cm stalk by using a sharp knife. After harvesting the main curd, secondary shoots were developed from the leaf axils, which also developed into small secondary curds and were harvested over a period of time. The crop under investigation was harvested for the first time around 60 days after transplanting and the last harvesting was done around 75 days later when the experiment was over.

Parameters measured

Six plants were randomly selected from the middle rows of each unit plot for avoiding border effect, except

yields of curds, which was recorded plot wise. Data on height of the plant and crown spread of the plant were collected at 30, 45 and 60 days after transplanting (DAT). All other parameters were recorded during maximum vegetative stage, harvest and after harvest. Data on several parameters such as plant height (cm), number of leaves per plant, length of largest leaf (cm), crown spread of plant (cm), length and diameter of stem (cm), length of root (cm), days required for initiation of curd, diameter of central curd (cm), weight of central curd (g), fresh weight of leaves per plant (g), dry weight of leaves per plant (g), fresh weight of root per plant (g), yield per plant (g), yield per plot (kg), yield per hectare (t) were recorded during experimental period.

Statistical analysis

For statistical evaluation of data on various parameters, Statistix 10 software was used. All the collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the significance of difference between pairs of means was evaluated by the least significance difference (LSD) test at 1% and 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

Plant height

The use of different levels of cowdung influenced plant height significantly. Plant height was recorded at 30, 45, and 60 days after transplanting (DAT). At 60 days after transplanting, the highest plant height (58.79 cm) was observed in the C3 treatment while it was lowest (54.23 cm) in the C1 treatment (Fig. 1). Main effect of micronutrients on the height of broccoli was also statistically significant. The tallest broccoli plant (58.00 cm) at 60 DAT was found in the M2 treatment (Fig. 2). In case of M0, the recorded plant height (53.21 cm) was minimal. The combined effect of different levels of cowdung and different doses of micronutrients on plant height was found statistically significant at 30, 45, and 60 DAT. For the interaction effect of various levels of cowdung and micronutrients, the maximum plant height (61.90 cm) was obtained from the treatment combination of C2M2 and the minimum (53.21 cm) from the combination of C0M0 (no cowdung and no micronutrient) (Table 1). The finding is consistent with the report of Basak et al., (2022) where organic and inorganic integrated fertilization gave significantly higher plant height. The increase in growth attributes with highest level of cowdung and micronutrients may be due to better uptake and assimilation of essential elements. Mallick and Muthukrishnan, (1979) explained that, the presence of zinc activates the synthesis of tryptophan which is the precursor of IAA and responsible for stimulation of plant growth.

Table 1. Combined effect of cowdung and micronutrients on plant height and number of leaves/plant at different days after transplanting (DAT) of broccoli

Treatment combination	Plant height (cm) at DAT			Number of leaves/plant at DAT		
	30	45	60	30	45	60
COM0	28.21	45.21	53.21	7.30	10.50	15.50
C1M1	29.35	46.23	54.19	7.99	10.99	16.21
C1M2	30.95	47.29	55.30	8.20	11.23	17.22
C1M0	30.21	45.99	53.20	8.55	12.21	18.99
C1M1	32.23	48.22	55.99	8.69	12.69	18.95
C1M2	24.50	49.30	56.80	8.99	12.71	19.17
C2M0	34.10	45.21	54.13	8.20	12.20	18.20
C2M1	35.20	51.23	60.33	8.95	12.99	19.70
C2M2	36.21	52.55	61.90	9.12	13.22	20.55
LSD _{0.05}	0.41	0.43	0.69	0.19	0.23	0.71
LSD _{0.01}	0.57	0.59	0.95	0.27	0.32	0.98
Level of significance	**	**	**	**	*	**

** = Significant at 1% level of probability * = Significant at 5% level of probability. Here, C0: No cowdung (control), C1: Cowdung: 7 t/ha, C2: Cowdung @ 10 t/ha and M0: No Micronutrients (control), M1: B @ 1 kg/ha + Zn @ 2 kg/ha, M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha

