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Response of Blackgram (*Vigna mungo* L.) to Different Levels of Phosphorus and Molybdenum

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Abstract

A field experiment was conducted to study the effect of different levels of phosphorus and molybdenum as foliar spray in blackgram on sandy loam soils at Agricultural College Farm, Mahanandi campus of Acharya N. G. Ranga Agricultural University during *rabi*, 2022-2023. The treatments consist of three levels of phosphorus (20, 30, 40 kg ha^{-1}) and three levels of molybdenum (0.5, 1.0 and 1.5 kg ha^{-1}) applied as alone and by combined foliar spray. The design adopted was randomized block design with nine treatments and replicated thrice. It was observed that growth and yield attributing characters increased with the combined application of phosphorus and molybdenum at all stages of crop growth. The higher growth parameters *viz*, plant height, number of branches plant^{-1}, dry matter production and number of root nodules plant^{-1} and yield parameters such as number of pods plant^{-1} and seed pod^{-1} and seed yield and haulm yield were recorded with the foliar application of phosphorus @ 40 kg ha^{-1} + molybdenum @ 1.5 kg ha^{-1} (T_9) which was on par with foliar application of phosphorus alone @ 40 kg ha^{-1} (T_6). Test weight and harvest index were found non-significant with different levels of phosphorus and molybdenum.

***Key words*:** Blackgram, Phosphorus, Molybdenum, Foliar spray, Growth parameters, Yield

India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world. Among the pulse crops, blackgram is a short duration pulse crop and it thrives well in *kharif*, *rabi* and summer seasons either as a sole crop or as an intercrop. About 70 per cent of the world's blackgram production comes from India. India produces about 24.5 lakh tonnes of blackgram annually from about 4.6 million hectares of area, with an average productivity of 533 kg ha^{-1} in 2020-2021 (www.agricoop.nic.in). According to 2nd advance estimates during 2021-2022 in Andhra Pradesh, blackgram was grown in 3.93 lakh hectares with a production of 3.65 lakh tonnes and productivity of 929 kg ha^{-1} (www.des.ap.gov.in, 2021-2022). Generally, legumes require higher amount of phosphorus by seeds for enhancing the metabolic activities, blooming and protein synthesis and also an essential part of phospholipids and nucleic acids [1]. Pulses also shows a great response to molybdenum that significantly increases the vegetative growth, nodule count, protein content and yield of blackgram [2].

Soil application of nutrients is often not enough to meet the growing demand particularly in short duration crops like blackgram. Therefore, foliar application in addition to soil application is corresponding with prevailing weather particularly rainfall will go a long way in meeting crop nutrition requirement and enhance productivity. Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of loss through leaching and fixation and regulating the uptake of nutrients by plant [3]. The foliar application of phosphorus and molybdenum is more advantageous and gives better yield when compared to single nutrient application. The phenomenal increase in growth and yield of blackgram was due to mutual benefit of these nutrients in improving absorption and utilization of nutrients. The synergetic interaction of phosphorus and molybdenum also influences the availability of certain essential nutrients that result in better uptake and maintain source and sink relationship [4]. Keeping this in a view, the present field experiment was conducted to study the effect of foliar application of phosphorus and molybdenum on growth and yield of blackgram.

MATERIALS AND METHODS

A field trail was carried out at College Farm, Agricultural College, Mahanandi, Acharya N. G. Ranga Agricultural University during *rabi*, 2022-2023. The experiment was laid out in randomized block design with 10 treatments and replicated thrice. The treatments comprised of foliar application of molybdenum alone @ 0.5 kg ha^{-1} (T_1), foliar application of molybdenum alone @ 1.0 kg ha^{-1} (T_2), foliar application of molybdenum alone @ 1.5 kg ha^{-1} (T_3), foliar application of phosphorus alone @ 20 kg ha^{-1} (T_4), foliar application of phosphorus alone @ 30 kg ha^{-1} (T_5), foliar

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application of phosphorus alone @ 40 kg ha^{-1} (T_6), foliar application of phosphorus @ 20 kg ha^{-1} + molybdenum @ 0.5 kg ha^{-1} (T_7), foliar application of phosphorus @ 30 kg ha^{-1} + molybdenum @ 1.0 kg ha^{-1} (T_8), foliar application of phosphorus @ 40 kg ha^{-1} + molybdenum @ 1.5 kg ha^{-1} (T_9).

