International Journal of Plant & Soil Science

Volume 36, Issue 8, Page 391-399, 2024; Article no.IJPSS.120415
ISSN: 2320-7035

Effect of Foliar Application of Moringa (*Moringa oleifera*) Leaf Extract and Potassium on Yield and Economics of Blackgarm

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Authors' contributions

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

Article Information

DOI: https://doi.org/10.9734/ijpss/2024/v36i84868

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/120415

Original Research Article

Received: 25/05/2024
Accepted: 27/07/2024
Published: 31/07/2024

ABSTRACT

A field experiment was conducted during Rabi, 2023-24 at Krishi Vigyan Kendra, Palem, to evaluate the effect of foliar application of moringa (*moringa oleifera*) leaf extract (MLE) and potassium on yield and economics of blackgarm**.** The experiment was laid out in a Randomized Block Design with

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Cite as: *Laxmi, Y. Vijaya, T. Prabhakar Reddy, K. Pavan Chandra Reddy, and S.G. Mahadevappa. 2024. "Effect of Foliar Application of Moringa (Moringa Oleifera) Leaf Extract and Potassium on Yield and Economics of Blackgarm". International Journal of Plant & Soil Science 36 (8):391-99. https://doi.org/10.9734/ijpss/2024/v36i84868.*

three replications. The results of this experiment revealed that application of 100% RDF + 20 kg MOP as basal + 8% MLE at 30 and 45 DAS recorded significantly higher no of pods per plant (25.23), seeds per pod (7.8), test weight (42.87 g) seed yield (1757 kg ha^{-1}) and stover yield (2738 kg ha^{-1}). In terms of economic analysis, this treatment also exhibited the highest gross returns (₹ 1,47,588 ha^{-1}), net returns (₹ 93,119 ha^{-1}) and BC ratio (2.71). Conversely, the control recorded the lowest no of pods per plant (11.13), seeds per pod (3.9) test weight (28.96 g) seed yield (572 kg ha^{-1}), stover yield (1434 kg ha^{-1})., as well as lower gross returns (₹ 63,168 ha^{-1}), net returns (₹ 13858 ha^{-1}) and BC ratio (1.28). Based on these findings, it is recommended to adopt application of 100% RDF + 20 kg MOP as basal + 8% MLE at 30 and 45 DAS to achieve maximum yield and economic returns of blackgram. From this observation, it was revealed that 8% concentration of moringa leaf extract gives more seed yield than 4% concentration of moringa leaf extract. Basal application of potassium as MOP is more beneficial than foliar application of potassium as KNO_3 in blackgram in terms of seed yield and cost of cultivation. The economic analysis revealed that combined foliar application of MLE and potassium (MOP) was cost effective for maximizing seed yield and income.

Keywords: Potassium; moringa leaf extract; yield and economics; blackgram

1. INTRODUCTION

"Pulses are the second most important crop in Indian agriculture after cereals due to their high protein content and significant role in human diet. Among the pulses, blackgram (*Vigna mungo*. L) is the third most important crop after bengalgarm and redgram. In India blackgram is popular is as Urd dal and is highly prized pulse among all the pulses. India is the major producer of black gram in the world and grown in almost all in all the states. India contributes more that 70% of world's black gram production. India has area of 46 lakhs hectares with the total production of about 24.5 lakhs tonnes of grain with a productivity of about 533 kg ha^{-1}. In Telangana, it is grown in about 38,564 hectares with the total production of 41,168 tonnes and the productivity of 1067 kg ha^{-1}"(www.Indiastat.com [1].

A set of physio-chemical, biological and, integrated approaches is available for reducing yield losses [2]. "Among them, the use of organic (bio-stimulants) and inorganic nutrients are considered viable approaches to compensate yield losses. Bio-stimulants are natural growth enhancers that stimulate crop yield via enhanced nutrient uptake and efficiency, improved tolerance to biotic and abiotic stresses and enhancement of the rhizospheric activities" [3].