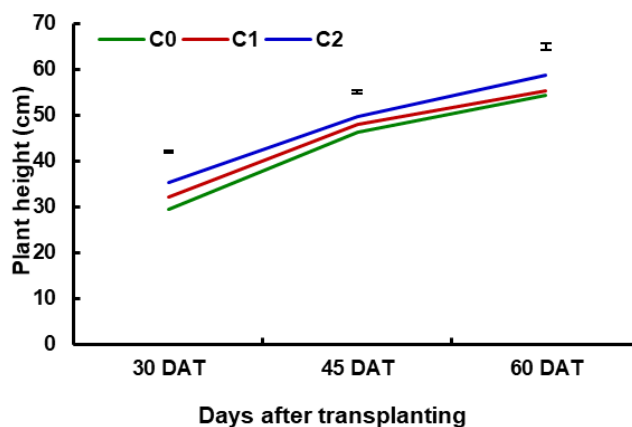


Fig. 1. Main effect of cowdung on plant height. Vertical bars indicate the LSD at 1% level of significance. C0: No cowdung (control), C1: Cowdung @ 7 t/ha, C2: Cowdung @ 10 t/ha

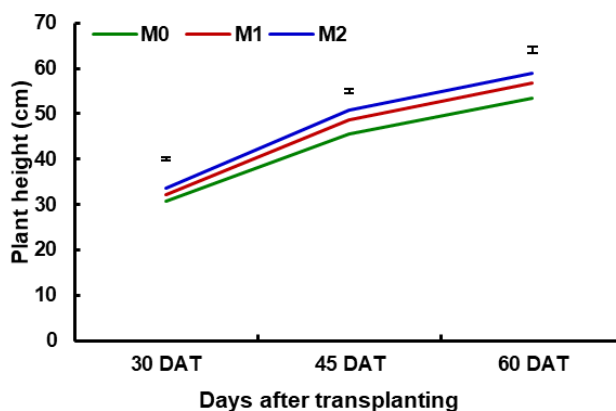


Fig. 2. Main effect of micronutrients on plant height of broccoli (cm). Vertical bars indicate the LSD at 1% level of significance. Here, M0: No Micronutrients (control), M1: B @ 1 kg/ha + Zn @ 2 kg/ha, M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha

Number of leaves per plant

The number of leaves per plant responded significantly due to the main effect of various levels of cowdung. Maximum number of leaves per plant (19.48) was recorded in C2 and it was minimum (16.31) in C0 treatment at 60 DAT (Fig. 3). Plants receiving M2 treatment acted with producing the highest number of leaves (18.98) while the lowest (17.56) was recorded in control treatment M0 (Fig. 4). Impact of cowdung and micronutrient was statistically significant. The result indicated that the C2M2 treatment combination at 60 DAT had the largest number of leaves (20.55) followed by C2M1 (19.17) and the C0M0 combination responded with the lowest number of leaves (15.50) preceded by C0M1 (16.21) (Table 1). The results coincide with the results of Narayanamma et al., (2007), who reported that the number of leaves in broccoli was increased by foliar application of zinc and boron. The same results were presented by (Mahmud et al., 2007; Moniruzzaman et al., 2008; Islam et al., 2010) on broccoli growth as affected by zinc and boron concentrations. Zinc is one of the elements that work on the transfer of active substances in the plant such as sugars from the manufacturing areas to the areas of consumption sinks which work to elongate cells. It is also included in the formation of the amino acid tryptophan which acts on the formation of the IAA hormone and also works to stimulate the enzyme carbonic anhydrase and cytochrome and thus elongate cells and increased leaf area as a result of increasing the number of leaves per plant (Hassan et al., 1990).

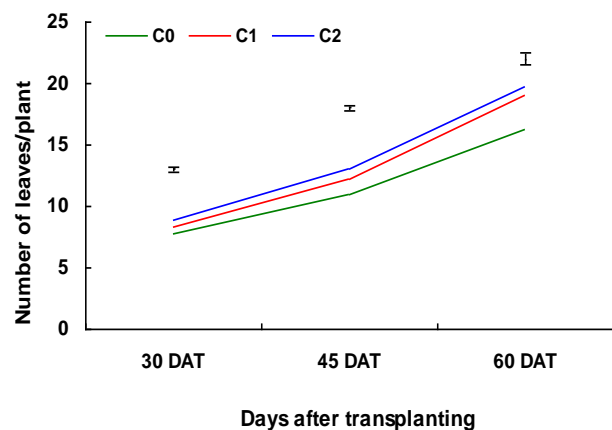


Fig. 3. Main effect of cowdung on number of leaves per plant. Vertical bars indicate the LSD at 1% level of significance. Here, C0: No cowdung (control), C1: Cowdung @ 7 t/ha, C2: Cowdung @ 10 t/ha

