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RESEARCH ARTICLE

IMPROVING GROWTH AND YIELD PERFORMANCE OF CAULIFLOWER THROUGH FOLIAR APPLICATION OF MORINGA LEAF EXTRACT AS A BIO-STIMULANT

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ABSTRACT

Plant bio-stimulants play a significant role in triggering growth and boosting economic yield of crops. Even so, little information is found on the use of moringa leaf extract (MLE) as a natural bio-stimulant to improve growth and yield of vegetable crops in Bangladesh. Therefore, a field study was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh, during rabi season in order to investigate the effect of MLE on growth and yield of cauliflower. The experiment was laid out in a randomized complete block design with four treatments and three replications. The treatments were T_1 (control) and T_2 (MLE sprayed at 2 weeks after transplanting only), T_3 (MLE sprayed at 2 weeks and 4 weeks after transplanting), T_4 (MLE sprayed at 2 weeks after transplanting and after every two weeks thereafter). The rate of MLE application was 25 mL plant^{-1}. All the treatments received recommended dose of N, P, K, S, Zn and B fertilizers. Application of MLE significantly improved the growth and yield attributes as well as gross yield and marketable yield of cauliflower. Among the parameters plant height (34.10 cm), length of the largest leaf (29.50 cm in length), fresh weight of root (9.50 g), fresh weight of stem (19.13 g), curd thickness (5.37 cm), curd diameter (16.03 cm), curd weight (0.48 kg), total weight of plant (0.76 kg), gross yield (12.81 t ha^{-1}) and marketable yield (5.52 t ha^{-1}) were the highest in T_4 where MLE was sprayed at 2 weeks after transplanting and after every two weeks thereafter. The lowest values of all these parameters were found in T_1 where no MLE was sprayed. This study suggests that MLE should be applied in cauliflower crop as a foliar spray at growth stages for obtaining higher growth and yield.

KEYWORDS

Growth, Yield, Cauliflower, Foliar application, Moringa leaf extract

1. INTRODUCTION

Bangladesh is one of the densely populated countries in the world whose population is increasing day by day but most of the people of the country suffer from malnutrition. Vegetables are rich in minerals, vitamins and phytochemicals. According to the FAO recommendation, the amount of consumption of vegetables should be at least 200 g/day/person but the average intake of vegetables by the people of Bangladesh is far below the standard [1]. Cole crops are very popular, inexpensive and economically important vegetables in our country. By increasing the production of these vegetable crops, we can ensure nutritional demand of the country and contribute in national economy. Cauliflower (*Brassica oleracea var. botrytis L.)* belongs to Brassicaceae family that is introduced from cooler regions, but now-a-days, many of the tropical type varieties are well-adapted producing good curds as well as seeds under our climatic conditions. In Bangladesh, cauliflower occupied 47749 acres of land with the total production of 268484 metric tons in [2]. However, the production of cauliflower is quite low and hence need to be enhanced by adopting new technology.

Moringa (*Moringa oleifera*) is an economically valuable species which is found wild and cultivated in many countries of the world. In our country, it is a homestead multipurpose tree grown sporadically through the roadside of the northwestern region and popular for use as vegetables. Many researchers have indicated that moringa is a highly valued plant with multipurpose effects [3-7]. The leaves of moringa contain significant amount of phytohormones namely zeatin (cytokinin) and gibberellic acid in addition to other growth-enhancing compounds such as ascorbates, phenolics, and minerals [8]. Due to the cumulative effects of hormones, proteins, minerals, vitamins, essential amino acids, glucosinolates, isothiocyanates and phenolics in Moringa leaf Extract (MLE), it has become a novel, natural bio-stimulant whose application to crop can enrich nutritional status, improve plant antioxidant system and boost the growth and yield of crop. Now-a-days, a number of research works have been conducted by many scientists to unravel the role of MLE on the growth and yield enhancement of vegetable and pulse crops under normal as well as stress situations [9-22].