The soil of the experimental field was sandy loam in texture with neutral in reaction (pH 7.34), low in organic carbon (0.47 %), available nitrogen (256 kg ha^{-1}) and medium in available phosphorus (46 kg ha^{-1}) and high in available potassium (582 kg ha^{-1}). The blackgram variety of LBG 884 is selected for this study which is an early maturing, polished and high yielding variety having duration of 80-85 days was sown with a spacing of 30 cm x 10 cm. A uniform dose of Nitrogen and Potassium through urea and muriate of potash respectively to all the treatments. Phosphorus and Molybdenum through SSP (by soaking the powder overnight) and Ammonium molybdate were quantified as per the treatments. Pre-emergence herbicide Pendimethalin 30% EC was done at the time of sowing. Two irrigations were given at flowering and pod formation stages of the crop.

The observations were recorded on growth parameters (plant height, number of branches plant^{-1}, dry matter production and number of root nodules plant^{-1}), yield attributes (number of pods plant^{-1}, number of seeds pod^{-1} and test weight), yield parameters (seed yield, haulm yield and harvest index). The data were collected on five randomly selected plant and the data were subjected to statistical analysis.

RESULTS AND DISCUSSION

Effect on growth parameters

Significantly higher plant height (30.60 cm) was recorded with the combined application phosphorus @ 40 kg ha^{-1} + molybdenum @ 1.5 kg ha^{-1} as foliar spray which was on par with the application of phosphorus alone @ 40 kg ha^{-1} as foliar spray (T_6) (30.23 cm) and lowest plant height (23.40 cm) was recorded with the application of molybdenum alone @ 0.5 kg ha^{-1} (T_1) as foliar spray. The increase in plant height might be due to combined effect of macro and micronutrient in tissue development, cell division, development of vigorous and stronger root system that enabling the plant to derive the nutrients rapidly and easy for accelerating various physiological processes, which ultimately increased the plant height [5-7].

Table 1 Growth parameters of blackgram as influenced by foliar application of different levels of phosphorus and molybdenum

Treatments	Plant height (cm)	Number of branches plant^{-1}	Dry matter production (kg ha^{-1})	Number of root nodules plant^{-1}
T_1: Foliar application of Molybdenum alone @ 0.5 kg ha^{-1}	23.40	6.03	3668	17.10
T_2: Foliar application of Molybdenum alone @ 1 kg ha^{-1}	25.60	6.16	3938	17.93
T_3: Foliar application of Molybdenum alone @ 1.5 kg ha^{-1}	29.00	6.93	4283	20.16
T_4: Foliar application of Phosphorus alone @ 20 kg ha^{-1}	24.08	6.00	3927	15.03
T_5: Foliar application of Phosphorus alone @ 30 kg ha^{-1}	27.24	6.36	4149	18.70
T_6: Foliar application of Phosphorus alone @ 40 kg ha^{-1}	30.23	7.13	4606	19.20
T_7: Foliar application of Phosphorus @ 20 kg ha^{-1}+ Molybdenum @ 0.5 kg ha^{-1}	26.67	6.60	4440	17.73
T_8: Foliar application of Phosphorus @ 30 kg ha^{-1} + Molybdenum @ 1 kg ha^{-1}	28.15	7.30	4521	19.23
T_9: Foliar application of Phosphorus @ 40 kg ha^{-1}+ Molybdenum @ 1.5 kg ha^{-1}	30.60	7.86	4966	26.73
S.Em ±	0.50	0.28	143.16	0.55
CD (P = 0.05)	1.52	0.84	429.21	1.66

Table 2 Yield attributes of blackgram as influenced by foliar application of different levels of phosphorus and molybdenum