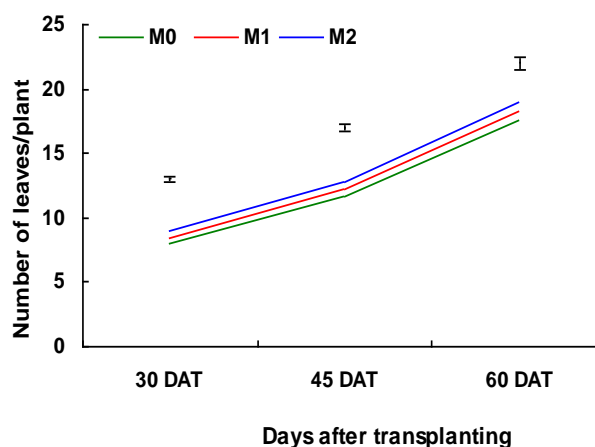


Fig. 4. Main effect of micronutrients on number of leaves per plant. Vertical bars indicate the LSD at 5% level of significance. Here, M0: No Micronutrients (control), M1: B @ 1 kg/ha + Zn @ 2 kg/ha, M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha

Crown spread of plant

The widest crown spread (59.87 cm) was achieved in the C2 treatment followed by the C1 treatment (58.51 cm) at 60 DAT (Table 2). In contrast, the smallest (54.77 cm) was observed in C0. The crown spread of plants responded significantly to micronutrients. The result indicated that the M2 treatment gave the largest crown spread (59.04 cm) whereas the M0 treatment showed the smallest crown spread (56.87 cm) of plant (Table 3). Cowdung and micronutrients had a significant interaction effect on the number of leaves per plant at 30, 45, and 60 DAT. At 60 DAT, the widest crown spread (61.30 cm) was measured in the C2M2 combination whereas C0M0 showed the lowest crown spread (53.60 cm) (Table 4). A study conducted by Basak et al., (2022) found that the widest plant canopy (58.23 cm) was achieved with the F4 (F2 50% + F3 50%) treatment with organic and inorganic fertilizer administration. The enhancement of crown spread may be due to the dual effect of cowdung and micronutrients which are essential for plant growth and have a well-known effect on physiological activities.

Table 2. Main effects of cowdung on some growth traits of broccoli at different days after transplanting (DAT)

Cowdung	Crown spread of plant (cm) at DAT			Length of the largest leaf (cm) at DAT			Length of stem (cm)
	30	45	60	30	45	60	
C0	28.87	45.14	54.77	54.77	26.63	38.24	18.19
C1	33.91	48.24	58.51	58.51	29.70	42.87	24.69
C2	35.26	50.17	59.87	59.87	31.83	45.80	26.55
LSD _{0.05}	0.51	0.77	0.59	0.67	0.51	0.18	0.67
LSD _{0.01}	0.71	1.06	0.97	0.93	0.71	0.24	0.92
Level of significance	**	**	**	**	**	**	**

** = Significant at 1% level of probability; Here, C0: No cowdung (control), C1: Cowdung @ 7 t/ha, C2: Cowdung @ 10 t/ha

Length of the largest leaf

The length of the largest leaf was measured at 30, 45, and 60 DAT. It increased gradually up to 60 DAT. At 60 DAT, plants receiving C2 treatment produced the longest leaf (51.45 cm) and C0 treatment generated the shortest leaf (44.23 cm) (Table 2). In the M2 treatment, the longest leaf length (49.71 cm) was determined at 60 DAT followed by M1 (48.26 cm) (Table 3). The shortest leaf length (46.20 cm) was measured in the M0 treatment. The combination of C2 with M2 treatment was measured to have the longest leaf (53.95 cm) at 60

DAT whereas the COM0 treatment combination was observed with the shortest leaf length (43.20 cm) preceded by COM1 (Table 4). The present findings are almost similar to the results as replied by Basak et al., (2022). They found that at 60 DAT at the maximum vegetative stage, the treatment combination of organic and inorganic fertilizer generated the longest leaf (52.51 cm). This increased leaf length and width may be due to involvement of zinc, boron in cell division and meristematic growth of the tissue (Singh et al., 2018).