The farmers of our country are highly dependent on inorganic fertilizers as a source of plant nutrients and the high cost of chemical fertilizers is associated with land and soil degradation as well as environmental pollution [21]. Therefore, it is high time to search for alternative safe natural sources of plant nutrients to improve plant and soil health. To fulfill the demand of organic fertilizer, one of such option is use of MLE as fertilizer for crop plants [23]. If MLE can increase the growth and yield of vegetable crops like cauliflower, the smallholder farmers in Bangladesh would be benefitted because MLE is a low-cost, easily available and environment friendly technology. Although a very few literatures cited the effect of MLE on growth and yield of vegetable crops, the use of MLE for agricultural purposes to enhance growth and yield of vegetable crops in Bangladesh has not yet been thoroughly investigated. Therefore, more research work needs to be performed to explore the novel effect of MLE as an organic fertilizer for developing sustainable agricultural practice in Bangladesh. The present study was undertaken to investigate the effect of foliar application of MLE on growth and yield performance of cauliflower.

2. MATERIALS AND METHODS

2.1 Experimental Site and Soil

The research work was carried out at the Soil Science Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh during Rabi season from November 2017 to February 2018. Geographically the field is located at 24°75′ N latitude and 90°50′ E longitude at the elevation of 18 m above the sea level. The topography of the land was medium high belonging to the Sonatala series of Non-Calcareous Dark Grey Floodplain Soils of AEZ-9 named Old Brahmaputra Floodplain [24]. The land was moderately well drained with a silty loam texture and sufficient sunshine was available throughout the experimental period. The soil was silt loam in texture having pH 6.28, organic matter content 1.12%, total N 0.152%, available P 11.08 ppm, exchangeable K 0.053 me% and available S 9.83 ppm.

2.2 Treatments and experimental design

The experiment was laid out in a randomized complete block design (RCBD) with three replications and four treatments which were T_1 Foliar spray with water (control), T_2 (MLE foliar spray at 2 weeks after transplanting), T_3 (MLE foliar spray at 2 weeks and 4 weeks after transplanting), T_4 (MLE foliar spray at 2 weeks after transplanting and after every two weeks thereafter). The experimental area was divided into three blocks representing the replication and each block was subdivided into four-unit plots. The treatments were randomly distributed to the unit plots in each block. The total number of plots was 4×3 = 12. The unit plot size was 2.5m × 2m. The spacing between blocks was 0.8 m and the plots were separated from each other by a space of 0.5 m.

2.3 Seedling transplanting

Cauliflower (hydrid variety named White 770) was used as test crop in this experiment. About 25-days-old seedlings of cauliflower were transplanted in the experimental plots on the 14th November 2017. The seedlings were uprooted carefully from the seedbed to avoid damage of the root system and transplanted in the afternoon followed by light irrigation for their better establishment. The line to line distance was 60 cm and plant to plant distance was 50 cm. The young seedlings were provided shade by banana leaf sheath during daytime to protect from scorching sunshine up to 5 days until they were set in the soil. The seedlings were kept open at night to allow them to receive dew. A number of extra seedlings were also planted on the border of the experimental plots for gap filling.

2.4 Fertilizer application

The full amount of triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc oxide and boric acid were added during final land preparation at the rate of 60, 76, 21, 3 and 1 kg ha ^{1}, respectively according to the Fertilizer Recommendation Guide [25]. Urea was applied in three installments and the dose was 160 kg ha ^{1}. The first split was applied as basal during final land preparation, while the second split and third split were applied as top dressing at 30 and 45 DAT (days after transplanting), respectively.

2.5 Collection and preparation of MLE

Young leaves of moringa were collected from young full-grown trees located at different places of Bangladesh Agricultural University Campus, Mymensingh. For preparation of MLE, young leaves of about 100 g were taken into a mortar with a pinch of water (10 ml/100 g fresh material) and ground with a pestle. The juice was extracted by hand pressure and was filtered through a cheese cloth followed by re-filtering using Whatman filter paper No. 2. Following the method developed by Fuglie, the extract was diluted with distilled water at a ratio of 1:32 (v/v) and then sprayed directly onto the cauliflower plants [26]. The remaining extract was stored at 0ºC temperature and only taken out when needed for use.

2.6 Foliar application of MLE in cauliflower

The prepared MLE was sprayed @ 25 mL plant^{-1} as per treatments in the late afternoon using hand sprayer with special attention for complete coverage of plants with MLE. Water was sprayed in the control plots instead of MLE and special attention was given to avoid drifting of spray materials from one plot to another.

2.7 Intercultural operations

Light watering was given by a watering can at every morning and afternoon following seedling transplanting and was continued for a week for rapid and well establishment of the transplanted seedlings. After the establishment of seedlings, flood irrigation was given in the field at 30 DAT and 45 DAT. Other intercultural operations such as weeding, fencing, gap filling, and pesticide application were done as and when necessary.