Treatments	Number of pods plant^{-1}	Number of seeds pod^{-1}	Test weight (g)
T_1: Foliar application of Molybdenum alone @ 0.5 kg ha^{-1}	27.53	6.20	4.36
T_2: Foliar application of Molybdenum alone @ 1 kg ha^{-1}	32.13	6.43	4.30
T_3: Foliar application of Molybdenum alone @ 1.5 kg ha^{-1}	36.16	6.81	4.43
T_4: Foliar application of Phosphorus alone @ 20 kg ha^{-1}	28.26	6.36	4.33
T_5: Foliar application of Phosphorus alone @ 30 kg ha^{-1}	33.36	6.50	4.36
T_6: Foliar application of Phosphorus alone @ 40 kg ha^{-1}	40.03	6.80	4.40
T_7: Foliar application of Phosphorus @ 20 kg ha^{-1} + Molybdenum @ 0.5 kg ha^{-1}	37.87	6.34	4.43
T_8: Foliar application of Phosphorus @ 30 kg ha^{-1} + Molybdenum @ 1 kg ha^{-1}	41.43	6.56	4.50
T_9: Foliar application of Phosphorus @ 40 kg ha^{-1} + Molybdenum @ 1.5 kg ha^{-1}	44.06	6.83	4.53
S.Em ±	0.79	0.12	0.12
CD (P = 0.05)	2.38	0.37	NS

Maximum number of branches plant^{-1} (7.86) was recorded with combined application phosphorus @ 40 kg ha^{-1} + molybdenum @ 1.5 kg ha^{-1} as foliar spray which was at par with the combined application of phosphorus @ 30 kg ha^{-1} + molybdenum @ 1.0 kg ha^{-1} as foliar spray (T_8) (7.30) and lowest number of branches plant^{-1} (6.00) was recorded with the foliar application of phosphorus alone @ 20 kg ha^{-1} (T_4). Increase in number of branches plant^{-1} due to the fact that foliar application of nutrient would be easily available and translocated in the plant without any loss and application of phosphorus increased the photosynthesis activity of plants resulting in producing more number of branches plant^{-1} [8-9].

Higher dry matter production (4966 kg ha^{-1}) was observed with the combined application phosphorus @ 40 kg

ha^{-1} + molybdenum @ 1.5 kg ha^{-1} as foliar spray and lowest dry matter accumulation was recorded with application of molybdenum alone @ 0.5 kg ha^{-1} (T_1) as foliar spray (3668 kg ha^{-1}) compared to rest of the treatments. It might be due to better utilization of nutrients by foliar application of fertilizers which increases the photosynthetic process which finally resulted in increased dry matter production by the plant at each growth stage of the crop [10-11].

Higher number of root nodules $plant^{-1}$ (26.73) was recorded with the foliar application of phosphorus @ 40 kg ha^{-1} + molybdenum @ 1.5 kg (T_9) and lowest number of nodules $plant^{-1}$ (15.03) was recorded with the foliar application of phosphorus alone @ 20 kg (T_4) over rest of the treatments. Foliar application of nutrient helps in spreading of root system and gives more site for rhizobia infection and increase their proliferation in rhizosphere, helps in forming more effective nodules [12-13].

Effect on yield attributes

More number of pods $plant^{-1}$ (44.06) was recorded with the combined application of phosphorus @ 40 kg ha^{-1} + molybdenum @ 1.5 kg ha^{-1} as foliar spray (T_9) which showed significant difference with the following treatments viz., combined application of phosphorus @ 30 kg ha^{-1} + molybdenum @ 1.0 kg ha^{-1} as foliar spray (T_8) (41.43). The lowest number of pods $plant^{-1}$ was recorded with the application of molybdenum alone as foliar spray @ 0.5 kg ha^{-1} (T_1) (27.53) on par with the application of phosphorus alone @ 20 kg ha^{-1} as foliar spray (T_4) (28.26). Foliar application of fertilizers made the availability of nutrients rapidly and easy and plant took all the nutrients for accelerating various physiological processes, which ultimately improved the plant growth and number of pods per plant. The foliar application of phosphorus and molybdenum enhanced the number of pods $plant^{-1}$ in blackgram [9], [13].

More number of seeds pod^{-1} (6.83) in blackgram was recorded with the foliar application of phosphorus @ 40 kg ha^{-1} + molybdenum @ 1.5 kg ha^{-1} (T_9) and the lowest number of seeds pod^{-1} (6.20) was recorded with the foliar application of molybdenum alone @ 0.5 kg ha^{-1} (T_1). Increase in number of seeds pod^{-1} might be due to application of nutrients by foliar spray at critical stage has helped in more translocation of photosynthates to the developing pods which helped in better filling thus increase in the number of seeds pod^{-1} [7], [9]. The test weight of seed was found non-significantly affected by the treatments.

