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Review on: Response of secondary, micro nutrients and naphthalene acetic acid (NAA) on growth, yield and quality of blackgram [*Vigna mungo* (L.)]

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Abstract

Pulses are commonly known as food legume while are secondary to cereals in production and consumption in India. Black gram [*Vigna mungo* (L) Hepper] also known as urd, udid or mash is one of the important short duration pulse crop. The crop has its own importance due to high nutritional value of grains as human food and fodder as rich feed for cattle. The grains contain about 24 per cent protein on dry weight basis, which is more than twice than that of cereals. It is a good green manure and erosion resisting cover crop. The crop also improves soil fertility by symbiotic fixation of atmospheric nitrogen in root nodules. Application of 40 kg sulphur ha^{-1} + 5.0 kg Zinc ha^{-1} + 1.0 kg Molybdenum ha^{-1} + 40 ppm (NAA) significantly increased growth, yield and quality 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}), harvest index (36.39), gross return (43581.0 Rs ha^{-1}), net return (10273.0 Rs ha^{-1}) and B:C ratio (1.63). This review article throws light on some important aspects on Secondary, Micro Nutrients and Naphthalene Acetic Acid (NAA) on Growth, Yield and Quality of Blackgram. References from various research articles & literature were compiled systematically with respect to the topic. Evidence based research studies were also reviewed in this regard.

Keywords: NAA, stover, ppm, nodules, and one quadrate

Introduction

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 [1]. The United Nations, declared 2016 as international Year of Pulses (IYP) to heighten public awareness of the nutritional benefit 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 importer 14% of pulses in the world [2].

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 plant during the same period has increased from 8.41 million ha^{-1} to 19.27 million ha^{-1} an increase of over 100% [1]. In 2014-15 17.20 million tones and estimate production for 2015-16 about 18.32 million tons [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 gm day^{-1} 1971 to 41.9 gm day^{-1} 2013 as against WHO recommended of 80 gm 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 [2].

Blackgram is scientifically known as Vigna mungo (L.) and commonly known as urd in India. It is a tropical leguminous plant, which belong to the Asiatic *vigna* species along with *v. radiata, v. trilobata, v. acontifolia and v. glaberecence*. It has distributed mainly in tropical to sub-tropical countries. India is a primary origin and it is restricted to wet tropics and it is mainly cultivated in Asian countries including Pakistan, Myanmar, Srilanka, Burma, and some other countries of south East Asia, Africa and America. In India blackgram is very popularly grown in Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Uttar Pradesh, west Bengal, Punjab, Haryana, and Karnataka. This crop is grown in intercropping system as a mixed crop, catch crop, sequential crop, besides growing as a sole crop under residual moisture conditions. It is grown in *kharif* as well as *zaid* season, sowing between mid Feb to march is found to be optimum time for *Zaid* season. Blackgram seeds are highly nutritive value with protein (25-26%), carbohydrates (60%), fat (1.5%), minerals, amino acids and vitamin [3].

Sulphur is recognized as fourth major plant nutrient along with N, P, K, performance many important functions in the plant and plays an important role in improving yield and quality of pulses. Sulphur 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 [4]. 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 [5]. Molybdenum is one of the most recognized micronutrient elements as constituent of nitrate reductase and Nitrogenase enzymes; molybdenum directly influences nitrogen assimilation and its fixation in pulse crop [6]. 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). The objective of this study is to find out the effect of sulphur, zinc, molybdenum and NAA on growth, yield quality & economics of blackgram.

Effect of Sulphur on growth and yield of blackgram

Sulphur 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. Sulphur is required in plant for the synthesis of chlorophyll and essential for activation of certain proteolytic enzymes such as papinase. Increased use of sulphur-free fertilizers, intensive cropping, and use of high-yielding varieties have led to Sulphur deficiency in many countries. Sulphur deficiency is increasingly becoming one of the limiting factors to further sustainable increase in agricultural production. Sulphur fertilizer, besides enhancing yield and quality of crops, enhances nutrient uptake, particularly nitrogen, and fertilizer-use efficiency through interaction of sulphur with other fertilizer nutrients. Sulphur is needed for conversion of reduced nitrogen into protein in symbiotic nitrogen fixation in pulses (like greengram), thus its positive effect on nitrogen absorption is quite likely. Sulphur not only improved grain yield but also improved the quality of crops [7].