Table 3. Main effects of micronutrients on some growth traits of broccoli

Micronutrients	Crown spread of plant at DAT			Length of the largest leaf (cm) at DAT			Length of stem (cm)
	30	45	60	30	45	60	
M0	31.34	45.59	56.87	27.90	40.80	46.20	21.99
M1	32.88	48.47	57.23	29.86	42.51	48.26	23.36
M2	33.83	49.50	59.04	30.40	43.60	49.71	24.07
LSD _{0.05}	0.51	0.77	0.67	0.51	0.18	0.67	0.43
LSD _{0.01}	0.71	1.06	0.92	0.71	0.24	0.92	0.59
Level of significance	**	**	**	**	**	**	**

** = Significant at 1% level of probability; M0: No Micronutrients (control), M1: Micronutrients B @ 1 kg/ha + Zn @ 2 kg/ha, M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha

Length of stem

Significant variation was observed among different levels of cowdung in respect of stem length. The longest stem (26.55 cm) was measured on the C2 treatment whereas on the C0 treatment, the shortest stem (18.19 cm) was measured (Table 2). Stem length also differed significantly due to micronutrients. The longest stem (24.07 cm) was acquired in plants that were treated with M2 treatments followed by M1 (23.36 cm) (Table 3). The length of the stem was determined largest (27.88 cm) in the M2C2 treatment and smallest in the COM0 (16.48 cm) treatment (Table 4). Most of the similar findings have also been obtained from Mishra et al., (2020) as they replied that use of different organic formulation enhanced the length of broccoli stem. Cowdung coupled with micronutrients might be helpful to increase length of stem by ensuring better nutrient utilization by plants. Quick decomposition of organic

substances results more supply of N, P, K and micro nutrients to the crop that enhanced plant growth.

Diameter of stem

It was noted that the application of cowdung at different levels was significant on the diameter of the stem. C2 treatment showed superior performance in case of stem diameter which gave the highest values in this trait (4.10 cm) (Table 5). The lowest diameter of the stem (3.44 cm) was achieved in the C0 treatment. The M2 treatment produced the stem of the highest diameter (4.01 cm) (Table 6). The diameter of the stem was the smallest in the M0 treatment (3.54 cm). In the C2M2 treatment combination, the highest diameter of the stem (4.50 cm) was recorded followed by C2M1 (4.11 cm) (Table 7). The above results are also corroborated with the findings of Khomami et al., (2004). The increment of stem diameter may be due to the positive influence of cowdung and micronutrients.

Table 4. Combined effect of cowdung and micronutrients on some growth traits of broccoli at different days after transplanting (DAT)

Treatment combination	Crown spread of the plant (cm) at DAT			Length of the largest leaf (cm) at DAT			Length of stem (cm)
	30	45	60	30	45	60	
COM0	27.30	44.22	53.60	24.59	37.20	43.20	16.48
C1M1	28.12	45.21	54.20	27.30	38.21	44.29	18.95
C1M2	31.20	45.99	56.50	27.99	39.30	45.20	19.13
C1M0	33.21	46.22	58.90	28.90	41.20	47.21	24.50
C1M1	35.22	48.21	57.30	29.99	43.11	48.30	24.36
C1M2	33.29	50.30	59.33	30.22	44.30	49.99	25.20
C2M0	33.50	46.33	58.11	30.20	43.99	48.20	24.99
C2M1	35.29	51.99	60.20	32.30	46.22	52.20	26.78
C2M2	36.99	52.20	61.30	32.99	47.20	53.95	27.88
LSD _{0.05}	0.89	1.33	1.17	0.89	0.31	1.16	0.75
LSD _{0.01}	1.22	1.83	1.61	1.23	0.42	1.60	1.04
Level of significance	**	**	**	*	**	**	**

