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Yield performance of *Vigna unguiculata* (L.) as influenced by the application of *Moringa* leaf extract

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Abstract- This study was done at the home garden in the Eastern province of Sri Lanka to determine the efficiency of *Moringa* leaf extract (MLE) on the yield of *Vigna unguiculata* cv. waruni. This experiment was laid out in a completely randomized design and it is comprised of six treatments including T1 (distilled water as a control), T2 (10% MLE), T3 (20% MLE), T4 (30% MLE), T5 (40% MLE) and T6 (50% MLE). The 80 g of powdered *Moringa* leaves were ground with 300 ml water to prepare 100% MLE. Once in two weeks, MLE was applied and it was practiced from two weeks after planting. The findings indicated that the MLE application exhibited remarkable ($P<0.05$) yield performances compared to the control. MLE with 50% foliar application at two weeks intervals enhanced plant height, leaf stalk and leaflet numbers, dry weights of crop residues, single pod weight, seed number in pod, 100 seed weight, seed weight per pod, harvested pod number, pod weight and seed weight for a plant as well as seed yield. The 50% *Moringa* leaf extract significantly increased the seed yield (428.89 g/m^2) of cowpea than the control treatment (193.56 g/m^2). Furthermore, no significant difference ($p<0.05$) was observed in seed yield between T5 (340.89 g/m^2) and T6 (428.89 g/m^2). Hence, it could be concluded that 40% - 50% *Moringa* leaf extract application with compost increases the yield of cowpea as it is one of the eco-friendly ways to increase the cowpea yield.

Keywords: Compost, cowpea, foliar application, *Moringa* leaf, yield

I. INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is a significant source of dietary protein as well as a valuable product that produces income for farmers in the developing world (Langyintuo et al., 2003). It is used in human food and animal feeding. Cowpea grains contain about 25% protein (Boukar et al., 2011), and they have health-beneficial compounds such as soluble and insoluble dietary fiber, phytochemicals and proteins (Jayathilake et al., 2018). Cowpea can fix atmospheric nitrogen and refurnish soil fertility for succeeding cereal crops (Timko et al., 2007). Cowpea is companionable as an intercrop with maize as it is a shade-tolerant crop (Iqbal, 2015). Crop production is affected by the deficiencies of micronutrients in different areas (Bose and Tripathi, 1996). The application of organic manure provides the necessary macro and micronutrients to obtain higher crop yields. It improves soil nutrients and reduces environmental and health problems (Suthamathy and Seran, 2016).

The application of liquid organic fertilizer known as Amuthakaraisal improves yield and its components of groundnut (Hassaan and Seran, 2015). Thus, nutrients are applied as a foliar spray (Sajid et al., 2013), and *Moringa* leaf extract (MLE) is used to boost the crop yield in an eco-friendly and economical manner (Makkar et al., 2007). Foliar spray can be regarded dissemble economic method to improve plant nutrients (Girma et al., 2007). The use of *Moringa* leaf extract is a low-cost and environmentally secure method for enhancing crop yield by small farmers (Kanchani and Harris, 2019). MLE contains more phytohormones (Rehman et al., 2017) which would be used to promote plant growth directly or indirectly (Kurepin et al., 2014). The application of MLE increases the micro and macronutrients in the soil for yield increases in many

crops (Anyaegbu, 2014). MLE in many crops has some remarkable results such as bigger fruits and higher sugar levels (Foidl et al., 2001). Therefore, this research work aimed to determine the effect of *Moringa* leaf extract (MLE) spray with compost on the yield of cowpea (*Vigna unguiculate* L.) cv waruni.

II. MATERIALS AND METHOD

A. Experimental site

The study was performed at the home garden in the Eastern province of Sri Lanka, in 2020 to determine the effect of MLE spray in cowpea cultivation. This area is under the low country zone which is situated in the Latitude of 7° 17' 51.14" N and Longitude of 81° 40' 55.27". The annual temperature and rainfall of the province are 30±2°C and less than 1750 mm respectively. In this experiment, a completely randomized design (CRD) was employed with six treatments (Table 1) with five replicates.