"Moringa tree can be grown successfully in subtropical, semiarid, and tropical areas. Moringa grows well in dry sandy soil, along the coast, and in poor soil; it is a fast growing, drought resistant tree. It is a most nutritious plant, providing antioxidants and amino acids with antiaging and anti-inflammatory properties. This miracle tree is a rich source of calcium, iron, vitamin C, and highly digestible proteins. This diverse composition indicates that MLE can be used as a plant bio-stimulant for promoting crop growth and productivity (Arif et al, [4]). All parts of moringa are consumed as food" [5,6]. "The charisma of moringa leaf juice is a substance "zeatin" which is a natural plant growth hormone from the cytokinins group and it has been reported that improvements in crop growth and yield results from the influence of zeatin" (Phiri, [7]. "Many studies are already reported regarding the use of moringa for agricultural purpose to enhance seed germination, growth and yield of agronomic crops. In addition to mineral nutrients, some natural growth enhancers have also been reported to improve growth, yield and quality" (Balakumbahan and Rajamani, [8]. The replacement of costly synthetic chemical fertilizers with organic fertilizers is highly promoted as a sustainable agriculture strategy because organic fertilizers promote plant growth without risks of chemical pollution.

"Potassium (K) is major element which has important role in many plant processes and its application is usually abandoned causing nutrient imbalances that reduce crop yields. Soil and foliar feeding of K improves enzymatic systems, water use efficiency, protein formation, nitrogen assimilation and photosynthesis" [9]. Currently, farmers are conscious about inorganic fertilization to increase crop production and maintaining soil fertility but there is need to promote the use of organic fertilizers and explore safe, alternative and natural plant-based nutrients. Karthikeyan et al. [10] reported that "potassium significantly influenced the grain and haulm yield of black gram, optimum levels of potassium (MOP) increased the grain and haulm significantly".

A few studies were conducted on the influence of MLE and potassium sources on the growth, yield and quality in different crops. Moringa leaf extract application It is hypothesized that exogenous application of MLE and sources of potassium may positively affect the growth, productivity and quality of blackgram. Hence the present study was undertaken to investigate the effect of MLE and potassium on growth and development of blackgram and to determine its effect on yield and yield components of blackgram.

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was carried out at Krishi Vigyan Kendra, Palem during Rabi, 2023-24. The field is geographically located at 16°51'N Latitude, 78°25'E Longitude. Throughout the crop growth period, a total rainfall of 2 mm was received in 0 rainy days. The experimental soil was sandy loam with a neutral pH (7.02), EC (0.18dS m^{-1}), low in organic carbon (0.58 g kg^{-1}) and available N (141.6 kg ha^{-1}), medium in available P_2O_5 (32 kg ha^{-1}) and medium in available K_2O (228 kg ha^{-1}).

2.2 Moringa Leaf Extracts Preparation and Analysis

Young leaves of moringa were harvested from a fully grown trees located at different places of the KVK, Palem. For preparation of MLE, young leaves of about 100g were taken into a mortar with a pinch of water (10ml/100g fresh material) and ground with a pestle. The juice was extracted by hand pressure and was filtered through the cheese cloth or cotton cloth. The solution was refiltered using Whatman No.2 filter paper. Following the method developed by Fuglie [11], the extract was diluted with distilled water at ratio of 1:5 and 2:5 and then sprayed directly onto the blackgram plants.

Moringa leaves were shade dried for 1 week followed by oven dry for 4-5 hours at 60oC and then this oven dried sample is grinded into fine powder. Fine powder is for analyses of major and micronutrients and other primary and secondary metabolites, vitamins, enzymes, amnio acids etc., are determined by using fresh leaf sample.