2.8 Harvesting and data collection

The crop under investigation was harvested on the 16th February 2018 at full maturity. Data on growth and yield parameters such as plant height, leaf number, length, breadth and weight of the largest leaf, weight of root and stem, curd thickness, curd diameter, curd weight, total weight of plant, gross yield and marketable yield were recorded at the time of harvesting of the crop.

2.9 Statistical analysis

The collected data on different parameters were analyzed statistically to obtain the level of significance using the MSTAT–computer package program developed by Russel [27]. The differences among treatment means were compared by Duncan's New Multiple Range Test (DMRT) at 5% level of probability [28].

3. RESULTS AND DISCUSSION

3.1 Effect of MLE on growth parameters of cauliflower

Application of MLE had significant positive effects on growth parameters of cauliflower such as plant height, length of the largest leaf, root weight and stem weight (Table 1). The highest values of plant height (34.10 cm), length of the largest leaf (29.50 cm), root weight (9.50 g), stem weight (19.13 g) were recorded from treatment T_4 (MLE foliar spray at 2 weeks after transplanting and After every two weeks thereafter). The lowest values of plant height (30.60 cm), length of the largest leaf (25.50 cm), fresh weight of root (7.00 g) and stem (16.20 g) were recorded from treatment T_1 (control). Treatments T_4 and T_3 were statistically identical in case of all the growth parameters of cauliflower. Foliar application of MLE showed no significant effect on other growth parameters viz. number of leaves plant^{-1}, breadth and weight of the largest leaf but these parameters were improved with the increase of the frequency of MLE application. However, maximum values of number of leaves plant^{-1} (18.67), breadth (15.13 cm) and weight of the largest leaf (21.63 g) were obtained from treatment T_4. On the other hand, the minimum values of number of leaves plant^{-1} (16.67), breadth (13.50 cm) and weight of the largest leaf (20.07 g) were recorded in control treatment (T_1) where no MLE was applied. These results are in agreement with many researchers who suggested significantly higher growth and improved growth parameters including plant height, weight of shoot, number of leaves etc [10-16]. in different vegetables and legume crops such as okra, pepper, snap bean, common bean, eggplant, tomato etc. by applying MLE compared to control.

In a column, figures with same letters or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per Duncan's New Multiple Range Test (DMRT). T_1 = Control (foliar spray with water), T_2 = MLE sprayed at 2 weeks after transplanting, T_3 = MLE sprayed at 2 weeks and 4 weeks after transplanting, T_4 = MLE sprayed at 2 weeks after transplanting and after every two weeks thereafter
=** Significant at 5% level of probability, *=** Significant at 1% level of probability, NS= Not significant, CV = Co-efficient of variation.

3.2 Effect of MLE on yield of cauliflower

The effect of foliar application of MLE was significant on gross yield and marketable yield of cauliflower (Table 2). The maximum gross yield (12.81 t ha^{-1}) as well as marketable yield (5.52 t ha^{-1}) was observed with the highest application of MLE (T_4). On the contrary, the minimum gross yield (8.9 t ha^{-1}) and marketable yield (3.7 t ha^{-1}) were recorded in T_1 (control). For both gross yield and marketable yield, the treatments may be ranked in the order of T_4>T_3>T_2>T_1. The percent increase in gross yield and marketable yield of cauliflower over control due to different treatments is shown in Figure 1. The percent increase in gross yield over control ranged from 20 to 43.9 and that of marketable yield 20.54 to 49.18. These results are accorded to those of some researchers. who suggested 10-45% yield

Table 1: Growth parameters of cauliflower as influenced by different treatments

Treatments	Plant height (cm)	Number of leaf plant^{-1}	Length of the largest leaf (cm)	Breadth of the largest leaf (cm)	Weight of the largest leaf (g)	Fresh weight of root (g)	Fresh weight of stem (g)
T_1	30.60b	16.67	25.50c	13.50	20.07	7.00b	16.20b
T_2	30.73b	17.33	27.97b	13.53	20.43	8.50b	17.17b
T_3	33.40a	18.00	28.67ab	14.97	21.57	9.20a	18.57a
T_4	34.10a	18.67	29.50a	15.13	21.63	9.50a	19.13a
CV (%)	6.08	5.57	8.79	9.32	7.78	2.79	7.73
Level of sig.	*	NS	**	NS	NS	**	*

increase in crop with MLE application [30]. For both gross yield and marketable yield, treatments T_4 and T_1 gave the highest and the lowest yield increase over control, respectively.

