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Effect of foliar application of moringa leaf extract on growth and fruit yield of *Capsicum annuum* L. (CHILLI) CV. MIPC-1

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Abstract

This study was carried out in the Crop Farm of Eastern University, Sri Lanka during the period from January to May 2019 to ascertain the effect of foliar application of moringa leaf extract (MLE) on growth and fruit yield of Capsicum annumL.cv (chilli) MIPC-1. This investigation was followed in a pot experiment with Completely Randomized Design (CRD) with seven treatments and seven replicates. The concentrations of Moringa leaf extract were 10%, 20%, 30% in addition to 0% (distilled water) as control. The treatments included were; T_0 - control (Distilled water), T_1 - 10% MLE at once a week interval, T_2 - 10% MLE at once in two weeks interval, T_3 - 20% MLE at once a week interval, T_4 - 20% MLE at once in two weeks interval, T_5 - 30% MLE at once a week interval and T_6 - 30% MLE at once in two weeks interval. The Moringa oleifera leaf extract was sprayed on leaves and axial parts starting from two weeks after transplanting (WAT) and it was continued until pod formation. 25ml of MLE was sprayed per plant. The results of the experiment showed that the foliar application of MLE with 10% concentration at one-week interval had significant ($p<0.05$) effects on the plant height, number of branches/plant, dry weight of leaves/plant, stems/plant, roots/plant, fruit/plant and total dry of plant were statistically analysed using Statistically Analytical Software (SAS). The results indicated that the foliar application of moringa leaf extract stimulated the growth and fruit yield of chilli. Based on the results, it was concluded that MLE helps in improving the growth and fruit yield of Chilli and MLE with 10% concentration at one-week interval is recommended for improved growth and fruit yield of Capsicum annuum L.cv. (Chilli) MIPC-1.

Keywords: Chilli, moringa leaf extract, plant growth, yield.

Introduction

*Capsicum annuum*L.cv (Chilli) is one of the well-known members of the Solanaceae family and it is used as a spice and both green and ripe dried forms are used on a large scale due to its pungency. Although chilli is grown as a vegetable and also a condiment the peak use of chilli throughout the world is as a spice on account of its pungency and pleasant flavour. Nowadays chilli can be considered as one of the most important cash crops grown in Sri Lanka.

The use of synthetic plant growth regulators to enhance the crop growth and yield, have been reported to have adverse effects on agricultural products, humans and ecosystem.

Therefore, there is a dire need to evaluate the potentials of certain organic materials to improve crop yield. *Moringa oleifera* is one of the best alternatives and has a positive effect on growth and yield of crops and thus its application can be promoted among farmers as a possible substitute for synthetic plant growth regulators. As it is applied in the form of foliar application it is more beneficial than soil application due to the effective utilization of foliar applied nutrients by plants than soil-applied nutrients[1]. MLE is considered as a rich source of growth regulators such as zeatin (a cytokinin), ascorbate, phenolics, and also many other essential plant minerals[2]. Therefore, it can be efficiently used as a foliar spray on chilli among farmers with the idea of enhancing the growth and yield of chilli. Considering the above, the present investigation was carried out to study the effect of different concentrations and application frequencies of MLE as a foliar application with recommended fertilizer on growth and fruit yield of *Capsicum annum* L.cv. (Chilli) MIPC-1.

Materials and methods

A pot experiment was carried out in the Crop Farm, Eastern University, Sri Lanka during the period from January to May 2019. The experiment was laid out in a Completely Randomized Design (CRD). Polythene bags of 30cm×50cm of dimension were used by filling with the potting mixture of topsoil: sand: compost (1:1:1) and leaving a half inch at the top to hold the water. Thirty days-old seedlings of chilli MIPC-1 were transplanted from nursery to each poly bag and nitrogen, phosphorous and potassium fertilizers were applied according to the recommendation of the Department of Agriculture.

Preparation of moringa leaf extracts (MLE): The young Moringa leaves were collected and they were placed in polythene bags immediately after harvesting.

Then, they were transported to the Crop Science Laboratory, Eastern University, Sri Lanka. After that, they were cleaned orderly with tap water and distilled water. After, they were shade dried for four days. MLE was prepared according to the methodology described by Rama Rao[3]. The different concentrations of MLE such as 10%, 20% and 30% were prepared by adding distilled water on a volume basis.

