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Foliar Application of Tropical Trees Leaf Extract for Improve Growth and Yield of Blackgram [*Vigna mungo* (L). Hepper]

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Blackgram (*Vigna mungo* L.), the most important pulse crop is grown throughout India. The productivity of blackgram in India is relatively low compared to the world's average productivity. Nowadays for improving productivity foliar spraying of nutrients plays a major role. The available synthetic formulations for foliar spraying are polluting and highly expensive. Hence, the leaf extracts of tropical trees can be utilized as an alternative source since they have enormous bioactive compounds able to stimulate plant growth and improve productivity without any harmful effects.

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Therefore, the present study was conducted on a sandy loam farm of The Indian Agriculture College, Radhapuram from March 2023 to May 2023 to evaluate the effect of leaf extracts like *Moringa oleifera* (Moringa), *Annona squamosa* (Custard apple) and *Nerium oleander* (Nerium) at different concentration *viz.,* 5% and 10% on cultivation of blackgram crop, variety VBN 8. The results revealed that foliar spraying of *Moringa oleifera* leaf extract @ 10% + RDF significantly improves the growth components like plant height (27.87 cm and 34.6 cm at 35 DAS and 50 DAS respectively), LAI (2.87 and 4.06 at 35 DAS and 50 DAS respectively), dry matter accumulation (141 g/m^2 and 266 g/m^2 at 35 DAS and 50 DAS respectively), Crop growth rate (5.77 and 8.33 g/m^2/day at 20 to 35 DAS, 35 to 50 DAS respectively), Relative Growth Rate (0.064, 0.042 g/g/day at 20 to 35 DAS, 35 to 50 DAS respectively) and yield attribute like average number of pods per plant (36.9) and seed yield (648 kg/ha) over other treatments and it was on par with RDF + Foliar application of Custard apple leaf extract @ 10%.

Keywords: Blackgram; leaf extract; Moringa olifera; high yield; eco-friendly.

1. INTRODUCTION

Pulses are the second most important crop in Indian agriculture after cereals due to their high protein content and significant role in the human diet. Among the pulses, blackgram botanically *Vigna mungo* (L.) Hepper is the third most important crop after bengalgram and redgram since it contains high-quality protein (25g/100g) with good digestibility along with water-soluble vitamins *viz.*, niacin, riboflavin, and thiamine, etc.) and minerals like Iron, copper, calcium, magnesium and phosphorus also present [1,2].

In India, blackgram productivity is lower than average world productivity due to a lack of quality seeds, growing under marginal and less fertile soil with residual moisture conditions, poor nutrient management, and unscientific post-harvest and storage practices [3]. The productivity of blackgram can be greatly increased by using high-yielding varieties and improved nutrient management techniques [4]. Nowadays, farmers depend on fertilizers and synthetic growth regulators to meet the nutrient demand of the crop [5,6,7]. Indiscriminate and unscientific usage of these synthetic sources deteriorates soil fertility, causing environmental pollution, contaminating the soil and water bodies, and causing ill effects to humans [8,9].

As an alternate option, many researchers are focusing on biostimulants, which contain a diverse group of phenological compounds like phenols, flavonoids, minerals, and natural phytohormones directly and indirectly improve the plant metabolic processes [10]. Biologically active ingredients can be extracted from various plant parts of trees like *Moringa oleifera*, *Pongamia pinnata, Annona squamosa, Nerium oleander, and Morinda tinctoria* [11,12,13]. These Plant extracts are effective as growth stimulants, pest and disease control agents. Moringa, bael, notchi, and Albizia amara tree leaf extracts have nutritional, insecticidal, and fungicidal properties [14]. Similarly, the tree leaf extracts had improved the growth and yield of the crops [15,14,16,17]. However, the standardization of various leaf extracts with effective concentration is need to be studied. The present study was, therefore, planned and conducted to evaluate the effect of foliar spraying of leaf extract from different tropical trees at different concentrations on the growth and yield of blackgram.

