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Response of Secondary, Micro Nutrients and Naphthalene Acetic Acid (NAA) on Growth, Yield and Economics of Summer Blackgram [*Vigna mungo* (L.) Hepper]

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Abstract The experiment consisted of two levels of sulfur (20 and 40 kg ha^{-1}), zinc (2.5 and 5 kg ha^{-1}), molybdenum (1 kg ha^{-1}) and NAA (40 ppm) with 15 treatments replicated thrice in a randomized block design. Application of 40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA significantly increased growth and yield parameters viz. Plant height (31.0 cm), number of branches plant^{-1} (19.40), number of nodules plant^{-1} (28.33), number of pods plant^{-1} (31.46), seed yield (8.63 q ha^{-1}), stover yield (23.73 q ha^{-1}) and harvest index (36.39) while number of seeds pod^{-1}, test weight were non-significant. Similarly, application of 40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA recorded highest gross return (43581.0 Rs ha^{-1}), net return (24635.0 Rs ha^{-1}) and B:C ratio (2.30) while lowest gross return (26409.0 Rs ha^{-1}), net return (10273.0 Rs ha^{-1}) and B:C ratio (1.63) was obtained in treatment T_1 (control) respectively.

Keywords Blackgram, NAA, Growth, Yield, Economics.

Introduction

Pulses are commonly known as food legumes which are secondary to cereals in production and consumption in India. Pulses are an integral part of many diets across the globe and they have great potential to improve human health, conserve our soils, protect the environment and contribute to global food security. The United Nations, declared 2016 as International Year of Pulses (IYP) to heighten public awareness of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition. India is the largest producer and consumer of pulse contributes 25% of global production, 27% of world consumption and impoter 14% of pulse in the world. The area under pulse has increased from 19 m ha^{-1} in 1950-51 to 25 m ha^{-1} in 2013-14, indicating an increase of 31% whereas production of pulse during the same period has increased from 8.41 million ha^{-1} to 19.27 million ha^{-1} an increase of over 100% [1].

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Table 1. Effect of secondary, micro nutrients and NAA on growth of blackgram.

Treatments		Plant height (cm) 45 DAS	Plant height (cm) 60 DAS	No. of branches plant^{-1} 45 DAS	No. of branches plant^{-1} 60 DAS	No. of nodules plant^{-1} 45 DAS	No. of nodules plant^{-1} 60 DAS	Dry weight g plant^{-1} 45 DAS	Dry weight g plant^{-1} 60 DAS
T_1	Control	23.93	29.13	13.33	16.86	15.5	10.33	3.33	7.58
T_2	20 kg S ha^{-1}	24.53	30.53	13.40	16.93	16.33	11.00	3.62	7.53
T_3	40 kg S ha^{-1}	24.47	30.27	13.87	17.00	17.66	11.33	3.87	7.64
T_4	20 kg S ha^{-1} + 2.5 kg Zn ha^{-1}	25.20	31.00	13.93	17.40	18.16	11.67	3.75	7.34
T_5	40 kg S ha^{-1} + 2.5 kg Zn ha^{-1}	26.93	32.67	14.06	17.80	19.33	12.33	4.18	7.29
T_6	20 kg S ha^{-1} + 5.0 kg Zn ha^{-1}	25.20	31.07	14.00	17.53	19.00	11.17	4.07	7.57
T_7	40 kg S ha^{-1} + 5.0 kg Zn ha^{-1}	26.07	32.2	14.26	17.93	20.33	12.50	3.92	7.10
T_8	20 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	26.60	32.4	14.40	18.06	20.30	11.83	3.98	6.52
T_9	40 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	27.33	33.8	14.66	18.33	22.00	12.17	4.05	8.22
T_{10}	20 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	26.93	33.2	14.43	18.2	21.15	11.50	3.62	6.95
T_{11}	40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	29.60	37.33	15.20	19.06	26.5	12.67	4.93	8.19
T_{12}	20 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	27.87	34.47	14.73	18.53	22.66	12.00	3.97	7.34
T_{13}	40 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	30.07	37.8	15.26	19.13	25.5	13.33	3.95	6.94
T_{14}	20 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	28.8	36.87	14.80	18.66	24.00	13.17	3.67	7.31
T_{15}	40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	31.00	39.33	15.53	19.4	28.33	13.50	4.58	7.71
	CD at 5%	4.03	3.86	0.74	0.71	1.27	NS	NS	NS
	CV (%)	8.93	6.89	3.07	2.38	3.6	10.21	12.96	7.45