Foliar application of MLE was started at 2 weeks after transplanting (2 WAT) and continued until to pod formation. 25ml of MLE was applied to each plant at a time. All the agronomic practices were carried out according to the Department of Agriculture recommendation.

Data Collection and Analysis: The growth and yield parameters were collected in the experiment at 6 and 9 and 11 WAT. Data were statistically analysed using statistical software SAS 9.4 and the mean comparison within treatments were performed by Duncan Multiple Range Test (DMRT) at 5 % significant level.

Results and discussion

Plant height: As shown in Table-1, different concentrations and application frequencies of MLE was significantly influenced ($p<0.05$) the plant height of chilli. At 6 WAT, the highest plant height of 32.20 cm was reported in T1, followed by T3 (29.25 cm) and T6 (25.40 cm) and then T5 (22.35 cm) (Table- 1).

The lowest plant height was recorded in the control treatment (T0). At 9 WAT, the highest plant height of 39.70cm was observed ($p<0.05$) in T1, followed by T5 (33.85cm) and T6 (34.45cm) and the lowest plant height of 21.30cm was observed in control treatment (T0). At 11 WAT, the highest plant height (60.25cm) was recorded in T1 which was significantly higher than the other treatments (Table- 1).

The lowest plant height was recorded in T0 (30.35 cm). In general, the highest plant height was observed in T1 and the lowest plant height was observed in T0. Therefore, application of MLE at the rate of 10% concentration at one-week interval had a significant effect ($p<0.05$) on the plant height.

This might be due to the plant growth stimulating effect of zeatin, carotenoids, ascorbates, phenols, potassium and calcium which are essential for the growth[4].

These findings are in agreement with the results of Taha *et al.*[5] who reported that the application of MLE (10%) increased the plant height in the Jojoba plant by 103.24%.

Furthermore, research studies have reported that the foliar application of MLE increased the plant height in many crops such as sunflower[6], wheat[7], sweet corn[8] and tomato[9] and okra[10].

Table-1: Effect of different concentrations of Moringa Leaf Extract (MLE) on plant height at different stages of crop.

Treatment	WAT		
	6	9	11
T0	$16.40^{e} \pm 1.09$	$21.30^{c} \pm 0.57$	$30.35^{c} \pm 0.90$
T1	$32.20^{a} \pm 0.97$	$39.70^{a} \pm 1.07$	$60.25^{a} \pm 1.68$
T2	$20.25^{d} \pm 0.91$	$24.95^{c} \pm 0.81$	$46.30^{b} \pm 1.51$
T3	$29.25^{b} \pm 1.27$	$36.85^{ab} \pm 1.67$	$43.35^{b} \pm 0.85$
T4	$29.75^{ab} \pm 0.30$	$36.80^{ab} \pm 0.49$	$50.1^{b} \pm 0.24$
T5	$22.35^{d} \pm 1.03$	$33.85^{b} \pm 1.10$	$50.0^{b} \pm 0.39$
T6	$25.40^{c} \pm 1.09$	$34.45^{b} \pm 0.74$	$48.9^{b} \pm 0.33$
P Value	0.0001	0.0003	0.0005

* $p < 0.05$- NS; Not Significant.

Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT).

Number of branches/plant: The number of branches of chilli was significantly influenced ($p<0.05$) by the application of MLE at the rate of 10% concentration (Table-2). At 6 WAT, the maximum number of branches was given in T1 (9.5) and the minimum number of branches was given in T0 (2.0) (Table-2). At 9 WAT, a significant increase in the number of branches/ plant was observed in T1 (15.0) compared to the other treatments while the minimum number of branches/plant was recorded in control treatment (3.5). At 11 WAT, the maximum number of branches/plant (22.0) was observed in T1 followed by T3 (17.0). The minimum number of branches/plant was observed in T0 (5.5). T2 was par with T3 (Table-2). Therefore, the application of different concentrations of MLE was significantly ($p<0.05$) influenced the number of branches per plant. The obtained results illustrated that the application of MLE at the rate of 10% at one-week interval increased the number of branches/plant. This might be due to the presence of naturally occurring growth regulators such as zeatin, abscisic acid and gibberellin which play an important role in cell division and elongation of crops leading to improved growth of plants[11]. These findings are in consistent with the study of Bashir *et al.*[12] who reported that the foliar application of MLE increased the number of branches/plant in tomato which is belonged to family Solanaceae. Likewise, the results are agreed with Zaki and Rady[13] who reported that foliar application of MLE improves crop performances as it is a good source of zeatin that is responsible for the rate of cell-division and cell-enlargement.