B. Preparation of Moringa leaf extract

Moringa leaves were used to prepare *Moringa* leaf extract in this experiment. After collecting *Moringa* leaves, they were washed thoroughly with water to get rid of the dust particles and other foreign particles on the surface of the samples. They were spread on the blotting papers to remove excess water. *Moringa* leaves were shade dried for four days. The dried leaves were then made into powder using a blender. Subsequently, the powdered material was used to prepare the *Moringa* leaf extract (MLE) described by Nguemezi and Dzukam (2016), where 80 g of powdered leaves was macerated in 300 ml water subsequently the leaf extract was filtrated using a nylon cloth. The various concentrations of MLE were then prepared by adding water on a volume basis, as indicated in Table 1.

Table 1. Treatments used in this study.

Treatment code	Concentrations
T1	Control (water)
T2	10% MLE
T3	20% MLE
T4	30% MLE
T5	40% MLE
T6	50% MLE

MLE- *Moringa* leaf Extract

C. Agronomic practices

In this experiment, seeds of cowpea cv waruni were planted in polybags (30 cm length and 30 cm width) containing topsoil and compost (1:1 v/v). Watering was done every four days during the first three weeks and then every seven days. Foliar application of MLE (T2-T6) was made four times in two weeks intervals during the experimental period starting at the 3-5 leaf stage of cowpea plants after planting. MLE at a rate of 25 ml was sprayed on every plant at each application, and water was applied for the control (T1). Hand weeding was carried out at a one-week interval to maintain weed-free until the final harvest. Anthracnose was observed during the vegetative stage therefore, Mancozeb was used at the rate of 2 g/L.

D. Data collection

Plant height, leaf stalk, and leaflet numbers, and also dry weight of crop residues were taken as growth parameters and measurements were obtained at two weeks intervals during the vegetative phase. Pod weight, pod length, flower number for a plant, number of harvested pods, seed number and weight in a pod, 100 seed weight, pod and seed weights (g) for a plant and seed yield (g/m^2) were taken as yield parameters. Lengths of leaf stalks and pod were measured by using measuring tape while crop residue, pod and seed weights were measured by using electronic balance (SF- 400A). Data were collected from the two plants in each replicate,.

E. Statistical analysis

Statistical software (SAS 9.4 version) was used to analyze the measured data, and the treatment mean was compared using Duncan Multiple Range Test (DMRT) at P=0.05.

III. RESULTS AND DISCUSSION

The average plant height of cowpea from 4^{th} to 10^{th} weeks after planting is given in Table 2. The different MLE concentrations were affected remarkably ($P<0.01$) on plant height in the 8^{th} week and 10^{th} week. In 4^{th} week, the high value (31.42 cm) was noted in T5 followed by T6 (29.80 cm). The plant height of (21.40 cm) was recorded as the lowest plant height in T3. However, there was no remarkable variation among treatments (Table 2). At the 8^{th} and 10^{th} weeks, the significantly high plant height was recorded in T6 (187.84 cm and 231.64 cm) among treatments except for T5 and the low value was recorded in T1 (99.76 cm and 123.44 cm) respectively. MLE 50% (v/v) at two weeks intervals boosted plant growth, which may be as a result of plant growth stimulating substance available in MLE as stated by (Chattha et al., 2018).