It was observed from this experiment that the higher the frequency of MLE application during the growth stage, the higher the yield of the crop. Some researchers reported that a cytokinin related hormone named zeatin in the extract is responsible for the improved growth and yields of MLE-treated crops [8, 18, 20]. However, the role of phytohormones in MLE to enhance plant crop still remains unclear. Besides, moringa leaves are a rich source of essential nutrient elements for plants and thus MLE can also supply additional nutrient elements to crops for betterment of growth and yield [31, 32].

Table 2: Yield parameters of cauliflower as influenced by different treatments

Treatments	Curd thickness (cm)	Curd diameter (cm)	Curd weight (kg)	Total weight of plant (kg)	Gross yield (t ha^{-1})	Marketable yield (t ha^{-1})
T_1	3.60c	12.13c	0.29d	0.46d	8.90d	3.70c
T_2	4.40b	14.07b	0.34c	0.58c	10.68c	4.46b
T_3	4.90b	15.67ab	0.40b	0.69b	11.69b	4.99b
T_4	5.37a	16.03a	0.48a	0.76a	12.81a	5.52a
CV (%)	6.58	1.29	5.64	6.05	3.78	5.40
Level of sig.	*	**	*	*	**	**

In a column, figures with same letters or without letter do not differ significantly whereas figures with dissimilar letter differ significantly as per Duncan's New Multiple Range Test (DMRT). T_1 = Control (foliar spray with water), T_2 = MLE sprayed at 2 weeks after transplanting, T_3 = MLE sprayed at 2 weeks and 4 weeks after transplanting, T_4 = MLE sprayed at 2 weeks after transplanting and after every two weeks thereafter
=** Significant at 5% level of probability, *=** Significant at 1% level of probability, CV = Co-efficient of variation

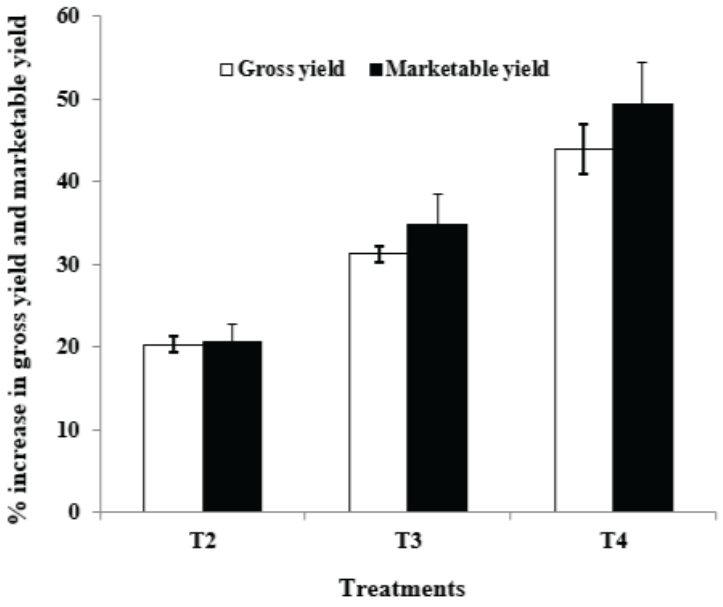

Figure 1: Percent increase in gross yield and marketable yield over control of cauliflower as influenced by different treatments