Sulphur is one of the essential plant nutrients for all plants and is indispensable for the growth and metabolism. Sulphur has a number of oxidizing function in soil and plant nutrition. It is a constituent of certain amino acids like methionine, cystine and cysteine and also a constituent of Fe-S proteins called ferrodoxin. The acidity produced by oxidation helps to solubilizing plant nutrients and improves alkali soils [8]. Sulphur 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. Gypsum is preferred more as a source of sulphur because of its diverse role in soil especially in saline and alkaline soils; gypsum is used as amendments also. The objective is to bring soil pH to range favorable for nutrient availability, plant growth and development and also to improve the soil structure. Sulphur at 40 kg ha^{-1} exhibited its superiority by registering the highest number of pods plant^{-1} which was on par with 30 kg ha^{-1}. Also there is significant effect of source and levels of S on grain yield of black gram during both the seasons. Gypsum yielded 1245 kg ha^{-1} and 979 kg ha^{-1} of grain during kharif and rabi season of 1995 while it was 1209 kg ha^{-1} and 1023 kg ha^{-1} during 1996 respectively [9]. Sulphur at 30 kg ha^{-1} application resulted increased growth attributes, yield attributes & protein content. The S-containing amino acids viz; methionine, Cystine and cysteine content of the grains, were highest with the application of 30 kg S ha^{-1}, which was at par with the application of 20 kg S ha^{-1} [10]. The yield attribute except pod length and number of grains pod^{-1} of green gram increased significantly with increasing level of sulphur 30 kg ha^{-1} [11]. Sulphur at 40 kg ha^{-1} gave the highest number of pods plant^{-1}, number of seed pod^{-1}, 1000 - Seed weight, seed yield, net return and rupees invested [12]. Successive increase in Sulphur levels upto 20 kg ha^{-1} significantly increased plant height, number of leaves plant^{-1}, number of branches plant^{-1}, plant dry weight, seed and straw yield by 3.67, 21.29, 5.29, 8.12 and 5.92 percent, respectively. Application of 40 kg S ha^{-1} showed significant increase in the length and vertical spread of root, nodules/plant and dry weight of nodules at 40 and 60 DAS over 20 kg S ha^{-1} and control [13].

Similar trend was observed in case of grain yield and with the application of 40 kg S ha^{-1} recorded highest grain yield of blackgram (980 kg ha^{-1}). Application of 20 kg ha^{-1}sulphur as gypsum synthesized more protein and account as 24.45% and application of sulphur recorded significantly higher number of pods per plant (22.77), pod length (5.10 cm), seed per pod (6.77) and 100 seed weight (4.88 g) also synthesized more protein and accounted as 24.48 percent [14]. Enhancement in protein content may be due to sulphur which plays a vital role in nodulation and amino acid synthesis [4]. Rhizobium inoculation with sulphur and micronutrients give maximum grain yield (11.32 and 10.81 q ha^{-1}) as compared to any other treatment. Yield attributing characters like number of pods (55 and 54) and 100 grain weight (4.69 and 4.165) were also higher in the treatment comprising Rhizobium, sulphur and all the micronutrients [15].

Application of gypsum at the rate of 60Kg ha^{-1} produced significantly higher pod length, seed pod^{-1} to 1000 seed weight in black gram; these findings are revealed by [16]. Similarly application of 40 kg sulphur ha^{-1} in mungbean was beneficial and increase growth and yield was reported by [17]. Increasing levels of phosphorus and sulphur enhanced the growth, plant height, yield attributes like number of nodules plant^{-1}, dry weight of nodules, number of pods plant^{-1}, number of grains pods^{-1}, 1000 weight, grain yield, and straw yield showed maximum increase at 45 kg P ha^{-1} and 30 kg S ha^{-1} respectively [18]. Sulphur @ 40 kg ha^{-1} recorded maximum growth, yield and nutrient content in comparison to other levels which was reported by [19, 20].