** = Significant at 1% level of probability * = Significant at 5% level of probability. Here, C0: No cowdung (control), C1: Cowdung: 7 t/ha, C2: Cowdung @ 10 t/ha and M0: No Micronutrients (control), M1: B @ 1 kg/ha + Zn @ 2 kg/ha, M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha

Table 5. Main effects of cowdung on some other growth traits and yield of broccoli

Cowdung	Diameter of stem(cm)	Length of roots(cm)	Days required to curd initiation	Diameter of central curd(cm)	Wt. of central curd(g)	Yield per plant (g)	Yield/plot (kg)	Yield (t/ha)
C0	3.44	19.63	71.21	12.74	178.81	237.04	4.71	7.44
C1	3.79	22.94	67.41	16.11	290.59	338.37	6.11	9.64
C2	4.10	24.89	59.88	18.05	484.85	443.08	6.71	10.99
LSD _{0.05}	0.09	0.42	0.45	0.24	5.81	5.59	0.21	0.33
LSD _{0.01}	0.13	0.57	0.62	0.34	7.99	7.72	0.29	0.46
Level of significance	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability; Here, C0: No cowdung (control), C1: Cowdung @ 7 t/ha, C2: Cowdung @ 10 t/ha

Table 6. Main effects of micronutrients some other growth traits and yield of broccoli

Micronutrients	Diameter of stem(cm)	Length of roots(cm)	Days required to curd initiation	Diameter of central curd(cm)	Wt. of central curd (g)	Yield per plant (g)	Yield/plot (kg)	Yield (t/ha)
M0	3.54	20.82	68.19	14.71	293.70	281.82	4.86	8.21
M1	3.79	22.64	66.07	15.91	333.55	349.96	6.01	9.54
M2	4.01	24.01	64.25	16.29	327	386.70	6.65	10.32
LSD _{0.05}	0.09	0.42	0.45	0.24	5.81	5.59	0.21	0.33
LSD _{0.01}	0.13	0.57	0.62	0.34	7.99	7.715	0.29	0.46
Level of significance	**	**	**	**	**	**	**	**

** = Significant at 1% level of probability; M0: No Micronutrients (control), M1: Micronutrients B @ 1 kg/ha + Zn @ 2 kg/ha, M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha

** = Significant at 1% level of probability * = Significant at 5% level of probability. Here, C0: No cowdung (control), C1: Cowdung: 7 t/ha, C2: Cowdung @ 10 t/ha and M0: No Micronutrients (control), M1: B @ 1 kg/ha + Zn @ 2 kg/ha, M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha

Length of root

A significant result in the length of root was noticed with different doses of cowdung. Root length (24.89 cm) markedly increased in the C2 treatment but declined (19.63 cm) in the C0 treatment (Table 5). The M2 treatment attained maximum root length (24.01 cm) which was in contrast to the minimum root length (20.81 cm) producing the M0 treatment (Table 6). The combined effect of cowdung and micronutrients was significant in this respect. The highest root length (26.92 cm) was found in the treatment combination of C2M2

and the lowest (19.28 cm) was noticed in the treatment combination of COM0 (Table 7). A similar result was in agreement with the finding of Kumar, (2009) and Sharma, (2012) in broccoli for a positive influence of zinc sulphate on root length. Boron is associated with the cell wall development and with the process of cell differentiation, helping in the root and shoots growth of the plant (Kumar and Sen, 2004). Organic material offers good environment condition for roots systems development of broccoli plants (Indriyati and Nugroho, 2022).

Days required to curd initiation

The application of different levels of cowdung markedly influenced the time needed for curd initiation in broccoli. The maximum time (71.21 DAT) to curd initiation was recorded in the C0 treatment and the minimum (59.88 days) to curd initiation was recorded in the C2 treatment (Table 5). The application of micronutrients had significant effects on the days required for visible curd initiation of broccoli. The maximum time (68.19 days) to curd initiation was recorded in the M0 treatment and the minimum days (64.25 DAT) to curd initiation was recorded in the M2 treatment (Table 6). The combined effect of cowdung and micronutrients on time required for visible curd initiation of broccoli was found to be statistically significant. The longest time (72.33 DAT) was required in the treatment combination of COM0. On the other hand, the lowest time (57.30 DAT) needed for curd initiation was in the C2M2 treatment combination (Table 7). Sani et al., (2018) conducted an experiment with cauliflower and observed that the curd initiation period required in plants decreased with the increasing levels of micronutrient application. This might be due to the positive role played by the regulating micronutrients in the balanced absorption of nutrients might improve physiological activities.