2.3 Experimental Details

The experiment was laid out in a Randomized Block Design (RBD) during Rabi 2023-24, consisting of ten treatments with replicated thrice having net plot size of 4 x 6 m^2. The blackgram variety MGB 1070 was sown on sandy loam soil with a spacing of 30 cm×10 cm on 24th October 2023. Nitrogen was applied in the form of urea as per the treatments; Phosphorus was applied as basal dose in the form of SSP. Potassium (50 kg ha^{-1}) was applied in the form of muriate of potash (MOP) along with nitrogen and also as foliar spray in the form of KNO_3 at 45 DAS (flowering stage), moringa leaf extract was applied at

Table 1. Chemical composition of moringa leaf extract

Name of nutrient element/enzymes	Values
Total soluble protein (mg g^{-1})	1.40
Super oxide dismutase (SOD)	191.86
Peroxidase (POD)	21.99
Catalase (CAT)	7.09
Total phenolic contents (mg g^{-1})	8.19
Ascorbic acid (m mole g^{-1})	0.36
Gibberellins (mg g^{-1})	0.74
Zeatin (mg g^{-1})	0.96
Nitrogen (%)	1.933
Phosphorus (%)	0.180
Potassium (%)	2.187
Calcium (%)	2.433
Magnesium (%)	0.012
Zinc (mg kg^{-1})	38.333
Copper (mg kg^{-1})	3.50
Iron (mg kg^{-1})	544.0
Manganese (mg kg^{-1})	49.667
Boron (mg kg^{-1})	21.333

30DAS (vegetative stage) and 45 DAS (flowering stage) as per treatments, all recommended agronomic practices and plant protection measures were taken as per requirement. The recommended dose of fertilizers: 20 kg N, 50 kg P_2O_5 and 0 kg K_2O per hectare.

The current study comprised of 100% RDF, muriate of potash 20kg (as basal), potassium nitrate @ 0.5% (foliar spray), alone and combined with foliar spray of Moringa Leaf Extract (MLE), keeping tap water spray as a control, Bio stimulant was foliar applied twice was assessed at 30 and 45 DAS. The parameters were compared between treatments with moringa leaf extract application (at 30 and 45 DAS) and those without moringa leaf extract, under potassium source and 100% RDF.

Treatment details of the experiment

- T_1 : Control
- T_2 : 100%RDF (20:50:0, kg ha^{-1} N: P_2O_5: K_2O)
- T_3 : 100% RDF+ 20 kg MOP as basal
- T_4 : 100% RDF + 0.5% Potassium Nitrate as foliar spray at 45 DAS
- T_5 :100%RDF + 4% MLE at 30 and 45 DAS
- T_6 : 100% RDF+ 20 kg MOP as basal+ 4% MLE at 30 and 45 DAS
- T_7 : 100% RDF + 0.5% Potassium Nitrate as foliar spray at 45 DAS+ 4% MLE at 30 and 45 DAS
- T_8 : 100%RDF + 8% MLE at 30 and 45 DAS
- T_9 : 100% RDF+ 20 kg MOP as basal+ 8% MLE at 30 and 45 DAS
- T_{10} : 100% RDF + 0.5% Potassium Nitrate as foliar spray at 45 DAS+ 8% MLE at 30 and 45 DAS

2.3.1 Yield attributes

The yield attributes of blackgram consists of Number of pods per plant, seeds per pod and Test weight. Yield attributes have direct influence on seed yield of blackgram.

2.3.2 No. of pods per plant

Five plants were randomly selected from each experimental plot at harvest and the number of pods from these five plants were counted individually. These individual counts were then averaged and expressed as the number of pods per plant.

2.3.3 Seeds pod^{-1}

The number of seeds per pod were counted from the five pods within the net plot of each plot of experimental unit. These individual counts were then averaged and expressed as the number of seeds per pods.

2.3.4 Test Weight (g)

The test weight is the average weight of 1000 seeds obtained after removal of seeds from pods. It is measured from each plot and is expressed in grams as test weight.

2.4 Seed Yield (kg ha^{-1})

Seed obtained from each plot of experimental unit was weighed using an electronic balance. The seed yield from each plot was weighed in grams per plot and yield was converted to kg ha^{-1}.

2.5 Stover Yield (kg ha^{-1})

The stover obtained from each plot after seed removal was weighed separately using an electronic balance. Stover yield was weighed in terms of g per plot and was converted into kg ha^{-1}.