3.3 Correlation between yield and plant parameters

Yield is a complex character that results from the interaction of many plant growth parameters and yield contributing characters like plant height, length of largest leaf, root weight, stem weight, curd thickness and curd diameter. In order to observe the interrelationship among the plant characters studied, correlation matrices were formed. The correlation matrix between yields and growth characters of cauliflower are summarized in Table 3. Gross yield was significantly correlated with length of the largest leaf (r = 0.908**), fresh weight of root (0.819**), fresh weight of stem (0.795**) and marketable yield (0.967**). In the same manner, the marketable yield was significantly correlated with length of the largest leaf (r = 0.943**), fresh weight of root (r = 0.761**), fresh weight of stem (r = 0.736**) and gross yield (r = 0.967**). Besides, significant correlation was found between plant height and leaf number (r = 0.704*), length and breadth of the largest leaf (r = 0.638*), length of the largest leaf and fresh weight of stem (r = 0.704*), fresh weight of stem and root (r = 0.831**). Again, Table 4 indicates the correlation matrix between yields and yield characters of cauliflower. Gross yield was significantly correlated with curd thickness (r = 0.907**), curd diameter (r = 0.947**), curd weight (r = 0.964**), total weight plant^{-1} (r = 0.987**), and marketable yield (r = 0.966**). The marketable yield was also significantly correlated with curd thickness (r = 0.876**), curd diameter (r = 0.937**), curd weight (r = 0.897**), total weight of plant (r = 0.884**), and gross yield (r = 0.966**). Significant correlation was observed between curd thickness and diameter (r = 0.914**), curd diameter and weight (r = 0.741*), curd weight and total weight plant^{-1} (r = 0.991**).

Table 3: Correlation matrix between yield and growth parameters of cauliflower

	Plant height (cm)	Leaf number	Length of the largest leaf (cm)	Breadth of the largest leaf (cm)	Weight of the largest leaf (g)	Fresh weight of root (g)	Fresh weight of stem (g)	Gross yield (t ha^{-1})	Marketable yield (t ha^{-1})
Plant height (cm)	1	0.704*	-0.108	-0.056	0.038	0.022	-0.214	0.009	0.06
Leaf number	.704*	1	-0.128	-0.136	-0.318	0.076	0.004	0.044	0.061
Length of the largest leaf (cm)	-0.108	-0.128	1	0.638*	0.378	0.781	.704*	.908**	0.943**
Breadth of the largest leaf (cm)	-0.056	-0.136	0.638*	1	-0.059	0.466	0.525	0.482	0.571
Weight of the largest leaf (g)	0.038	-0.318	0.378	-0.059	1	0.286	0.227	0.472	0.39
Fresh weight of root (g)	0.022	0.076	0.781	0.466	0.286	1	0.831**	0.819**	0.761**
Fresh weight of stem (g)	-0.214	0.004	0.704*	0.525	0.227	0.831**	1	0.795**	0.736**
Gross yield (t ha^{-1})	0.009	0.044	0.908**	0.482	0.472	0.819**	0.795**	1	0.967**
Marketable yield(t ha^{-1})	0.06	0.061	.943**	0.571	0.39	0.761**	0.736**	0.967**	1

** Indicates significant at 1% level of probability
* Indicates significant at 5% level of probability

Table 4: Correlation matrix between yield and yield parameters of cauliflower

	Curd thickness (cm)	Curd diameter (cm)	Curd weight (kg)	Total weight of plant (kg)	Gross yield (t ha^{-1})	Marketable yield (t ha^{-1})
Curd thickness (cm)	1	0.911**	0.897	0.673	0.907**	0.876**
Curd diameter (cm)	0.911**	1	0.741*	0.706	0.947**	0.937**
Curd weight (kg)	0.897	0.741*	1	0.991**	0.964**	0.897**
Total weight plant^{-1} (kg)	0.673	0.706	0.991**	1	0.987**	0.884**
Gross yield (t ha^{-1})	0.907**	0.937**	0.964**	0.987**	1	0.966**
Marketable yield (t ha^{-1})	0.876**	0.947**	0.897**	0.884**	0.966**	1

** Indicates significant at 1% level of probability
* Indicates significant at 5% level of probability

4. CONCLUSION

Recently, natural plant growth stimulants are intensively studied to improve crop performance under field conditions due to their ecofriendly nature, low cost and easy availability. The present study suggests that foliar use of moringa leaf extract on cauliflower had significant positive effects on growth parameters such as plant height, length of the largest leaf, fresh weight of root and stem, etc. Application of MLE as a bio-stimulant significantly improved various yield components viz. curd

thickness, weight and diameter and also total weight of plant resulting in a remarkable increase in gross and marketable yield of the vegetable crop. Notably, the highest frequency of moringa application during the growth stage of crop (T_4) gave the maximum yields. In conclusion, cauliflower fertilized with MLE at 2 weeks after transplanting and after every two weeks thereafter is a promising practice for higher growth and yield and therefore, application of MLE at growth stages of vegetable crops especially low yielding varieties should be recommended for improved performance. Further research in other crops is necessary to unravel the novel effect of MLE and its use as a sustainable agricultural practice in Bangladesh.

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