Table 3 Seed, haulm yield (kg ha^{-1}) and harvest index (%) of blackgram as influenced by foliar application of different levels of phosphorus and molybdenum

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
T_1: Foliar application of Molybdenum alone @ 0.5 kg ha^{-1}	955	1762	35.24
T_2: Foliar application of Molybdenum alone @ 1 kg ha^{-1}	1222	2448	33.34
T_3: Foliar application of Molybdenum alone @ 1.5 kg ha^{-1}	1426	2553	36.08
T_4: Foliar application of Phosphorus alone @ 20 kg ha^{-1}	1275	2427	34.12
T_5: Foliar application of Phosphorus alone @ 30 kg ha^{-1}	1593	2523	35.13
T_6: Foliar application of Phosphorus alone @ 40 kg ha^{-1}	1640	2726	36.23
T_7: Foliar application of Phosphorus @ 20 kg ha^{-1} + Molybdenum @ 0.5 kg ha^{-1}	1609	2572	34.13
T_8: Foliar application of Phosphorus @ 30 kg ha^{-1} + Molybdenum @ 1 kg ha^{-1}	1750	2747	34.64
T_9: Foliar application of Phosphorus @ 40 kg ha^{-1} + Molybdenum @ 1.5 kg ha^{-1}	1944	2992	34.58
S.Em ±	70.41	201.60	2.16
CD (P = 0.05)	211.10	604.40	NS

Effect on yield parameters

The higher seed yield (1994 kg ha^{-1}) was obtained with the combined application of phosphorus @ 40 kg ha^{-1} + molybdenum @ 1.5 kg ha^{-1} as foliar spray (T_9) and it was on par with the application of phosphorus @ 30 kg ha^{-1} + molybdenum @ 1.0 kg ha^{-1} as foliar spray (T_8) (1750 kg ha^{-1}). The lowest seed yield (955 kg ha^{-1}) was recorded in the treatment foliar application of molybdenum alone @ 0.5 kg ha^{-1} (T_1). The synergetic interaction of phosphorus and molybdenum also influence the availability of certain essential nutrients that employs better uptake and maintain source and sink relationship that resulted in better crop growth and development, increased number of pods $plant^{-1}$, seeds pod^{-1} and 1000 seed weight which led to the increased grain yield of blackgram [9], [13-14]. The higher haulm yield (2992 kg ha^{-1}) was recorded with the combined application of phosphorus @ 40 kg ha^{-1} + molybdenum @ 1.5 kg ha^{-1} as foliar spray (T_9) and it was on par with the treatments combined application of phosphorus @ 30 kg ha^{-1} + molybdenum @ 1.0 kg ha^{-1} as foliar spray (T_8) (2747 kg ha^{-1}). The lowest haulm yield (1762 kg ha^{-1}) was recorded with the foliar application of molybdenum alone @ 0.5 kg ha^{-1} (T_1). Combined application of ph osphorus and molybdenum recorded higher haulm yield might be due to higher vegetative growth with taller plants and higher dry matter accumulation, improved nitrogen fixation, transport of sugars and better uptake and assimilation of available nutrients by the plants during the entire growth period [13-14]. Harvest index was found non-significantly affected by the treatments.

CONCLUSION

The study demonstrated that the combined foliar application of phosphorus and molybdenum significantly improved the growth parameters, yield attributes, and overall productivity of blackgram. The treatment with phosphorus at 40 kg ha^{-1} and molybdenum at 1.5 kg ha^{-1} (T_9) consistently resulted in the highest plant height, number of branches, dry matter production, root nodules, and number of pods per plant. These improvements can be attributed to the synergistic effects of phosphorus and molybdenum, which enhanced nutrient uptake, physiological processes, and photosynthetic activity. Consequently, this treatment also led to the highest seed and haulm yields, underscoring the importance of balanced nutrient management for optimizing blackgram productivity. The findings suggest that integrating phosphorus and molybdenum through foliar applications is a promising strategy for maximizing the growth and yield of blackgram.

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