2.6 Cost of Cultivation

The cost of cultivation was worked out on the basis of existing local prices of different inputs i.e., labour, seed, fertilizers and chemicals etc.

2.7 Gross Returns

It was assessed by multiplying the yield with prevailing market price.

2.8 Net Returns

Net returns were calculated by subtracting the cost of cultivation from gross returns.

2.9 Benefit Cost Ratio

Benefit cost ratio was calculated by dividing gross returns with cost of cultivation.

2.10 Statistical Analysis

Statistical analysis was carried out following the procedure of ANOVA for randomized block design as suggested by Panse and Sukhatme, [12].

3. RESULTS AND DISCUSSION

3.1 Number of Pods Plant^{-1}

Among all the treatments, maximum no. of pods plant^{-1} were recorded with 100% RDF + 20 kg MOP as basal + 8% MLE at 30 and 45 DAS (25.23) and the lowest no. of pods plant^{-1} were recorded in T_1: control (11.13). Number of pods harvested per plant differed significantly due to foliar spray of MLE and various sources of potassium on blackgram (Table 2). Higher number of pods per plant was observed with the application of MLE and potassium as MOP basal. Among all treatments, the treatment that receives potassium as MOP recorded significantly the highest growth and yield of blackgram when compared with foliar treatments. Irshad et al, [13], confirmed that combined application of MLE+K produced maximum pods per plant, grain weight, grain yield and harvest index.

3.2 Seeds/Pod

Among all the treatments, maximum seeds/pod were recorded with 100% RDF + 20 kg MOP as basal + 8% MLE at 30 and 45 DAS (6.03) which is on par with 100% RDF + 0.5% Potassium Nitrate as foliar spray at 45 DAS + 8% MLE at 30 and 45 DAS (5.8), 100% RDF+ 8% MLE at 30 and 45 DAS (5.77), 100% RDF + 20kg MOP as basal + 4% MLE at 30 and 45 DAS (5.77), 100% RDF + 20 kg MOP as basal (5.53), 100% RDF + 0.5% Potassium Nitrate as foliar spray at 45 DAS + 4% MLE at 30 and 45 DAS (5.37), 100% RDF + 0.5% Potassium Nitrate as foliar spray at 45 DAS (5.37) and 100% RDF+ 4% MLE at 30 and 45 DAS(5.13) (Table 2). The lowest was recorded in control (2.67). Seeds/pod was not influenced by the application of moringa leaf extract and potassium which might be due to characters highly influenced by its genetic makeup.

3.3 Test Weight (g)

Test weight was significantly influenced by potassium and moringa leaf extract in which maximum boll weight was recorded with the application of 100% RDF+ 20 kg MOP as basal + 8% MLE at 30 and 45 DAS (42.87g) which is on par with T_{10}:100% RDF + 0.5% Potassium Nitrate as foliar spray at 45 DAS + 8% MLE at 30 and 45 DAS (41.05g) and T_8:100% RDF+ 8% MLE at 30 and 45 DAS (41.07g) (Table 2). Application of 8% MLE combined with potassium produced the highest values of test weight/plot with slight variation with 4% concentrations of MLE mixed with potassium source. Moreover, yield components of mung bean (number of pods, pod dry weight, seed dry weight and shelling out turn) were positively affected by high concentration of MLE [14].

3.4 Seed Yield (kg ha^{-1})

A perusal of the data recorded on seed yield reported that there was a significant influence of moringa leaf extract and potassium source on blackgram seed yield (Table 3). Significantly highest seed yield was recorded with 100% RDF + 20 kg MOP as basal + 2 sprays of 8% MLE at 30 and 45 DAS (1757 kg ha^{-1}). The treatment T_{10}:100% RDF+ 0.5% Potassium Nitrate as foliar spray at 45 DAS + 8% MLE at 30 and 45 DAS recorded seed yield of 1527 kg ha^{-1} , which is on par with all other treatments T_6, T_8, T_3, T_7, T_4, T_5 and T_2, 1496 kg ha^{-1}, 1461 kg ha^{-1}, 1454 kg ha^{-1}, 1397 kg ha^{-1}, 1395 kg ha^{-1}, 1362 kg ha^{-1} and 1347 kg ha^{-1} except T1:control (752 kg