Application of 20 kg S ha^{-1} recorded significantly higher seed yield (1088 kg ha^{-1}) compared to without sulphur 824 kg ha^{-1}. The growth components were enhanced by the higher levels of sulphur at 40 kg ha^{-1} leaf area index 2.33 and Chlorophyll Content 2.42 and number of branches 8.91.This might be due to the high dose of sulphur and increased availability of sulphur along with other major nutrients was concluded by[21]

Similarly sulphur up to 60 kg ha^{-1} increased the plant height, branches $plant^{-1}$, number and weight of root nodules $plant^{-1}$ and dry matter $plant^{-1}$ almost significantly in blackgram and also the factors which are responsible for ultimate grain production viz., pods $plant^{-1}$, grains pod^{-1}, 1000 grain weight and seed weight $plant^{-1}$ were increased due to increased supply of sulphur up to 60 kg ha^{-1}, grain yield was 11.97 q ha^{-1} and harvest index 38.36% [23].

Sulphur @ 40 kg ha^{-1} significantly increased the plant height (39.59%), number of leaves $plant^{-1}$ (15.86), grain yield q ha^{-1} (13.46) and haulm yield (10.93%) of blackgram as compared to no sulphur treatment [23]. Similarly sulphur @ 40 kg ha^{-1}recorded significantly highest seed yield $plant^{-1}$ and seed yield (1435.95 kg ha^{-1}) over 40kg ha^{-1}sulphur level and control, as well as observed significantly higher straw yield (2161.79 kg ha^{-1}) over control but it is at par with 20kg ha^{-1}sulphur. As sulphur level increased, there was significant progressive increase in protein content (%). 20kg ha^{-1} and 40kg ha^{-1} sulphur levels increased protein content by 4.21 and 18.45 per cent respectively over control [24].

Application of phosphorus and sulphur provided maximum grain yield (15.20 q ha^{-1}) and stover yield (19.80 q ha^{-1}) with the treatment N, K, P, S (20, 30, 40, 40 kg ha^{-1}) which was at par with treatment N, K, P, S (20, 30, 20, 40 kg ha^{-1}) and N, K, P, S (20, 30, 40, 20 kg ha^{-1}) which was significantly superior over other treatments [25]. Maximum plant height (49.95 and 50.12 cm), number of branches $plant^{-1}$ (12.68 and 12.72), number of nodules $plant^{-1}$ (34.75 and 35.25), number of pods $plant^{-1}$ (20.85 and 21.89), number of seeds pod^{-1} (12.49 and 12.99), test weight (37.83 and 38.73) and seed yield (11.89 and 12.51 q ha^{-1}) and protein content (23.92 and 24.07%) was obtained at 40 Kg S ha^{-1}. However, 60 Kg S ha^{-1} was statistically at par with 40 Kg S ha^{-1} in respect of growth and yield attributes, seed yield and protein content [8]. Protein in legume was appreciably increased with the application of phosphorus and adequate quantities of sulphur play an important role in improving the crop quality. Application of 40 kg S ha^{-1} may regarded as beneficial dose of sulphur application from the point of view of more protein content 23.94% in 2002-03 and 25.12% in 2003-04 in seed of blackgram [3]. Sulphur at 30 kg ha^{-1} registered significantly the highest grain (9.19 q ha^{-1}) and straw (18.06 q ha^{-1}) yield. Combined application of 20 kg K2O ha^{-1} along with 30 kg S ha^{-1} recorded significant increase in respect of yield attributes and yield [26]. Investigation data showed that significantly the highest plant height (43.53 cm), number of branches per plant (5.79), leaf area index (3.97, 4.17 and 4.65 at 20, 40 and 60 DAS) and dry matter content (4.64, 7.63 and 10.65 g $plant^{-1}$ at 20, 40 and 60 DAS, respectively) were observed in treatment (30 kg S ha^{-1}). With respect to yield attributes and yield the results indicated that significantly the maximum number of pods per plant (20.47), weight of 100 seeds (4.07 g), seed yield (819 kg ha^{-1}) and straw yield (1551 $kgha^{-1}$) were found with the application of 30 kg S ha^{-1}(27). Similarly application sulphur @ 45 kg ha^{-1} also increased number of nodules $plant^{-1}$ significantly over control [28]. The experimental data conclude that application of sulphur alone or combined with nitrogen, significantly increased plant height, number of seeds per pod and total seed yield [29].