Considerable differences ($P<0.05$) were noted in leaf stalk number among the treatments at the 8^{th} and 10^{th} weeks after planting and data showed non-significant variations among treatments at the 4^{th} and 6^{th} weeks (Table 3). In 4^{th} week, leaf stalk number was high in T2 (2.8) and low in T6 (2.2). On the other hand, in the 6^{th} week, the highest number of leaf stalks was observed in T6 (9.4) among treatments. In the 10^{th} week, the highly significant dissimilarity ($P<0.01$) was recorded among treatments and T6

reported remarkably highest number of leaf stalks (32.6) than other treatments except T5. According to the 10th week, the maximum number of leaf stalks was noted in 50% (v/v) *Moringa* leaf extract (T6) and minimum number of leaf stalks was observed in the control treatment (T1). High number of leaf stalks was recorded when *Moringa* leaf extract concentration was increased. Furthermore, these findings are inconsistence with Zaki and Rady (2015) reported that MLE increases crop growth due to zeatin presence in MLE which is accountable for cell growth in plants.

Table 2. Effects of *Moringa* leaf extract on plant height of cowpea.

Treatment codes	Treatments	Plant height (cm) at different weeks			
		4 week	6 week	8 week	10 week
T1	Water	26.60±2.08	95.46±18.61^{ab}	99.76±10.31^{c}	123.44±10.98^{b}
T2	10% MLE	26.76±2.93	83.76±9.42^{ab}	121.80±21.07^{bc}	130.96±8.05^{b}
T3	20% MLE	21.40±1.29	84.86±8.8^{ab}	107.62±7.23^{c}	138.92±7.38^{b}
T4	30% MLE	25.42±1.72	80.32±6.55^{b}	107.90±6.46^{c}	141.56±21.14^{b}
T5	40% MLE	31.42±2.29	108.64±14.03^{ab}	154.22±17.29^{ab}	203.52±19.14^{a}
T6	50% MLE	29.80±3.82	127.24±19.68^{a}	187.84±18.49^{a}	231.64±18.16^{a}
F test		P>0.05	P<0.05	P<0.01	P<0.01

MLE- *Moringa* leaf Extract. Mean values in a column having the similar letter/letters indicate non-significant variation according to Duncan Multiple Range Test at P=0.05.

Table 3. Influence of *Moringa* leaf extract on number of leaf stalks per plant of cowpea.

Treatments	Number of leaf stalks per plant at different weeks			
	4 week	6 week	8 week	10 week
T1	2.6±0.24	9.0±0.45	13.8±2.13^{b}	14.0±0.71^{b}
T2	2.8±0.20	9.0±0.77	11.0±0.55^{b}	14.8±0.37^{b}
T3	2.4±0.24	8.0±0.45	12.2±0.86^{b}	14.8±0.66^{b}
T4	2.6±0.24	9.2±0.20	12.0±0.45^{b}	15.8±1.96^{b}
T5	2.4±0.24	8.0±0.71	14.2±2.50^{b}	27.0±2.95^{a}
T6	2.2±0.20	9.4±0.60	21.6±3.96^{a}	32.6±3.7^{a}
F test	P>0.05	P>0.05	P<0.05	P<0.01

Mean values in a column having the similar letter/letters indicate insignificant difference according to Duncan Multiple Range Test at p=0.05.

Leaves are important plant parts for photosynthesis thus increase in the number of leaves causes high crop productivity. The leaflet number in a plant was considerably (P<0.05) differed among treatments at the 8th - 10th weeks. They did not remarkably influence (P>0.05) the leaflet number per plant in the 4th and 6th weeks after planting (Table 4). In 4th week after planting, the high leaflet number per plant was observed in T2 (11.2) and the low leaflet number per plant was noted in T1 (8.8).

In 6th week after planting, a high leaflet number was observed in T6 (29.4) while it was low in T1 (23.8). In the 8th and 10th week, the high value was noted in T6 (50.4 and 82.6) respectively whereas the low value was observed in T1. Results showed clearly that foliar spray of 50% (v/v) MLE raised the leaflet number of a plant at 8 and 10 weeks after planting. The findings are in concurrence with Mohammed et al. (2013) stated that MLE treatment with 50% onion plants produced more leaves and a number of bulbs.