Table 2. Yield attributes of blackgram influenced by Moringa (*Moringa oleifera*) Leaf Extract and potassium

Treatments	No of pods per plant	Seeds per pod	Test weight (g)
T_1: Control	11.01	2.67	28.96
T_2:100% RDF	14.77	4.53	34.92
T_3:100% RDF +20kg MOP as basal	17.07	5.53	38.27
T_4:100% RDF +0.5%Potassium Nitrate foliar spray at 45 DAS	17.47	5.37	38.93
T_5:T_2+4% MLE at 30 and 45 DAS	19.67	5.13	39.48
T_6:T_3+4% MLE at 30 and 45 DAS	19.73	5.77	39.74
T_7:T_4+4% MLE at 30 and 45 DAS	19.80	5.37	39.89
T_8:T_2+8% MLE at 30 and 45 DAS	22.15	5.77	41.07
T_9:T_3+8% MLE at 30 and 45 DAS	25.23	6.03	42.87
T_{10}:T_4+8% MLE at 30 and 45 DAS	23.07	5.80	41.05
SEM$\pm$	0.72	0.41	0.90
CD (P=0.05)	2.13	NS	2.68

ha-1). Conversely, the lowest seed yield was recorded with control. Combined application of moringa leaf extract and potassium gave more yield than sole application of potassium or moringa in addition with 100% RDF. Highest yield is observed in 8% concentration application of moringa leaf extract than 4% concentration of MLE. Seed yield is influenced by a number of factors, which have a direct or indirect impact. The factors which have direct influence on seed yield are the yield components *i.e.,* no. of pods plant^{-1} seeds/pod and test weight. Several researchers found similar results with different crops [15-17] in onion and kidney beans, Muhamman et al, [17] in tomato, Abdalla [18] in rocket.

3.5 Stover Yield (kg ha^{-1})

Data related to stover yield is presented in table 3. Stover yield includes dried stover, leaves and pods after seed removal at harvest. The treatment T_9: 100% RDF + 20 kg MOP as basal + 2 sprays of 8% MLE at 30 and 45 DAS (2738 kg ha^{-1}) recorded significantly highest stover yield. Remaining all other treatments T_8 (2441 kg ha^{-1}), T_6 (2414 kg ha^{-1}), T_3 (2410 kg ha^{-1}), T_7 (2380 kg ha^{-1}), T_4 (2365 kg ha^{-1}), T_5 (2361 kg ha^{-1}) and T_3 (2345 kg ha^{-1}) were on par with the treatment T_{10} (2510 kg ha^{-1}), except control: T1 (1434 kg ha^{-1}).

Based on the obtained results, the application of moringa leaf extract in combination with potassium gave higher stover yield. The stover yield was enhanced with the application of moringa leaf extract (30 and 45 DAS) at 8% concentration than at 4% concentration. Slightly increased in stover yield was observed with application of potassium as MOP than as foliar application of KNO_3.

3.6 Economics

The data pertaining to economic parameters indicated in Table 4.

3.6.1 Cost of cultivation (₹ ha^{-1})

Cost of cultivation varied from ₹54469 ha^{-1} to ₹ 49310 ha^{-1}. Higher cost (₹ 54469 ha^{-1}) was incurred due to application of 100% RDF + 20 kg MOP as basal + 8% MLE at 30 and 45 DAS (Table 4). The deviation in cost of cultivation was due to nitrogen fertilizer level, man power required for application of fertilizer and MLE, Manual Harvesting and Thrashing charges in case of high seed yield is also contributed towards escalated cost of cultivation.

3.6.2 Gross returns (₹ ha^{-1})

Perusal of data on gross returns indicated that higher gross returns (₹ 1,47,588 ha^{-1}) were observed with application of 100% RDF + 20 kg MOP as basal + 8% MLE at 30 and 45 DAS over rest of the treatments which was due to higher seed yield obtained in this treatment. While, lower gross returns were recorded with control (₹ 63,168 ha^{-1}) (Table 4).