Diameter of central curd

The main effect of different doses of cowdung on the diameter of the central curd was statistically significant. It was recorded as the highest (18.05 cm) in the C2 treatment followed by C1 (16.11 cm) and C0 (12.74 cm) treatment (Table 5). In the M2 treatment maximum diameter of the central curd (16.29 cm) was attained whereas it was minimum (14.71 cm) in the M0 treatment (Table 6). The combination of C2 with M2 generated the highest diameter of the central curd (19.20 cm) while the combination of COM0 produced the least diameter of the central curd (12.67 cm) (Table 7). The findings were also attained by Indriyati and Nugroho, (2022) and revealed that the application of organic materials significantly increased the diameter of broccoli head compared with untreated soil. According to Sani et al., (2018), the formation of bigger curd with the application of higher levels of micronutrients might be done to higher synthesis of carbohydrate and their translocation to the curd, which subsequently helped in the formation of higher curd of cauliflower.

Weight of Central Curd

Table 7. Combined effect of cowdung and micronutrients on some other growth traits and yield of broccoli

Treatment combination	Diameter of stem (cm)	Length of roots (cm)	Days required to curd initiation	Diameter of primary curd (cm)	Wt. of central curd (g)	Yield per plant (g)	Yield/plot (kg)
COM0	3.31	19.28	72.33	12.67	155.22	214.44	4.12
C1M1	3.47	19.44	71.20	12.78	183.33	224.89	4.43
C1M2	3.53	20.18	70.11	12.78	197.89	271.78	5.59
C1M0	3.61	20.80	69.56	14.67	282.44	290.90	5.05
C1M1	3.78	23.11	67.33	16.78	316.78	351	6.50
C1M2	3.99	24.92	65.33	16.88	272.56	373.22	6.77
C2M0	3.70	22.37	62.67	16.78	443.44	340.12	5.41

There was a considerable difference in the weight of the central curd due to the application of different levels of cowdung. The highest weight of central curd (484.85 g) was observed in the C2 treatment and the lowest (178.81 g) was found in the C0 treatment (Table 5). The main effect of micronutrients was also statistically significant in terms of central curd weight. The lowest central curd weight was measured in the COM0 treatment followed by COM1 whereas the highest central curd was measured in the C2M2 treatment combination (Table 7). Similar results have been reported by (Kotur, 1998; Singh, 2003; Prasad and Yadav, 2003). The enhancement of central curd weight might be associated with the addition of cowdung and balanced proportion of micronutrients which subsequently helped in improving physiological activities.

Yield per plant

The effect of different levels of cowdung on the yield of broccoli per plant was found to be statistically significant. The highest yield per plant (443.08 g) was recorded from the C2 treatment and the lowest (237.00 g) was obtained from the control treatment C0 (Table 5). The application of micronutrients also showed a highly significant influence on yield per plant. The treatment of M2 generated a maximum yield per plant (386.70 g) while the lower yield per plant (281.82 g) was recorded from the control treatment (Table 6). Maximum yield per plant (515.11 g) was achieved from the C2M2 combination and the minimum (214.44 g) from the COM0 treatment (Table 7). These findings are in coordination with the reports of Mal et al., (2014) where vermicompost was used as organic fertilizer and its application produced 38% greater central head weight and 43% higher total head yield over the control. The increased plant growth and yield of head of broccoli resulted from organic materials application may be attributed to presence more available form of nutrient for plants. It also enhanced other plant nutrients, such as micronutrient, and water holding capacity of soil (Indriyati and Nugroho, 2022). Present result also confirmed findings of Sani et al., (2018) who found maximum yield with the combined foliar application of boron and molybdenum in cauliflower. Increase in yield might be due to the combined application of boron and molybdenum at optimum levels under deficient condition increased uptake of major nutrients which resulted in sturdy plant growth and increased yield and quality.