2. MATERIALS AND METHODS

The field experiment was conducted at a sandy loam farm of The Indian Agriculture College, Radhapuram during March 2023 to May 2023 to study the effect of foliar spraying of leaf extract from different tropical trees on the growth and yield of black gram (*Vigna mungo*). The farm is geographically located at 8°15' N latitude and 77°39' E longitude at an elevation of 426.7 m above Mean Sea Level. The field is located in the southern agro climatic zone of the Tamil Nadu. Blackgram VBN 8 was used as the variety with having the duration of 65 to 70 days, specifically suitable to summer irrigated condition, having resistant to Mungbean Yellow Mosaic Virus (MYMV), leaf crinkle and moderately resistant to powdery mildew diseases. The experiment was laid out in randomized block design and replicated thrice with gross plot size of 20 m^2 (5.0 m x 4.0 m), border area of 0.48 m^2, sampling area of 0.48 m^2 and net plot area of 8.32 m^2. The objective of the study was to find the influence of leaf extracts on vegetative growth, yield and economics in blackgram cultivation.

2.1 Treatment Details

T_1 – RDF + Foliar application of Moringa leaf extract @ 5%
T_2 - RDF + Foliar application of Moringa leaf extract @ 10%
T_3 - RDF + Foliar application of Custard apple leaf extract @ 5%
T_4 - RDF + Foliar application of Custard apple leaf extract @ 10%
T_5 - RDF + Foliar application of Nerium leaf extract @ 5%
T_6 - RDF + Foliar application of Nerium leaf extract @ 10%
T_7 – RDF (control)

The recommended dose of fertilizer applied as per the guidance of TNAU crop production guide 2022. The leaf extracts for each species were prepared by grinding fresh leaves and distilled water at 1:1 proposition and the juice was extracted by hand pressure and was filtered through the cheese cloth. The extract was re-filtered by using Whatman No.2 filter paper and this served as a stock solution [15]. From the stock solution 5% and 10% solution was made and sprayed in the respective plots on 15, 25 and 35 DAS (Initial two sprays at vegetative stage and third spray at flowering stage). The performance was compared with control.

Data was collected on growth components *viz.,* plant height, Leaf Area Index and Dry Matter Production at 20, 35 and 50 DAS and yield attributes like grain yield, haulm yield and harvest Index at harvest subjected to statistical analysis as per the procedure given by Gomez and Gomez [18]. In addition, the crop growth rate (CGR) and relative growth rate (RGR) of blackgram were calculated on dry weight basis. The average CGR of plants/m^2 for a time “t” is defined as the enhance in dry weight “w” of plants/hill from a unit area per unit time. It was calculated using the periodic dry matter recorded at different stages [19].

$$CGR\ (g/m^2/day) = 1/A \times (W_2 - W_1) / (t_2 - t_1)$$

The immediate RGR of plants within a specific time interval "t" is precisely defined as the growth in dry biomass of the plants/unit of time. The RGR of the crop was computed as Radford [19].

$$RGR\ (g/g/day) = (\log W_2 - \log W_1) / (t_2 - t_1)$$

The economics of the experiment also calculated. For treatment differences found significant, critical difference was worked out at five percent probability level and values were furnished. Treatment differences that were not significant were denoted as "NS".

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

The performance of growth parameters is judged by observing parameters like plant height and leaf area index (LAI) in blackgram.

3.2 Plant Height (cm)

All the foliar leaf extract treatments exerted a significant influence on the height of blackgram plants at all stages during the ontogeny of the crop (Table 1). At 20 DAS, the plant height did not differ significantly due to the application of different foliar spray treatments. At 35 and 50 DAS, RDF + FA of Moringa LE @ 10 % (T_2) recorded significantly higher plant height (27.87, 34.60 cm respectively) over other treatments. It was on par with RDF + FA of Custard apple LE @ 10% (T_4) (25.02, 32.97 cm respectively). Taller plant was produced in the treatment with foliar spray of 10% moringa leaf extract might be due to a consistent supply of nutrients to the black gram plant, which might have released the nutrient present in the leaves resulting in increased cell division and cell elongation, thereby increased the plant height. Similar observations were supported by Biswas *et al*. [15] Chattha *et al*. [20] in maize and Merwad 2018 in peas. The control recorded lower plant height at both 35 and 50 DAS (21.93, and 27.80 cm respectively), since there was no external application of an organic source of nutrients.