In 2014-15 17.20 million tones and estimate production for 2015-16 about 18.32 million tons (Commodity Profile: DES, DAC and FW, and DoC 2015) [2]. Among the pulses production during 2014-15 blackgram produced 1870 thousand tones and which share 10.87% in total pulse production. The per capita net availability of pulses in India has reduced from 51.1 g day^{-1} 1971 to 41.9 g day^{-1} 2013 as against WHO recommended of 80 g day^{-1}. Among the pulses chickpea is leading producer and share 41.68% of total pulse production followed by pigeon pea 16.16%, blackgram 10.87%, greengram 8.77% and other pulse 22.50% respectively. India export major pulses to various countries and total pulses export 222.26 thousand tons in 2014-15, in which blackgram contribute 4.25 thousand tones (Commodity Profile: DoC 2015) [2].

Blackgram is scientifically known as *Vigna mungo* (L.) and commonly known as urd in India. Blackgram seeds are highly nutritious with protein (25–26%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamins. Sulfur is recognized as fourth major plant nutrient along with N, P, K, performs many important functions in the plant and plays an important role in improving yield and quality of pulses. Sulfur is also known to promote nodulation in legumes thereby enhancing the N fixation. It is a constituent of free amino acid such as methionine, cysteine, and plays a vital role in protein synthesis [3]. Zinc plays an important role in the synthesis of protein and nucleic acid and helps in the utilization of the nitrogen and phosphorus in plant. It promotes root nodulation and nitrogen fixation in legume crop and it also plays a vital role in starch formation and protein content increased with the use of zinc application in the grains [4]. Molybdenum is one of the most recognized mironutrient elements as a constituent of nitrate reductase and nitrogenase enzymes, molyb-

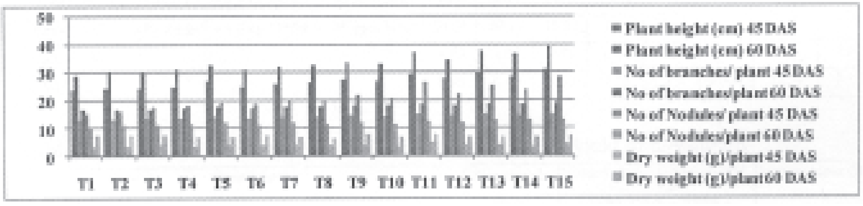

Fig. 1. Effect of secondary, micro nutrients and NAA on growth of blackgram.

denum directly influences nitrogen assimilation and its fixation in pulse crop [5]. The main role of NAA rests with the efficient transport of sugars from the photosynthesizing parts of the plant (Source) to the developing grains (Sinks).