Table-2: Effects of different concentrations of Moringa Leaf Extract (MLE) on Number of branches at different stages of crop.

Treatment	WAT		
	6	9	11
T0	$2.0^{d} \pm 0.53$	$3.5^{c} \pm 0.33$	$5.5^{d} \pm 0.35$
T1	$9.5^{a} \pm 0.67$	$15.0^{a} \pm 2.03$	$22.0^{a} \pm 2.12$
T2	$4.5^{bcd} \pm 0.67$	$5.0^{bc} \pm 0.67$	$15.5^{b} \pm 1.06$
T3	$4.0^{cd} \pm 1.36$	$7.5^{bc} \pm 0.33$	$17.0^{b} \pm 0.70$
T4	$4.5^{bcd} \pm 0.67$	$5.5^{bc} \pm 0.33$	$12.5^{bc} \pm 0.35$
T5	$7.0^{bc} \pm 1.36$	$9.5^{b} \pm 1.01$	$8.0^{cd} \pm 0.70$
T6	$6.0^{b} \pm 1.36$	$8.5^{bc} \pm 1.01$	$10.5^{c} \pm 0.35$
P Value	0.003	0.0124	0.0009

* p < 0.05- NS; Not Significant. Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT)[14].

Dry weight of leaves/plant: Foliar application of MLE significantly influenced ($p<0.05$) on the dry weight of leaves/plant (Table-3). At 6, 9 and 11 WAT, maximum dry weight was observed in T1 and the minimum dry weight in T0 (Table-3). It was observed an increment of the dry weight of leaves/plant with increasing growth of the plant. The number of leaves was increased with the foliar application of MLE as it is a rich source of essential nutrients for plant growth and it is the reason for the increased dry weight of leaves/plant. This is in concurrence with the research findings of Hashish *et al.*[15] who reported that the application of MLE increased the dry weight of leaves of *Alstonia scholaris* (Blackboard tree) compared with control treatment.

Dry weight of stems/plant: The effect of foliar application of MLE on the dry weight of stems/plant of chilli is given in Table-4. The application of MLE significantly increased the dry weight of stems/plant. At 6 WAT, the maximum dry weight of stems was reported in T1 (1.43g), and minimum dry weight was reported in T0 (0.52g). There was no significant difference among the treatments T0, T2, T3, T4, T5 and T6 (Table-4). At 9 WAT, the maximum dry weight of stems was observed in T1 (3.86g) while the minimum dry weight of stems was observed in T0 (1.20g). At 11WAT, foliar application of MLE was caused to a clear increment of the dry weight of stems/plant in T1 (11.68g). As well as, there was no significant difference in T0, T2, T3, T4, T5 and T6. MLE contains inorganic nutrients and growth-promoting hormones like auxins and cytokinins. This might have contributed to the acceleration in growth through rapid cell division, cell multiplication and enlargement[16,17]. Therefore, it has led to the increment of the dry weight of stems/plant.

Table-3: Effects of different concentrations of Moringa Leaf Extract (MLE) on dry weight of leaves (g/plant) at different stages of crop.

Treatment	WAT		
	6	9	11
T0	$0.37^{e} \pm 0.36$	$0.80^{c} \pm 0.08$	$3.90^{c} \pm 0.44$
T1	$2.32^{a} \pm 1.30$	$4.38^{a} \pm 0.98$	$9.0^{a} \pm 0.94$
T2	$1.04^{c} \pm 0.86$	$2.17^{bc} \pm 1.55$	$4.50^{bc} \pm 0.21$
T3	$1.58^{b} \pm 1.66$	$2.75^{b} \pm 1.44$	$4.76^{bc} \pm 0.81$
T4	$0.59^{de} \pm 0.72$	$2.49^{b} \pm 0.62$	$6.27^{bc} \pm 1.37$
T5	$0.73^{cd} \pm 0.79$	$2.39^{b} \pm 0.53$	$5.37^{bc} \pm 1.70$
T6	$0.92^{cd} \pm 0.50$	$2.73^{b} \pm 0.94$	$6.59^{b} \pm 0.68$
P value	0.0001	0.0134	0.0147

* p < 0.05- NS; Not Significant. Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT)[14].