3.3 Leaf Area Index

The Leaf Area Index (LAI) determines the total assimilating area available for translocation to the sink and shows a differential response. The LAI was significantly increased by foliar feeding of nutrients (Table 1). At 20 DAS, the LAI did not differ significantly due to the application of different foliar spray treatments. At 35 and 50 DAS, RDF + FA of Moringa LE @ 10% (T_2) recorded significantly higher LAI (2.87, 4.06 respectively) over other treatments. It was on par with RDF + FA of Custard apple LE @ 10% (T_4) (2.72, 3.86 at 35 and 50 DAS respectively). This could be because the crop had received nutrients at different stages of growth, which would have increased the LAI. The result findings accorded with Ngcobo and Bertling [21] and observed the

leaf area increased with the application of moringa leaf extract in cherry Tomato. Abohassan and Abusuwar [22] also found that the availability of higher concentrations of hormones like cytokinins increases the leaf area in green gram. The control recorded the least LAI (2.05 and 2.92 at 35 and 50 DAS respectively) this might be due to the low level of nutrients in the soil hence the utilization would have been also lower side.

3.4 Physiological Parameters

The transition of photosynthates from the leaves, which is the source to the other parts of the plant, could be explained all by the physiological changes in the crop. These physiological parameters were expressed through dry matter accumulation, crop growth rate, and relative growth rate.

3.5 Dry Matter Accumulation

Dry matter accumulation of plants was increased linearly at all stages of crop growth. Foliar application of leaf extracts significantly influenced the phytomass production of blackgram crop at all the stages (Table 2). At 20 DAS, the dry matter accumulation did not differ significantly due to the application of different foliar spray treatments. The maximum production of dry matter was observed under RDF + FA of Moringa LE @ 10% (T_2) (141 and 266 g/m^2, respectively at 35 and 50 DAS). The next best treatment was RDF + FA of Custard apple LE @ 10% (T_4) (121 and 212 g/m^2 at 35 and 50 DAS respectively). This might be due to better uptake of nutrients through foliar spray, improved plant growth, more photosynthate assimilation because of increased assimilatory surface area and specific weight Shwetha, [23]. Hoque *et al.* [24] reported that the root dry weight of Tomato and wheat increased with the application of moringa leaf extract. Biswas *et al*. [15] revealed that spraying of moringa leaf extract increased the vegetative growth and dry weight of root and shoot of many field crops due to the presence of secondary metabolites. Control plots consistently recorded the lower DMP of the crop at all stages of observation due to the competition exerted by nutrients.

3.6 Crop Growth Rate and Relative Growth Rate

Crop growth rate (CGR) and Relative Growth rate (RGR) are derived with biomass over time unit, hence these parameters improved with the corresponding increase in dry matter accumulation Arunvenkatesh, [25]. The crop growth rate and relative growth rate were significantly influenced with the foliar application of leaf extracts (Table 3). Higher CGR was observed with RDF + FA of Moringa LE @ 10% (T_2) recording 5.77 g/m^2/day between 20 to 35 DAS and 8.33 g/m^2/day between 35 DAS to 50 DAS compared to other treatments, which could be attributed to variation in leaf area. Gifford and Jenkins [26] reported that leaf area was the powerful determinant of variation in growth rate. Moringa leaf extracts have high nitrogen content, which is important for the rapid growth and best possible production of crops Tam and Cong [27] Hoa and Thanh [28]. In addition, moringa plant extracts also contain various antioxidant compounds like zeatin, ascorbic acid, phenolic, flavonoids, vitamin E, minerals, and many other growth hormones like indole-3-acetic acid (IAA), and gibberellins (GAs) [29,30].