The progressive increase in sulphur levels at 40 kg ha^{-1} recorded significantly higher plant height (34.06 and 59.0 cm) and branches $plant^{-1}$ (3.53, 5.67 and 8.00) at 60, 90 DAS and at harvest over control and 20 kg ha^{-1} but remained at par with 60 kg ha^{-1}& also observed that the number of total (27.06) and effective root nodules (15.00), leghaemoglobin content in root nodules (1.91 mg g^{-1}), and increasing application of sulphur up to 40 kg ha^{-1} (30). The yield of soybean (seed and straw) increased significantly due to application of 60 kg S ha^{-1} by 14.01% and 15.90%, respectively over control. The protein content recorded was 39.89, 36.09 and 37.805 due to application of 60 kg S ha^{-1} followed by 40, 20 kg S ha^{-1} during first year, second year and in pooled [31]. Application of 36 kg N, 70 kg P2O5 and 30 kg S/ha gave the maximum values of growth parameters, yield attributes and grain yield as well as removal of N, P and S over lower fertility levels. Further, under interaction effect the significantly highest grain yield was observed with the treatment combination of *Rhizobium* + PSB + 36 kg N, 70 kg P2O5, 30 kg S kg ha^{-1} (964.9 kg ha^{-1}) but remained at par with medium level of fertility 24 kg N, 50 kg P2O5, 20 kg S/ha (941.6 kg ha^{-1}) applied along with *Rhizobium* and PSB [32].

Highest growth parameters such as plant height (54.7 cm, 55.9 cm), Number of leaves $plant^{-1}$ (54.8, 58.8), Number of pods $plant^{-1}$ (34.7, 38.8), Number of seed pod^{-1} (7.4, 8.4) like yield parameters such as grain (1145, 1275 kg ha^{-1}) and straw yield (1645, 1990 kg ha^{-1}) and quality parameters viz., protein (23, 24.2%) and methionine (8.92, 8.97 mg g^{-1}) were significantly increased by the different S sources when compared to control in Vylogam and Peelamedu series. Irrespective of the different S sources, S @ 20 kg ha^{-1} as K2SO4 coupled with recommended dose of fertilizers plus 0.5% K2SO4 foliar spray at 30th and 45th DAS were significantly registered better response in blackgram at both the series (33). Application of 40 kg Sulphur $ha^{–1}$+ 5.0 kg Zinc $ha^{–1}$ + 1.0 kg Molybdenum $ha^{–1}$ + 40 ppm NAA significantly increased growth and yield parameters viz. Plant height (31.0 ppm), 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). 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 (10273.0 Rs $ha^{–1}$) and B: C ratio (1.63) was obtained in treatment T_1 control respectively [34].

Effect of Zinc on growth and yield of blackgram.

Effect of zinc on growth, yield and quality of black gram was experimented by various scientists and research persons in different agro climatic conditions across the country. The application of Zn results in the enhancement of grain yield and quality. Genetic variability for response to applied Zn has been noticed among different cultivars of pulses [35]. Spraying the leaves with the nutrient elements is one of the methods of plant supply. Although the leaves and shoots can absorb nutrients as well as water, gas through the stomata, leaf spraying method in addition to the rapid response, will also save money. The fertilization procedure in addition to economic aspects and the effectiveness of the immediate environment in order to achieve sustainable agriculture is also very effective and useful [36].