Table-4: Effects of different concentrations of Moringa Leaf Extract (MLE) on dry weight of stems (g/plant) at different stages of crop.

Treatment	WAT		
	6	9	11
T0	$0.52^{b} \pm 0.7$	$1.20^{e} \pm 0.57$	$4.46^{b} \pm 1.18$
T1	$1.43^{a} \pm 0.25$	$3.86^{a} \pm 1.89$	$11.68^{a} \pm 0.98$
T2	$0.53^{b} \pm 0.25$	$1.45^{de} \pm 0.78$	$4.26^{b} \pm 0.36$
T3	$0.78^{b} \pm 2.4$	$2.26^{c} \pm 0.36$	$6.39^{b} \pm 0.87$
T4	$0.44^{b} \pm 0.1$	$1.74^{d} \pm 4.78$	$5.71^{b} \pm 1.42$
T5	$0.57^{b} \pm 0.7$	$2.82^{b} \pm 1.47$	$6.51^{b} \pm 1.20$
T6	$0.54^{b} \pm 0.2$	$1.64^{de} \pm 0.57$	$3.76^{b} \pm 0.52$
P value	0.0181	0.0001	0.0139

*p < 0.05- NS; Not Significant. Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT)[14].

Dry weight of roots/plant: Table-5 is shown the effect of foliar application of MLE on the dry weight of roots/plant. Foliar application of MLE at 10% concentration had a significant ($p<0.05$) effect on the dry weight of roots/plant when compared to the control treatment (T0). This might be due to the presence of a high amount of phosphorous in the MLE that promotes the root development[18]. Besides, the improvement of the root system could be influenced due to the presence of auxin and cytokinin which are responsible for the growth promotion and also the other compounds in MLE[11]. This is in agreement with Culver *et al*.[9] and Ogbuehi *et al*.[19] who reported that the application of moringa leaf extract significantly increased the root dry weight in tomato and soyabean respectively.

Table-5: Effects of different concentrations of Moringa Leaf Extract (MLE) on dry weight of roots/plant at different stages of crop.

Treatment	WAT		
	6	9	11
T0	$0.39^{d} \pm 0.08$	$0.50^{c} \pm 0.51$	$1.73^{c} \pm 0.73$
T1	$0.84^{a} \pm 0.08$	$1.89^{a} \pm 1.37$	$3.09^{a} \pm 1.03$
T2	$0.60^{bc} \pm 0.01$	$1.37^{ab} \pm 1.20$	$2.26^{b} \pm 0.98$
T3	$0.73^{ab} \pm 0.11$	$1.14^{bc} \pm 0.79$	$2.36^{b} \pm 1.08$
T4	$0.56^{c} \pm 0.10$	$0.79^{bc} \pm 1.10$	$2.50^{b} \pm 0.64$
T5	$0.53^{cd} \pm 0.09$	$1.26^{ab} \pm 0.72$	$2.50^{b} \pm 1.33$
T6	$0.56^{c} \pm 0.15$	$0.87^{bc} \pm 0.96$	$2.24^{b} \pm 0.98$
P value	0.0025	0.0284	0.0075

*p < 0.05- NS; Not Significant. Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT)[14].

Total dry weight/plant (leaves, stems, roots and pod/plant): Data recorded on the effect of foliar application of MLE on total dry weight/plant is presented in Table-6. According to the results, at 6 WAT maximum dry weight/plant was recorded in T1 (4.59g/plant) followed by T3 (3.11g/plant) and T2 (2.21g/ plant). As well as the minimum dry weight was recorded in T0 (1.29g/plant) (Table-6). At 9 WAT, maximum dry weight was recorded in T1 (10.19 g/plant) followed by T5 (6.63g/plant), T6 (5.75g/plant) and T4 (5.03g/plant). The minimum dry weight was recorded in T0 (2.50g/plant). In general, total dry weight/plant increased with time. At 11 WAT, there was no significant difference observed among the treatments (Table-6). Therefore, MLE has significantly influenced ($p<0.05$) the total dry weight/plant. Application of MLE at one-week interval with a 10% concentration showed a significant difference in total dry weight/plant compared to control treatment. Makkar *et al*.[20] revealed that MLE is rich with significant quantities of calcium, potassium, and cytokinin in the form of zeatin, antioxidants proteins, ascorbates and phenols. Therefore, MLE can be considered to support the growth of plant parts and ultimately increase the total dry weight of plants. Especially, biomass production is increased with foliar application of MLE due to the presence of zinc as it is helps increase biomass production[21]. The results (Table-6) are corroborated with the research findings of Muhammad *et al*.[22] who found that plant dry weight was significantly affected by the foliar application of moringa leaf extract. Hashish *et al*.[15] also documented that the application of MLE at once after a month and another time after two months of planting with 5 cm/pot increased the dry weight of roots, leaves and stems of *Alstonia scholaris* (Blackboard tree) compared with the control treatment. As well as, Abdalla[23] reported that the foliar application of MLE at low concentration (2%) increased the total dry weight of the rocket plant.