Table 3. Seed yield (kg ha^{-1}) and Stover yield (kg ha^{-1}) of blackgram influenced by Moringa (*Moringa oleifera*) Leaf Extract and potassium

Treatments	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1: Control	752	1434
T_2:100% RDF	1347	2345
T_3:100% RDF +20kg MOP as basal	1454	2410
T_4:100% RDF +0.5%Potassium Nitrate foliar spray at 45 DAS	1395	2380
T_5:T_2+4% MLE at 30 and 45 DAS	1362	2361
T_6:T_3+4% MLE at 30 and 45 DAS	1429	2414
T_7:T_4+4% MLE at 30 and 45 DAS	1397	2365
T_8:T_2+8% MLE at 30 and 45 DAS	1461	2441
T_9:T_3+8% MLE at 30 and 45 DAS	1757	2738
T_{10}:T_4+8% MLE at 30 and 45 DAS	1527	2510
SEM$\pm$	67.48	73.33
CD (P=0.05)	200.49	217.87

3.6.3 Net returns (₹ ha^{-1})

Net returns obtained from blackgram were found to be higher with application of T_9: 100% RDF+20 kg MOP as basal + 8% MLE at 30 and 45 DAS (₹ 93,119 ha^{-1}) While, significantly lower net returns (₹ 13,858 ha^{-1}) were registered with application of T1: control. Higher net returns were due to higher seed yield obtained per hectare (Table 4). Yasmeen et al, [19,20] reported that exogenous application of different sources of potassium improved the productivity and net income.

3.7 Benefit Cost Ratio

An over view of data among treatments showed that higher B.C ratio (2.71) was recorded with T_9: 100% RDF + 20 kg MOP as basal + 8% MLE at 30 and 45 DAS and lower B.C ratio (1.28) was recorded with T1: control. The higher benefit cost ratio was due to higher seed yields and net returns over other treatments (Table 4).

Table 4. Economics as influenced by moringa (*Moringa oleifera*) Leaf Extract and potassium under blackgram

Treatments	COC (₹ ha^{-1})	GR (₹ ha^{-1})	NR (₹ ha^{-1})	B:C
T_1: Control	49310	63168	13858	1.28
T_2:100% RDF	52069	113148	61079	2.17
T_3:100% RDF +20kg MOP as basal	53269	122136	68867	2.29
T_4:100%RDF+0.5%Potassium Nitrate foliar spray at 45 DAS	52819	117180	64361	2.22
T_5:T_2+4% MLE at 30 and 45 DAS	53269	114408	61139	2.15
T_6:T_3+4% MLE at 30 and 45 DAS	54469	128436	73967	2.36
T_7:T_4+4% MLE at 30 and 45 DAS	54019	117348	63329	2.17
T_8:T_2+8% MLE at 30 and 45 DAS	53269	122724	69455	2.30
T_9:T_3+8% MLE at 30 and 45 DAS	54469	147588	93119	2.71
T_{10}:T_4+8% MLE at 30 and 45 DAS	54019	128268	74249	2.37

Fig. 1. Treatment T9 during flowering stage

Fig. 2. Over all view of the experimental site at KVK, Palem

4. CONCLUSION

Blackgram (*Vigna munga* 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 were highly expensive. Hence, for replacement of synthetic fertilizers with organic extracts, 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. Moringa leaf extract contain Zeatin type of cytokinin that play a major role to maintain photosynthetic area by delaying senescence and affecting source- sink relation strength to increase yield. Thus, MLE enhancement effects on growth parameters and yield attribute. Application of 8% concentration of moringa leaf extract was most effective on blackgram than 4% concentration. Based on these findings, it is recommended to adopt application of 100% RDF + 20 kg MOP as basal + 8% MLE at 45 and 60 DAS to achieve maximum yield and economic returns of blackgram.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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