C2M1	4.11	25.37	59.67	18.18	500.55	474	7.11
C2M2	4.50	26.92	57.30	19.20	510.55	515.11	7.60
LSD _{0.05}	0.16	0.72	0.78	0.43	10.06	9.69	0.37
LSD _{0.01}	0.23	0.99	1.08	0.59	13.86	13.36	0.51
Level of significance	**	**	**	**	**	**	**

Yield per plot and per hectare

A considerable difference in yield per plot and per ha was observed due to main effect of different levels of cowdung and micronutrients. The highest root yield per plot was recorded in the C2 treatment. Similarly, it was minimal in the C0 treatment combination (Table 5). The application of micronutrients also showed a highly significant influence on the yield per plot and per hectare. The yield per plot was increased with the increasing levels of micronutrients. The highest yield per plot (6.65 kg/ha) and ha (10.32 t) was obtained from M2 (1.5 kg B/ha+2.5 kg Z/ha) treatment while the lowest yield per plot (4.86 kg/ha) (Table 6) and (8.21 t) per hectare was recorded from the control treatment (Fig. 5). The combined effect of cowdung and

micronutrients on yield per plot and per hectare of broccoli was found to be statistically significant. The maximum yield per plot (7.60 kg/ha) and (12.20 t) per hectare was found in the treatment combination of C2M2 while the minimum yield (4.12 kg/ha) and (7.00 t) per hectare was observed from the treatment combination of C0M0 (control cowdung and no micronutrients) (Fig. 7). Indriyati and Nugroho, (2022) revealed that the yield of broccoli head tended to be higher in organic combination. Presence of cowdung and micronutrients may be the possible reason for enhancing plant growth by accelerating metabolic activities, carbohydrate synthesis and ultimately responsible for higher yield.

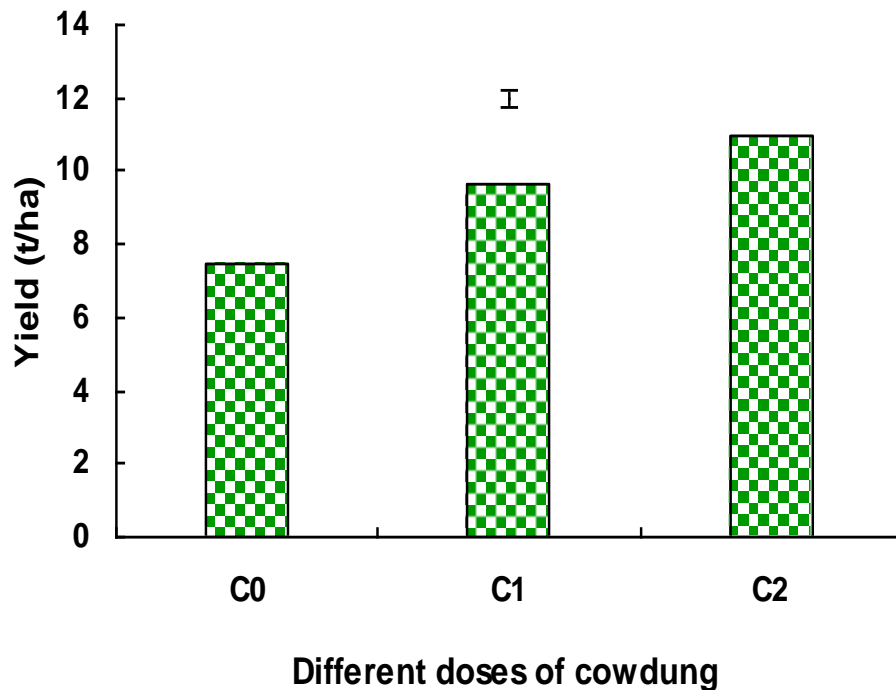


Fig. 5. Main effect of cowdung on yield. Vertical bar indicates the LSD at 1% level of significance. Here, C0: No cowdung (control), C1: Cowdung @ 7 t/ha, C2: Cowdung @ 10 t/ha