Zinc application contributed in increase in seed yield probably owing to its influence on Auxin synthesis, nodulation and nitrogen fixation, which promoted plant growth and development, there by favorably influencing grain yield [35]. Zinc is involved in Auxin metabolism like, Tryptophane synthesis, tryptamine metabolism, protein synthesis, formation of nucleic acid and helps in utilization of nitrogen as well as phosphorus by plants. Zinc also stimulates resistance for dry and hot weather, bacterial and fungal diseases and ribosomal fraction in the plants. It also promotes nodulation and nitrogen fixation in leguminous crops (24). Significant positive effect of zinc on dry matter, seed and straw yield of mungbean as well as crude protein found in the seeds [37]. The yield attributes and seed yield indicated that an application of 15 kg Zn ha^{-1} significantly enhanced the yield attributes as well as seed yield. The increase in yield may be due to increase in the application of this content, significant difference in plant height, dry matter per plant, seeds per pod and pods per plant was recorded with Zinc @ 15 kg ha^{-1} [35].

Similarly application of zinc also increased the growth, yield attributes and significantly upto 10 kg Zn ha^{-1} during both the years. The magnitude of increase in seed yield was 23.82% in first year and 25.48% in second year by seed, respectively as compared to control. The increase in growth, yield attributes and yield might be due to role of zinc in biosynthesis of indole acetic acid (IAA) and especially due to its role in initiating of primordial for reproductive parts and partitioning of photosynthesis towards them which resulted in better flowering and fruiting (8). Increase in level of zinc from 0 to 6 kg ha^{-1} resulted in a significant increase in the grain yield of lentil from 17.22 to 18.85 q ha^{-1} (38). Maximum plant height 24.75 cm and number of primary 4.11 and secondary branches 13.46 plant^{-1}of urdbean was significantly increased with the application of 2.5 kg Zn ha^{-1} as compared to control. Significantly higher number and dry weight of nodules plant^{-1} 5.55 23.78 and 7.58 13.82 at 30 and 45 days after sowing was recorded with the application of2.5 kg Zn ha^{-1} as compared to control. Similarly grain and stover yield of urdbean significantly increased upto 5.0 kg Zn ha^{-1} and grain and stover yield at this level were 11.60 q ha^{-1}and 21.87 q ha^{-1} respectively [5]. The research trial conducted on black gram by (39) observed that application of 40 kg S ha^{-1} + 5.0 kg Zn ha^{-1} + 1.0 kg Mo ha^{-1} + 40 ppm NAA increased yield and quality parameters viz, 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 protein content (24.73%) while lowest protein content was obtained in treatment T_1 (control) respectively.

Effect of molybdenum on growth and yield of blackgram

Effect of molybdenum on growth, yield and quality of black gram & other pulses was experimented by various scientists and research persons in different agro climatic conditions across the country to get progressive results over control treatment. Molybdenum is one of the most recognized nutrient elements considered to be essential for the growth of plant. Food insecurity in the 21st century will even increase due to heat and drought stress induced by the climate change, particularly in tropical and subtropical regions. Legumes are good and relatively cheaper source of proteins, carbohydrates and minerals for developing countries including India. The yield of greengram, blackgram and chickpea was found to increase progressively up to 1.5 and 1.0-1.5 kg Mo ha^{-1} at jessore and rahmatpur, respectively. Significantly higher yield was recorded only over molybdenum control while the other levels produced identical results in both the years and locations. The highest mean yield (1.85 t ha^{-1}) was obtained with 1.5 kg Mo ha^{-1} at Jessore, which was15% higher over control. However, at rahmatpur, the highest mean yield (1.35 t ha^{-1}) was obtained with 1.0 and 1.5 kg Mo ha^{-1}, which was 16% higher over control [40]. Research trial conducted on mungbean by [40]. reported that effect of molybdenum on mungbean stover yield was also influenced significantly. The stover yields (26.17 g plant^{-1}) with 1.0 kg Mo ha^{-1}, was significantly higher than the stover yield (25.98 g plant^{-1}) recorded with 1.5 kg Mo ha^{-1} and seed yield was significantly influenced by application of Molybdenum.