Materials and Methods

A field experinent was conducted during summer season 2015 at the Crop Research Farm, Department of Agronomy, Allahabad School of Agricultural, Sam Higginbottom Institute of Agriculture Technology and Sciences, Allahabad. The soil was sandy loam in texture having a pH (7.3), EC (0.26), organic carbon (0.40%), available N (250 kg ha^{-1}), P (13.50 kg ha^{-1}), K (313 kg ha^{-1}), S (13.93 kg ha^{-1}), and Zn (0.50 ppm) during the experimental year. The experiment was laid down in randomized block design (RBD) with two levels of sulfur (20 and 40 kg S ha^{-1}) and zinc (2.5 and 5 kg Zn ha^{-1}) and one level of molybdenum (1 kg ha^{-1}) and NAA (40 ppm) with 15 treatments and 3 replications. The summer urdbean variety Type-9 was sown in rows, 30 cm apart using 20 kg seeds ha^{-1} on 21 March in 2015. The crop was thinned after complete germination to maintain a plant to plant spacing of 10 cm apart. A common dose of nitrogen, phosphorus and potassium at 20:40:30 kg ha^{-1} was applied through urea, di-ammonium phosphate and murate of potash, respectively. The treatment consisted of T_1: (control), T_2: 20 kg S ha^{-1}, T_3: 40 kg S ha^{-1}, T_4: 20 kg S ha^{-1} + 2.5 kg Zn ha^{-1}, T_5: 40 kg S ha^{-1} + 2.5 kg Zn ha^{-1}, T_6: 20 kg S ha^{-1} + 5.0 kg Zn ha^{-1}, T_7: 40 kg S ha^{-1} + 5.0 kg Zn ha^{-1}, T_8: 20 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}, T_9: 40 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}, T_{10}: 20 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}, T_{11}: 40 kg S ha^{-1} + 5.0 kg Zn ha^{-1}+1.0 kg Mo ha^{-1}, T_{12}: 20 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA, T_{13}: 40 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA, T_{14}: 20 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA, T_{15}: 40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA. Sulfur, zinc, molybdenum and NAA were applied through gypsum, zinc sulfate, ammonium molybdate and α-Naphthalene acetic acid as per treatment and incorporated in soil followed by irrigation to ensure microbial activities to hasten oxidation of sulfur. To reduce the weed infestation, one hand weeding was carried out at 25 DAS.

Results and Discussion

Plant height (cm)

Maximum plant height (31.0 cm) and (39.33 cm) was recorded in treatment T_{15} at 45 DAS and 60 DAS respectively as compared to T_1 control (Table 1) and (Fig. 1). The application of sulfur increased the chlorophyll formation which enhances the photosynthesis resulting an increase in plant growth attributes and zinc increases the metabolism of growing plants which favorable response of zinc on plant height was also recorded by Shanti et al. [6]. Similar finding was also reported by Singh et al. [7].

Number of branches plant^{-1}

Maximum number of branches plant^{-1} (15.33) and (19.40) was recorded in treatment T_{15} while, minimum number of branches plant^{-1} (13.33) and (16.86) was recorded in treatment T_1 (control) at 45 DAS and 60

Table 2. Effect of secondary, micro nutrients and NAA on yield of blackgram.

	Treatments	No. of pods plant^{-1}	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
T_1	Control	23.93	29.13	13.33	16.86
T_2	20 kg S ha^{-1}	24.53	30.53	13.4	16.93
T_3	40 kg S ha^{-1}	24.47	30.27	13.87	17
T_4	20 kg S ha^{-1} + 2.5 kg Zn ha^{-1}	25.2	31	13.93	17.4
T_5	40 kg S ha^{-1} + 2.5 kg Zn ha^{-1}	26.93	32.67	14.06	17.8
T_6	20 kg S ha^{-1} + 5.0 kg Zn ha^{-1}	25.2	31.07	14	17.53
T_7	40 kg S ha^{-1} + 5.0 kg Zn ha^{-1}	26.07	32.2	14.26	17.93
T_8	20 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	26.6	32.4	14.4	18.06
T_9	40 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	27.33	33.8	14.66	18.33
T_{10}	20 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	26.93	33.2	14.43	18.2
T_{11}	40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	29.6	37.33	15.2	19.06
T_{12}	20 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	27.87	34.47	14.73	18.53
T_{13}	40 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	30.07	37.8	15.26	19.13
T_{14}	20 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	28.8	36.87	14.8	18.66
T_{15}	40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	31	39.33	15.53	19.4
	CD at 5%	1.88	0.32	1.48	2.57
	CV (%)	4.69	2.97	4.35	4.91