Figure 1 shows the effect of *Moringa* leaf extract application on flower numbers of T1, T5 and T6 at weekly intervals. In cowpea plants, flowering was started in 8th week after planting. T5 showed the highest number of flowers in the 14th week after planting (8.4). In the early weeks of flowering, T1 showed a high number of flowers compared to T5 and T6, but the gradually number of flowers reduced in T1 (control) compared to the plants that were treated with 40% of MLE (T5) and 50% of MLE (T6) at two weeks interval. According to the graph, the maximum number of flowers on plants showed by T6 compared to the T1 (control) from the 9th week. Therefore, the foliar spray of MLE 50% enhanced the flower formation in T6 than that in the control (T1). The use of plant growth regulators produces a high boll number in a plant from Bt cotton cultivar at 45 and 90 days after flowering (Sawan et al., 2006; Gebaly, 2011).

A remarkable difference (P>0.05) in pod length was not noticed between the treatments (Figure 2). Mean length values ranged from 16.13 cm to 17.72

cm at harvest after planting. The pod length (17.72 cm) was highest in T5 when treated with 40% (v/v) concentration of MLE and the pod length (16.13 cm) was lowest in T4 (30% concentration of MLE). Figure 3 shows the effect of *Moringa* leaf extract on cowpea pod length at each picking. At 1st picking, T6 showed the highest pod length (18.86 cm) and T1 showed the lowest pod length (16.93 cm) than the other treatments. At 2nd picking, the pod length was high (19.49 cm) in T6 which was treated by 50% MLE and the lowest pod length was 16.24 cm (T1) control. At 3rd picking, T5 showed the highest pod length (17.85 cm) and at 4th picking, T2 showed the highest pod length compared to other treatments. The increment in the fruit length was reported in snap beans (Emongor, 2015).

Table 4. Effects of *Moringa* leaf extract on number of leaflets of cowpea.

Treatments	Number of leaflets at different weeks			
	4 week	6 week	8 week	10 week
T1	8.8±0.58	23.8±1.88	30.8±2.18^{c}	36.8±2.18^{b}
T2	11.2±0.66	25.2±2.48	32.6±0.51^{c}	39.4±1.47^{b}
T3	9.8±0.97	26.0±0.95	34.2±1.28^{bc}	40.8±0.58^{b}
T4	11.0±1.48	26.2±2.15	37.0±5.76^{bc}	42.4±5.71^{b}
T5	9.4±0.81	27.0±0.55	46.8±2.03^{ab}	68.0±7.77^{b}
T6	9.0±0.63	29.4±1.40	50.4±7.70^{a}	82.6±7.16^{a}
F test	P>0.05	P>0.05	P<0.05	P<0.01

Mean values in a column having the similar letter/letters indicate non-significant variation according to Duncan Multiple Range Test at p=0.05.