Molybdenum is constituent of nitrate reductase and Nitrogenase enzymes; molybdenum directly influences nitrogen assimilation and its fixation in pulse crop. The highest seed yield (12.34 g plant^{-1}) was found with 1.0 kg Mo ha^{-1} and the lowest (11.58 g plant^{-1}) was recorded with 1.5 kg ha^{-1}(6). Similar findings are confirmed by (42). Application of 1.5 kg Mo ha^{-1} yield was 31.9 and 5.4% higher than the control (272 kg ha^{-1}) and 0.75 kg Mo ha^{-1} (378 kg ha^{-1}) treatments, respectively. All the growth attributes were significantly increased with increasing levels of Mo. Application of 1.5 kg Mo ha^{-1} produced the tallest plants with the highest number of branches, number of nodules and dry weight per plant. Also application of 1.5 kg Mo ha^{-1} recorded maximum protein content and protein yield. N, P and K uptake by crop was significantly influenced by increasing levels of Mo [43].

The yield parameters such as pods number and weight of pods per plant, weight of 100 seed and pods yield significantly increased as affected by different Mo doses compared with control in cowpea & pointed that Mo at 250 ha gave the best results like number and weight of pods per plant, weight of 100 seed and harvest index (%) in groundnuts [45]. The findings of research trial conducted by [45] revels that molybdenum is one of the most recognized micronutrient element considered to be essential for the growth of plants and improving the crop yield and quality. The highest pod (954 kg ha^{-1}) and seed yield (609.6 kg ha^{-1}) were recorded under 1000 g Mo. The fertilizer levels 1000 g ha^{-1} $Na_2 MoO_4$ - $2H_2$ O showed that expect plant height and number of branches other growth parameters were significantly influenced by Mo fertilization. The highest rate (1000 g ha^{-1}) of Mo application recorded 40% increase in pod and seed yield in comparison to control [46]. Findings shows that the application of molybdenum up to highest doses 1.0 kg ha^{-1}significantly plant height 26.13 cm number of primary and secondary branches 4.38 and 14.28, nodules number and dry weight of nodules 25.40 and 14.82 g respectively. Application of Molybdenum @ 0.5 kg ha^{-1} significantly increased both grain (1132 kg ha^{-1}) and straw yield (2088 kg ha^{-1}) of urdbean [5]

Effect of NAA on growth and yield of blackgram

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) and also facilitating nitrogen accumulation that probably resulted in higher total dry matter production. Foliar spray of 25 ppm NAA recorded significantly higher seed yield by 21 to 22 per cent over control through increased flower production, clusters per plant, pod setting percentage and pods per plant in mungbean [47] NAA spraying was found to be significant in influencing the yield attributes such as number of pods plant^{-1}(8.5 to 10.0), pod length (5.1 to 6.0 cm), number of seeds pod^{-1} (8.9 to 10.5) and 100 grain weight (2.9 to 3.0g) followed by MC at 50 ppm. Application of N at 50 kg ha^{-1} and NAA spraying registered the highest yield attributes and yield however there was no significant difference between their combinations [48].

The grain yield ranged from 717 to 1142 kg ha^{-1}, when foliar spraying of nutrient mix was given for the blackgram, the treatment (2% DAP + 1% MOP + 40 ppm NAA at 25, 32, 40 and 47 DAS) recorded the highest mean grain yield of 1142 kg ha-1 followed by (2% DAP + 1% MOP + 40 ppm NAA at 25, 32, and 40 DAS) with a grain yield of 1044 kg ha^{-1}. NAA @ (30 ppm) treatment was found to be effective to increase number of pods per plant, number of grains per pod, dry matter and grain yield (q ha^{-1}) [49]. The evidence are given regarding NAA had positive effect on the dry matter accumulation in black gram, green gram and chickpeas [50]. Similarly [51] has reported the finding of his experiment that NAA had been found to be effective in increasing number of pods in cowpea, lablab bean, Pigeon pea and Chickpea. NAA @ (30 ppm) concentration was found significantly superior to other treatments & the branches increased by NAA may be the reason to increase number of leaves [52]. The significant effect of NAA on biological yield 6393.77 kg ha^{-1} and 6543.85 kg ha^{-1} (2004-05) and 6466.38 kg ha^{-1} and 6552.38 kg ha^{-1} (2005-06) were recorded in control and plant growth regulator (NAA), respectively. NAA gave an increase of 2.35 and 2.87% in biological yield during 2004-05 and 2005-06, respectively. Similarly harvest index was 37.63 and 41.69% during 2004-05 and 40.44 and 43.05% was recorded during 2005-06 in control and plant growth regulator (NAA), respectively. As the harvest index is dependent on seed yield, NAA increased pods per plant by decreasing flower droppage and thus improved 11.07% harvest index. Harvest index was increased 11.07% by the application of NAA [53].