Table 1. Response of black gram to foliar application of leaf extracts on plant height (cm) and leaf area index

Treatment	Plant height (cm)			Leaf Area Index		
	20 DAS	35 DAS	50 DAS	20 DAS	35 DAS	50 DAS
T_1 – RDF + FA of Moringa LE @ 5%	16.76	24.43	31.03	1.61	2.34	3.61
T_2 - RDF + FA of Moringa LE @ 10%	16.57	27.87	34.60	1.49	2.87	4.06
T_3 - RDF + FA of Custard apple LE @ 5%	16.97	24.87	31.37	1.45	2.28	3.43
T_4 - RDF + FA of Custard apple LE @ 10%	17.23	25.02	32.97	1.59	2.72	3.86
T_5 - RDF + FA of Nerium LE @ 5%	15.46	23.17	30.24	1.36	2.6	3.34
T_6 - RDF + FA of Nerium LE @ 10%	17.07	23.73	30.67	1.42	2.26	3.31
T_7 – RDF (control)	16.9	21.93	27.80	1.45	2.05	2.92
S.EM	0.69	0.99	1.26	0.06	0.10	0.14
CD @ 5%	NS	2.99	3.81	NS	0.29	0.43
MEAN	16.71	24.43	31.24	1.48	2.45	3.50

RDF – Recommended dose of fertilizer, FA - foliar application, LE - leaf extract, DAS – days after sowing

Table 2. Response of black gram to foliar application of leaf extracts on dry matter accumulation (g/m^2)

Treatment	Dry matter accumulation (g/m^2)		
	20 DAS	35 DAS	50 DAS
T_1 – RDF + FA of Moringa LE @ 5%	52	125	193
T_2 – RDF + FA of Moringa LE @ 10%	54	141	266
T_3 – RDF + FA of Custard apple LE @ 5%	50	129	190
T_4 – RDF + FA of Custard apple LE @ 10%	55	121	212
T_5 – RDF + FA of Nerium LE @ 5%	47	118	173
T_6 – RDF + FA of Nerium LE @ 10%	49	115	167
T_7 – RDF (control)	50	112	154
S.EM	2.11	5.00	7.78
CD @ 5%	NS	15.16	23.59
MEAN	51	123	193

RDF – Recommended dose of fertilizer, FA – foliar application, LE – leaf extract, DAS – days after sowing

Table 3. Response of black gram to foliar application of leaf extracts on crop growth rate (g/m^2/day) and relative growth rate (g/g/day)

Treatment	Crop Growth Rate (g/m^2/day)		Relative Growth Rate (g/g/day)	
	20 to 35 DAS	35 to 50 DAS	20 to 35 DAS	35 to 50 DAS
T_1 – RDF + FA of Moringa LE @ 5%	4.81	4.53	0.058	0.029
T_2 – RDF + FA of Moringa LE @ 10%	5.77	8.33	0.064	0.042
T_3 – RDF + FA of Custard apple LE @ 5%	5.25	4.12	0.063	0.026
T_4 – RDF + FA of Custard apple LE @ 10%	4.37	6.07	0.052	0.038
T_5 – RDF + FA of Nerium LE @ 5%	4.79	3.65	0.062	0.025
T_6 – RDF + FA of Nerium LE @ 10%	4.36	3.51	0.056	0.025
T_7 – RDF (control)	4.12	2.82	0.054	0.021
S.EM	0.193	0.190	0.002	0.001
CD @ 5%	0.584	0.576	0.007	0.003
MEAN	4.78	4.72	0.06	0.03

RDF – Recommended dose of fertilizer, FA – foliar application, LE – leaf extract, DAS – days after sowing

Table 4. Response of black gram to foliar application of leaf extracts on yield attributes and yield