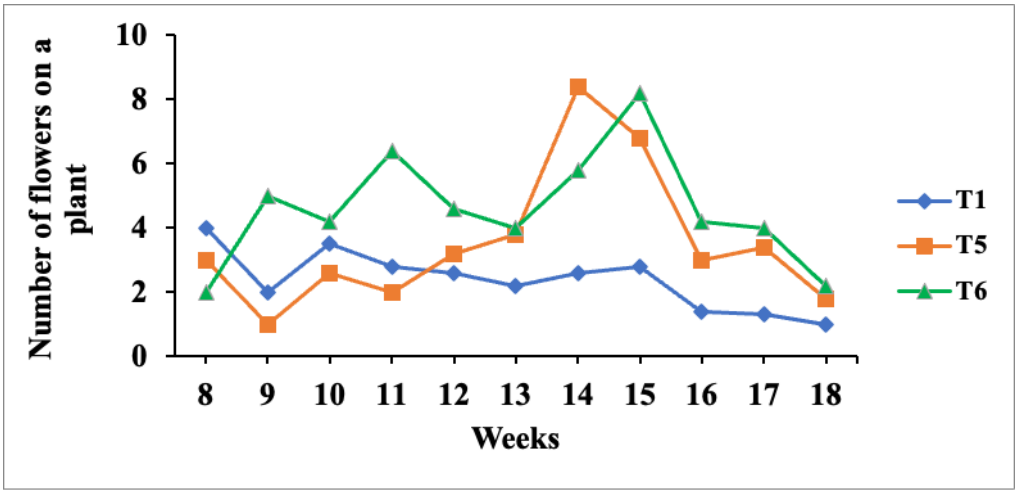

Figure 1. Effects of *Moringa* leaf extract on number of flowers on a cowpea plant.

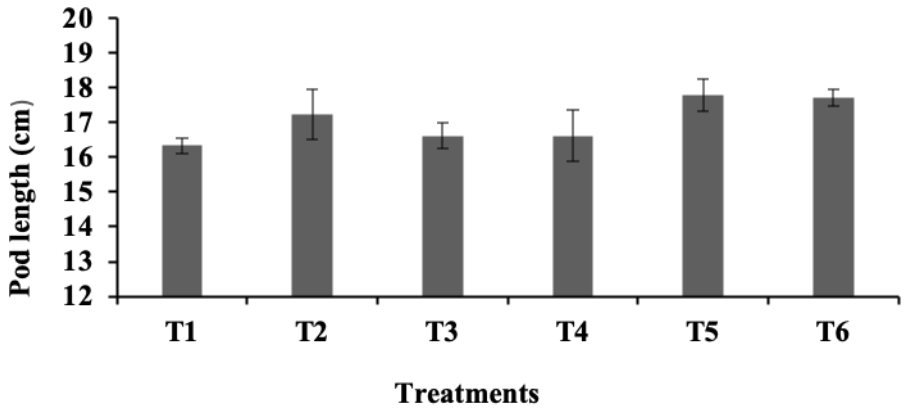

Figure 2. Effects of *Moringa* leaf extract on pod length of cowpea plant at harvest.

Foliar usage of MLE had a considerable effect d on the single pod weight in cowpeas (Table 5). The mean values of pod weight ranged from the highest value of 4.49 g (T6) to the lowest value of 2.90 g (T1). Figure 3 represents the influence of *Moringa* leaf extract on the pod length of cowpea at picking times. According to Figure 4, the 4th picking time showed a low value of pod weight compared to other picking times. At 1st picking time, T6 exhibited the highest value of 4.53 g and T2 showed the lowest value of 3.2 g. At 2nd and 3rd picking times, T6 gave the highest pod weight and T1 gave the lowest pod weight. At 4th picking period also the maximum value showed by T6 (2.73 g) and the minimum value showed by T1 (2.13 g). According to the analysed results, the foliar use of 50% MLE increased the single pod weight. An increase in fruit weight may result because of the availability of high levels of potassium and zinc content in MLE. Potassium has the competence to enhance fruit quality (Ramezani and Shekafandeh, 2011). This increase in the weight of pods is possibly a result of the cytokinin contribution that stimulates cell enlargement and division (Gebaly, 2011).

Table 5. Influence of *Moringa* leaf extract on pod weight and harvested pod number per plant, number of seeds per pod and 100 seed weight

Treatments	Single pod weight (g)	Number of harvested pods	Number of seeds per pod	100 seed weight (g)
T1	2.90±0.30^{b}	7.8±0.58^{c}	10.86±0.56^{c}	21.15±0.95^{b}
T2	3.13±0.20^{b}	8.2±0.37^{c}	11.61±0.64^{bc}	21.51±1.19^{b}
T3	3.56±0.24^{b}	9.0±0.84^{bc}	11.71±0.35^{bc}	21.98±1.05^{ab}
T4	3.76±0.44^{b}	11.0±2.28^{abc}	12.21±1.16^{abc}	22.54±1.12^{ab}
T5	4.28±0.51^{a}	12.0±1.79^{ab}	13.18±0.36^{ab}	23.76±1.85^{ab}
T6	4.49±0.09^{a}	13.6±1.44^{a}	14.02±0.37^{a}	23.90±0.50^{a}
F test	P<0.01	P<0.01	P<0.05	P<0.05

Mean values in a column having the similar letter/letters indicate insignificant difference according to Duncan Multiple Range Test at P=0.05.