DAS respectively (Table 1 and Fig. 1). The probable reason for increasing branches plant^{-1} may be due to beneficial effect of sulfur, zinc, molybdenum and NAA. Patel et al. [8]. Reported that application of 40 kg sulfur ha^{-1} recorded significantly maximum number of branches plant^{-1}, number of nodules plant^{-1}, seed yield and protein content. Khan and Prakash [4] reported zinc application had significant effect on number of primary and secondary branches plant^{-1} up to 5 kg Zn ha^{-1} as compared to rest of the treatments during both the years of study. Awomi et al. [9] reported all the growth attributes were significantly increased with the application of molybdenum.

Number of nodules plant^{-1}

Maximum number of nodules plant^{-1} (28.33) and (13.50) were recorded in treatment T_{15} while minimum number of nodules plant^{-1} was recorded in treatment T_1 (control) at 45 DAS and 60 DAS respectively. However treatment T_{11} was found to be statistically at par to treatment T_{15} (Table 1) and (Fig. 1). This could be attributed to sulfur is a constituent of three essential amino acids (cysteine, cystine and methionine). Sulfur is a constituent of ferrodoxin-containing nitrogenase, which takes part in the biological nitrogen fixation resulting the highest number of nodules plant^{-1}

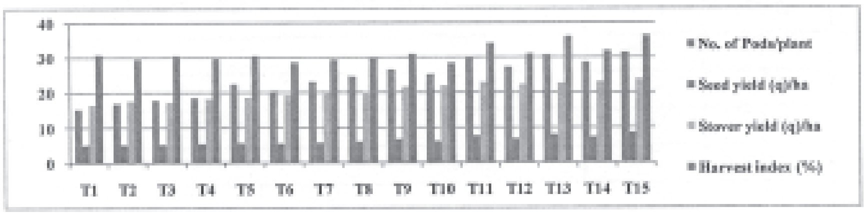

Fig. 2. Effect of secondary, micro nutrients and NAA on yield of blackgram.

Table 3. Effect of secondary, micro nutrients and NAA on economics of blackgram.

	Treatments	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
T_1	Control	26409	10273	1.63
T_2	20 kg S ha^{-1}	26914	10348	1.62
T_3	40 kg S ha^{-1}	27165	10169	1.6
T_4	20 kg S ha^{-1} + 2.5 kg Zn ha^{-1}	27985	10819	1.63
T_5	40 kg S ha^{-1} + 2.5 kg Zn ha^{-1}	29184	11588	1.65
T_6	20 kg S ha^{-1} + 5.0 kg Zn ha^{-1}	28637	10871	1.61
T_7	40 kg S ha^{-1} + 5.0 kg Zn ha^{-1}	30050	11845	1.65
T_8	20 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	31336	13770	1.78
T_9	40 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	34672	16676	1.92
T_{10}	20 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	32370	14204	1.78
T_{11}	40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1}	39721	21125	2.13
T_{12}	20 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	35541	17625	1.98
T_{13}	40 kg S ha^{-1} + 2.5 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	41038	22692	2.23
T_{14}	20 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	37789	19273	2.04
T_{15}	40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA	43581	24635	2.3

similar finding was also reported by Khan and Prakash [4]. Zinc increases the number of nodules it might be due to the enhanced and established good root system which favors more number of nodules plant^{-1}. Molybdenum is one of the most recognized nutrient elements considered to be essential for plant growth as a constituent of nitrate reductase and nitrogenase enzymes, molybdenum directly influences nitrogen assimilation and its fixation in pulse crop close findings are confined with Biswas et al. [5].