Treatments	No. of pods/ plant	No. of seeds/ pod	100 seed weight (g)	Grain Yield (kg/ ha)	Haulm Yield (kg/ ha)
T_1 – RDF + FA of Moringa LE @ 5%	30.10	5.70	4.88	554	1204
T_2 – RDF + FA of Moringa LE @ 10%	36.90	6.00	5.26	648	1360
T_3 – RDF + FA of Custard apple LE @ 5%	28.50	5.50	4.65	512	1168
T_4 – RDF + FA of Custard apple LE @ 10%	33.70	5.90	5.12	604	1296
T_5 – RDF + FA of Nerium LE @ 5%	25.20	4.70	4.44	462	1098
T_6 – RDF + FA of Nerium LE @ 10%	26.00	5.20	4.52	486	1124
T_7 – RDF (control)	22.30	4.40	4.07	435	1002
S.EM	1.29	0.22	0.20	27.24	50.79
CD @ 5%	3.9	NS	NS	83.93	156.5
MEAN	28.96	5.34	4.70	531	1178

RDF – Recommended dose of fertilizer, FA – foliar application, LE – leaf extract, DAS – days after sowing

Similarly, Higher RGR was observed with RDF + FA of Moringa LE @ 10% (T_2) recording 0.064 g/g/day between 20 to 35 DAS and 0.042 g/g/day between 35 DAS to 50 DAS compared to other

treatments. RGR declined at later stages of crop growth which might be due to partitioning of extra photosynthates towards the developing sink during reproductive development.

3.7 Yield Parameters and Yield

Yield is a function of number of pods per plant, pod length, number of seeds per pod, and test weight. The positive changes in majority of the yield parameters will favourably influence the yield.

3.8 No. of Pods Plant^{-1}, Number of Seeds Per Pod^{-1} and 100 Grain Weight (Table 4)

The number of pods per plant was significantly influenced by the different foliar sprays of nutrients. The Number of pods per plant was higher (36.9) with the RDF + FA of Moringa LE @ 10 % (T_2). The next best treatment was RDF + FA of Custard apple LE @ 10 % (T_4) recorded as 33.7. The lower value was recorded with control treatment (22.3). Abohassan and Abusuwar [22] also revealed that the number of pods get increased in mungbean with the application of moringa leaf extract. This could be because of availability of higher concentration of fibre, sugars, protein, vitamins, phenolics, free proline and phytohormones like gibberellins, cytokinins, and auxins in moringa leaf extract Mashamaite *et al*., [11]. The enhanced availability of nutrients increases the photosynthetic activity, biomass production and flowering [7].

The effect of foliar application of leaf extracts on number of seeds per plant and 100 grain weight are not differed significantly. The number of seeds per pod ranges between 4.57-6.00 and 100 grain weight ranges between value 4.07-5.26. It was in close similarity with Nivethadevi *et al.* [14]. The better performance of the 10% moringa leaf extract may be attributed to the higher values of growth and physiological characters as evidenced from this study. These findings are in confirmation with Gunasekar *et al.* [31]. The higher concentration of micronutrients in the foliar spray of 10% moringa leaf extract is also responsible for higher yield in blackgram.

3.9 Grain Yield

In summer irrigated black gram the RDF + FA of Moringa LE @ 10 % (T_2) recorded the higher grain yield of 648 kg/ha and it was comparable with the RDF + FA of Custard apple LE @ 10 % (T_4) (604 kg/ha). The lower yield was recorded in control plot (435 kg/ha) (Table 4). The increase in grain yield due to frequent application of moringa leaf extract was mainly due to the improvement of growth parameters like plant height, shoot length, fresh and dry weight of shoot and yield components like number of pods/plant, number of seeds per pod and 100 seed weight. The more number of leaves might have increased the photosynthates which could have led to a better source - sink relationship to accumulate more of the stored food. The increased plant height and dry matter production per plant improves the yield components and yield of urdbean (Shweta, 2016). Our finding is accorded with a few previous reports, Yaseen and Hajos [32] reported that the application of moringa leaf extract with the concentration of 10% increased the yield of lettuce and spinach. In another study Brockman et al. [33] found that the application of 10% MLE concentration increased grain yield of wheat by 19% with testing of various MLE concentrations; however, yield increases at higher MLE concentrations were not statistically significant. They also suggested that Nutrient use efficiency of phosphorous and potassium has improved with the application of moringa leaf extract hence the yield has been increased. The foliar application of tree leaf extracts increased yield and nutrition of black gram, due to the presence of microelements and plant growth regulators likely iron, calcium and potassium, amino acids, ascorbic acid, phenolics and Zeatin [10]. Similar observation was recorded by Chanthanousone *et al*. [16] in lettuce and spinach and Irshad *et al.* [17] in chickpea. The Control treatment recorded lower yield. This might be due to low level of nutrients in the soil.