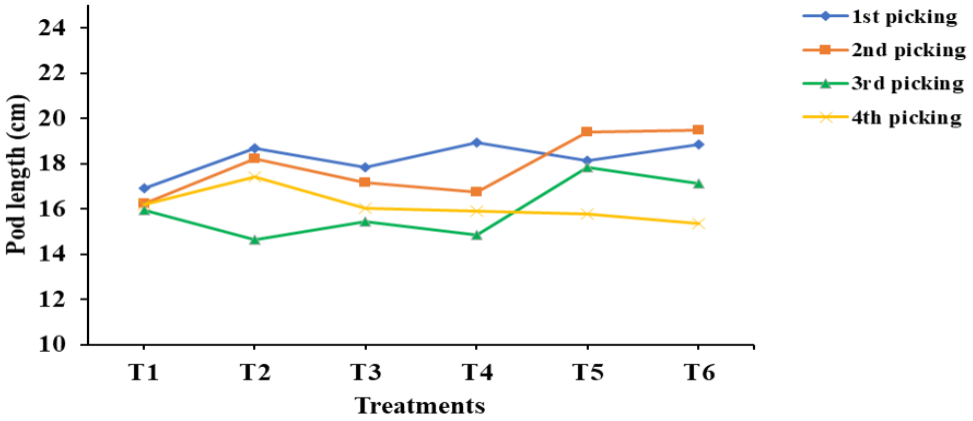

Figure 3. Effects of *Moringa* leaf extract on pod length of cowpea plant at pickings.

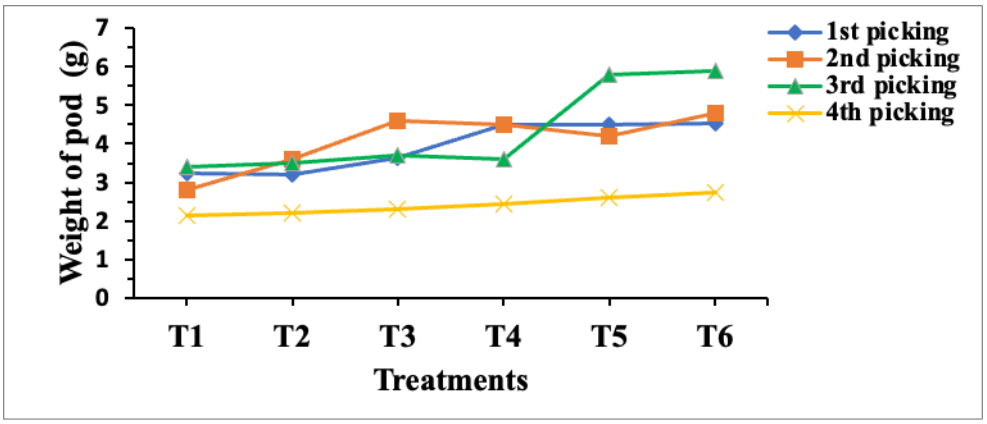

Figure 4. Effects of *Moringa* leaf extract on pod weight of cowpea at different pickings.

Data obtained on the mean harvested pod number per plant is given in Table 5. The mean value ranged from 7.8 (T1) to 13.6 (T6). Foliar use of 50% MLE remarkably ($P<0.05$) increased the number of harvested pods than control (T1). The MLE is abundant in adequate amounts of vital phytohormones such as cytokinin and gibberellic acid (Makkar et al., 2007). The MLE exhibited a noteworthy result ($p<0.05$) on seed number per pod (Table 5). The mean values range from the highest value of 14.02 (T6) to the lowest value of 10.86 (T1). Thus, 50% MLE influenced to increase in seed number per pod than T1 treatment. This is supported by Afzal et al. (2015) who documented that in wheat, MLE enhanced grain number in a spike.