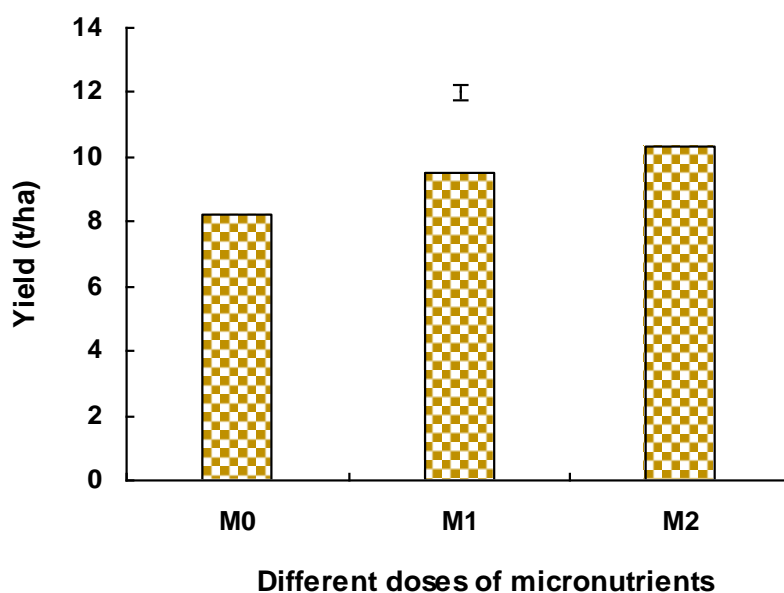


Fig. 6. Main effect of micronutrients on yield. Vertical bar indicates the LSD at 1% level of significance. Here, M0: No micronutrients (control), M1: B @ 1 kg/ha + Zn @ 2 kg/ha, M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha

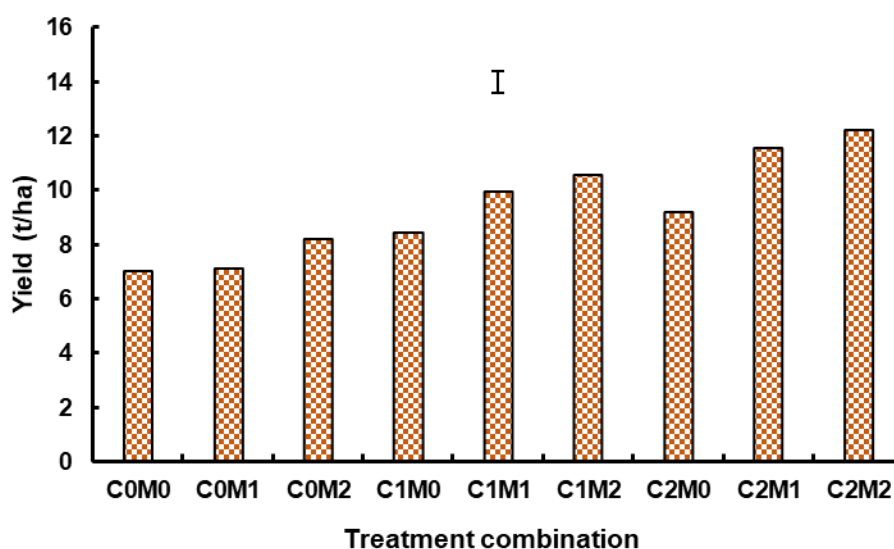


Fig. 7. Combined effect of cowdung and micronutrients on yield. Vertical bar indicates the LSD at 1% level of significance. Here, C0: No cowdung (control), C1: Cowdung @ 7 t/ha, C2: Cowdung @ 10 t/ha; M0: No micronutrients (control), M1: B @ 1 kg/ha + Zn @ 2 kg/ha, M2: B @ 1.5 kg/ha + Zn @ 2.5 kg/ha

Conclusion

According to the findings of this experiment, broccoli responded positively to the application of cowdung, micronutrients, and their combination in terms of growth and yield. In this experiment, the highest yield 12.20 t/ha was found from the treatment combination of cowdung 10 t/ha and micronutrients (1.5 kg/ha B and 2.5 kg/ha Zn). On the other hand, the lowest yield 7.00 t/ha was found from the control treatment combination of no cowdung with no micronutrients. The study concluded that a judicious integration strategy of using

cowdung and micronutrients is necessary for sustainable production of sprouting broccoli in Bangladesh

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