3.10 Haulm Yield

The data pertaining to haulm yield of blackgram recorded in different foliar applications of leaf extract treatments are presented in Table 4. Significant differences among the leaf extract treatments were observed with respect to haulm yield. RDF + FA of Moringa LE @ 10 % (T_2) recorded the maximum haulm yield (1360 kg/ha) followed by RDF + FA of Custard apple LE @ 10 % (T_4). The control plot (T_7) recorded the lower haulm yield (1002 kg/ha). Our finding is accorded with previous study, Merwad [34] found that the application of 4% moringa leaf extract increases the biological yield of pea.

Table 5. Response of black gram to foliar application of leaf extracts on economics

Treatments	Cost of cultivation (Rs.)	Gross income (Rs.)	Net income (Rs.)	B: C Ratio
T_1 – RDF + FA of Moringa LE @ 5%	33550	44320	10770	1.32
T_2 - RDF + FA of Moringa LE @ 10%	33550	51840	18290	1.54
T_3 - RDF + FA of Custard apple LE @ 5%	33550	40960	7410	1.22
T_4 - RDF + FA of Custard apple LE @ 10%	33550	48320	14770	1.44
T_5 - RDF + FA of Nerium LE @ 5%	33550	36960	3410	1.10
T_6 - RDF + FA of Nerium LE @ 10%	33550	38880	5330	1.15
T_7 – RDF (control)	32350	34800	2450	1.07
S.EM	1372	1706	381	0.05
CD @ 5%	NS	5259	1176	0.16
MEAN	33378	42297	8918	1.26

RDF – Recommended dose of fertilizer, FA - foliar application, LE - leaf extract, DAS – days after sowing

3.11 Economics

In any management practices, the benefit cost analysis needs to be focused to assess its suitability for adoption. The farmer is ultimately interested in a higher productivity coupled with quality and finally net gain over the cost invested. The most economic returns of a crop could be achieved either by increasing its production through judicious management practices or improving the quality of the produce to get premium price in the market.

The data on economics *viz*., cost of cultivation, gross return, net return and B: C ratio of irrigated blackgram influenced by various leaf extract treatments are presented in Table 5.

RDF + FA of Moringa LE @ 10 % (T_2) registered maximum gross return, net return and B: C ratio (Rs. 51840/ha, Rs.18290/ha and 1.55, respectively) followed by RDF + FA of Custard apple LE @ 10 % (T_4). This might be due to the availability of nutrient at lower cost through plant *spp*. which minimized the expenditure on inorganic fertilizers [35]. The control recorded the lower net return and benefit cost ratio. This may be attributed to the lower yield recorded in the control. The 10 per cent leaf extract of *Moringa oleifera* as foliar application may improve the quality of black gram in addition to higher price and without much scarification of yield.

4. CONCLUSION

The study highlights about planned and conducted to evaluate the effect of foliar spraying of leaf extract from different tropical trees at different concentrations on the growth and yield of blackgram. From the above study foliar application of 10 per cent leaf extract of *Moringa oleifera* along with RDF may improve the growth and yield of blackgram. Leaf extract of *Annona squamosa* can also be substituted for *Moringa oleifera* as a foliar spray. Since, Moringa leaf extract is an affordable, sustainable, environmentally safe and natural bio stimulant that can be applied to enhance the growth and productivity of blackgram.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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