Table-6: Effects of different concentrations of Moringa Leaf Extract (MLE) on total dry weight of chilli plant (g/plant) at different stages of crop.

Treatment	Weeks After Transplanting (WAT)		
	6	9	11
T0	$1.29^{f} \pm 0.29$	$2.50^{e} \pm 1.18$	$10.36^{b} \pm 0.59$
T1	$4.59^{a} \pm 1.41$	$10.19^{a} \pm 0.48$	$19.32^{a} \pm 1.92$
T2	$2.21^{c} \pm 0.97$	$4.99^{d} \pm 1.48$	$11.56^{b} \pm 0.25$
T3	$3.11^{b} \pm 1.12$	$5.65^{cd} \pm 1.70$	$13.92^{ab} \pm 0.78$
T4	$1.60^{ef} \pm 0.44$	$5.03^{d} \pm 0.44$	$14.84^{ab} \pm 1.34$
T5	$1.83^{de} \pm 1.53$	$6.63^{b} \pm 0.59$	$14.83^{ab} \pm 0.24$
T6	$2.02^{cd} \pm 1.61$	$5.75^{c} \pm 0.03$	$13.01^{ab} \pm 0.63$
P value	0.0001	*0.0001*	NS

* p < 0.05- NS; Not Significant. Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT)[14].

Dry weight of fruits/plant: Fruit weight is the most important yield contributing character for all the plant species. Experiment results revealed that there is a remarkable variation ($p<0.05$) in dry weight of fruits/plant at 9 and 11WAT (Table-7). At 9 WAT, the maximum dry weight of fruits/plant was recorded in T1 (2.01g/plant) while the minimum dry weight was observed in T0 (0.24g/plant). T3 was on par with T4 and T6 (Table-7). At 11 WAT, the highest dry weight was achieved in T1 (18.37g/plant) and the minimum dry weight was observed in T0 (1.29g/plant). As well as, T2 was par with T4, T5 and T6.

According to the results, it is clear that there is a significant increase in dry weight of fruits/plant in T1 compared to T0 (control) treatment. This compliances with the findings of Culver *et al*.[9] who found that MLE significantly increased the dry weight of tomato fruit (1:32) and similar results showed that the MLE can enhance the photosynthetic apparatus in the treated plant which in turn enhance the plant productivity and thereby dry matter content of fruit[24].

Table-7: Effects of different concentrations of Moringa Leaf Extract (MLE) on dry weight of fruits (g/plant) at different stages of crop.

Treatment	WAT	
	9	11
T0	$0.24^{c} \pm 0.05$	$1.29^{c} \pm 0.03$
T1	$2.01^{a} \pm 2.35$	$18.37^{a} \pm 1.34$
T2	$1.06^{ab} \pm 0.55$	$8.05^{b} \pm 0.15$
T3	$0.54^{b} \pm 0.05$	$5.04^{bc} \pm 0.50$
T4	$0.52^{b} \pm 0.47$	$7.81^{b} \pm 0.30$
T5	$1.05^{ab} \pm 0.65$	$8.12^{b} \pm 2.17$
T6	$0.62^{b} \pm 0.70$	$9.12^{b} \pm 0.25$
P value	0.038	0.0033

*p < 0.05- NS; Not Significant. Mean values in a column having the dissimilar letter/letters indicate significant differences at 5% level of significance according to Duncan Multiple Range Rest (DMRT)[14].

Conclusion

Foliar application of 10% MLE was caused for the significant increment of the growth and fruit yield of chilli according to the research findings. Therefore, it is concluded that the foliar application of 10% moringa leaf extract (MLE) can be recommended for enhancing the growth and fruit yield of chilli.

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