The results revealed that applications 2 per cent DAP + Rhizobium + Phosphobacter + residual effect of inorganic fertilizers and organic manures (M2S2) 40 ppm NAA & Rhizobium + Phosphobacter recorded the highest value of growth and yield attributes and yield of greengram. The maximum yields were recorded as 1082 kg ha^{-1} and 1119 kg ha^{-1}respectively in two seasons (M2S2) when compared to other treatments (54). Similar findings are also revealed by [20] in his experiment & reported that among the foliar sprays, spray comprised 2% DAP + 40 ppm NAA at 45 and 55 DAS recorded significantly higher seed yield (1202 kg ha^{-1}) in blackgram.

The effect of different treatments significantly influenced the number of branches per plant recorded at harvest. Significantly maximum number of branches per plant (10.63) was recorded with treatment (GA_3 20 ppm at 20 and 40 DAS), which was statistically at par with treatments (GA_3 40 ppm at 20 and 40 DAS) and treatment (NAA 40 ppm at 20 and 40 DAS) at harvest in green gram. Significant higher grain yield (1298 kg $ha^{-1)}$, haulm yield (1987 kg ha^{-1}), yield attributes (pod length, number of seeds pod^{-1}, test weight) and growth attributes (plant height, number of branches and total dry matter production) were recorded with application RDF + foliar spray of 40 ppm NAA + 0.5% chelated micronutrient + 2% DAP over rest of the treatments [55].

The highest protein content (22.7%) was obtained with 2% DAPS + 1% K +20 ppm NAA [56]. Improvement in the chlorophyll, carotenoids and total carbohydrates content as a result of foliar nutrition could be attributed to the mode of action of macro and micro elements in enhancing the photosynthetic activity and enzymes carbohydrates transformation [57]. Similarly [58] reported that application of RDF + Micronutrients Foliar spray of 40 ppm NAA has recorded significantly higher grain yield (1298 kg ha^{-1}), number of pods per plant (38.73), number of seed per pod(6.47) and test weight (61.90g) over rest of the treatments but it was at par with (RDF + Foliar spray of 2% DAP + 0.5% chelated micronutrient), (1237 kg ha^{-1}, 34.13 $plant^{-1}$, 6.33 pod^{-1} and 60.67^{-1}g) respectively. The highest seed yield with NAA 20 ppm application can be attributed to more value for the number of pods per plant (25.1), seeds per pod (7.0) and test weight (37.1 g) as compared to other treatments in green gram (47). Similarly findings by (59) shows that increase in chlorophyll content in blackgram by foliar application of 40 ppm NAA, 25 ppm mepiquat chloride, 0.1 ppm brassinolide and 100 ppm triacontanol. The maximum seed weight of 100 seeds (3.44 g) was recorded with treatment (NAA 30 ppm seed soaking + Rhizobium + NAA 30 ppm foliar spray at 25 and 40 DAS and 2.75 g in control.

Conclusion

From the present study conducted on response of secondary, micro nutrients and naphthalene acetic acid (NAA) on growth, yield and quality of blackgram [*Vigna Mungo* (L.)] it may be concluded that application of 40 kg sulphur 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 & protein content in blackgram. The findings are similar with various reviews which are presented in this article. This study will be helpful in increase the blackgram production per unit area by using necessary secondary, micro nutrients & growth regulator and similarly it also help to meet the daily protein, vitamin & minerals requirement in terms of nutritional security to small and marginal farmers.

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