Plant dry weight (g plant^{-1})

The observations regarding plant dry weight are being presented in the (Table 1) was observed non-significant difference between the treatments at different intervals. Maximum plant dry weight (4.93 g) was recorded in treatment T_{11}, while minimum plant dry weight (3.33 g) was recorded in T_1 control at 45 DAS. Whereas maximum plant dry weight (8.22 g) was recorded in treatment T_9, while minimum plant dry weight (6.52 g) was recorded in T_8 at 60 DAS (Table 1) and (Fig. 1). Probable reason for dry matter accumulation plant^{-1} may be due to beneficial effect of sulfur, zinc and molybdenum. However the essential role of zinc has been established as a component of several enzymes concerned with carbohydrate and nitrogen metabolism, in addition to its involvement directly or indirectly in regulating the various physiological processes of plants. Similar results were reported by Khatkar et al. [10]. Successive increase in S levels up to 20 kg ha^{-1} significantly increased plant height, number of leaves plant^{-1}, and number of nodules plant^{-1}, plant dry weight, seed and straw yield. Bhuiyan et al. [11] reported molybdenum 1.0 kg ha^{-1} performed better than higher dose the lowest dry weight of shoot was recorded in control.

Yield and yield attributes

Application of 40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA has significant influence on yield and yield attributes viz. number of pods plant^{-1}, seed yield, stover yield and harvest index of blackgram over control. Maximum number of pods plant^{-1} (31.46), seed yield q ha^{-1} (8.63), stover yield q ha^{-1} (23.73) and harvest index (36.39%) were recorded in treatment T_{15}, while minimum number of pods plant^{-1} (15.33), seed yield q ha^{-1} (5.13), stover yield q ha^{-1} (16.62) and harvest index (28.44%) were recorded in treatment $T_{.1}$ (control). However, treatment T_{11} was found to be statistically at par to treatment T_{15} with respect to number of pods plant, stover yield and harvest index. Whereas treatment T_{13} was found to be statistically at par to treatment T_{15} with respect to seed yield respectively (Table 2) and (Fig. 2). The probable reason

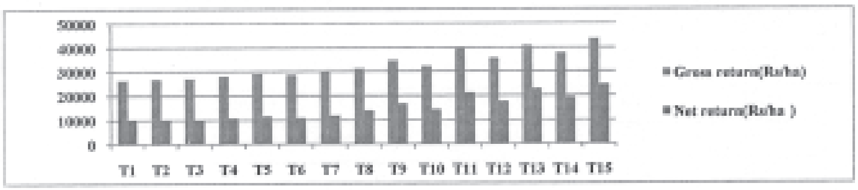

Fig. 3. Effect of secondary, micro nutrients and NAA on economics of blackgram.

may be due to beneficial effect of sulfur, zinc, molybdenum and MAA. Similar findings were also reported by Dhanushkodi et al. [3] the factor which are directly responsible for ultimate grain production pods/plant, were increased almost significantly due to increased supply of 40 kg S ha^{-1}+5.0 kg Zn ha^{-1}+1.0 kg Mo ha^{-1}+ 40 ppm NAA. Closer results are confined with Marko et al. [12]. NAA at 40 ppm was found to be effective in increase number of pods per plant, number of grains per pod, dry matter and grain yield. Similar results were reported by Kadam et al. [13].

Economics

Similarly, application of 40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA recorded highest gross return (43581.0 Rs ha^{-1}), net return (24635.0 Rs ha^{-1}) and B:C ratio (2.30), while lowest gross return (26409.0 Rs ha^{-1}), net return (10273.0 Rs ha^{-1}) and B:C ratio (1.63) was obtained in treatment T_1 control (Table 3) and (Fig. 3). The increase in gross return with application of sulfur, zinc, mo and NAA was due to increase in grain and stover yield of blackgram. Closer finding were reported by Marko et al. [12].

Conclusion

It may be concluded that among the different treatments (40 kg sulfur ha^{-1} + 5.0 kg zinc ha^{-1} + 1.0 kg molybdenum ha^{-1} + 40 ppm NAA) was found to be the best for obtaining highest seed yield, stover yield and benefit cost ratio in blackgram. Since the findings are based on the research done in one season it may be repeated for confirmation.

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