A remarkable difference was noted in 100 seed weights among treatments (Table 5). A maximum 100 seed weight was noticed in T6 (23.9 g) and a minimum value of 100 seed weight was recorded in T1 (21.15 g). Foliar use of MLE remarkably ($p<0.05$) influenced the 100 seed weight. Merwad (2017) also mentioned that all treatments of MLE significantly increased the 100 seed weight of the pea plant. The increase in dry mass accumulation stimulated by MLE was ascribed to the influence of endogenous cytokinins on assimilate distribution (Emongor, 2015). Treatments considerably varied ($P<0.05$) in seed weight for a cowpea plant (Table 6). The mean value ranged from 15.90 g (T1) to 38.60 g (T6). Maximum seed weight (38.60 g) was recorded in T6 while the least seed weight (15.90 g) was recorded in T1. The 50% MLE (T6) significantly enhanced ($P>0.05$) seed weight per plant than other treatments (T1-T4) except T5. Zeatin hormone in the extract responds to increasing yield clearly explained by Biswas et al. (2016).

The dry weight of crop residues (leaves, shoots, roots and stems) in the 18th week after planting is shown in Table 6. Statistical analysis of data related to dry weights of crop residues exhibited notable differences ($P<0.01$) among the treatments. Maximum dry weight (99.00 g) was recorded in T6 that was treated with 50% (v/v) concentration of MLE and minimum dry weight (27.33 g) was observed in plants treated with control treatment (T1). On account of the availability of zinc, MLE helps increase biomass accumulation (Cakmak, 2008).

Table 6. Effects of *Moringa* leaf extract on seed weight per plant, dry weight of crop residues per plant and seed yield of cowpea

Treatments	Seed weight (g) per plant	Dry weight of crop residues (g) per plant	Seed yield (g/m^2)
T1	15.90±2.49^{c}	27.33±01.45^{c}	193.56±27.71^{b}
T2	17.42±2.06^{c}	29.31±05.61^{c}	176.67±22.91^{b}
T3	20.60±2.31^{bc}	38.33±05.84^{bc}	228.89±25.62^{b}
T4	22.92±5.63^{bc}	51.32±12.20^{bc}	254.67±62.56^{ab}
T5	30.68±4.29^{ab}	62.67±02.91^{b}	340.89±47.68^{ab}
T6	38.60±3.87^{a}	99.00±16.20^{a}	428.89±42.97^{a}
F test	P<0.01	P<0.01	P<0.01

Mean values in a column having the similar letter/letters indicate non-significant variation according to Duncan Multiple Range Test at P=0.05%.

The highest yield was obtained in T5 (428.98 g/m^2) and the minimum yield was recorded from T1 (193.56 g/m^2) (Table 6). Therefore, it is clear that considerable increase in yield with foliar spray of 50% MLE than T1. Prabhu et al. (2010) stated that the MLE applied at 2% is caused by the increased dry herbage yield of sacred basil. Fernando and Seran (2023) reported that application of compost 14.3 t/ha) with 1.3 t/ha banana peel and *Moringa* leaf powders at a 1:1 ratio (w/w) increase seed yield of green gram in sandy regosol. when compared with compost alone

IV. CONCLUSION

The result revealed that foliar MLE spray remarkably ($P<0.05$) increased the cowpea yield than the control treatment. Among treatments, 40-50% MLE applied once in two weeks exhibited higher values in most of the measured parameters than the control treatment. Hence, naturally available and eco-friendly *Moringa* leaf extract at 40-50% concentration with compost could be used as a foliar spray for obtaining high yield in cowpea cultivation.

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