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CONTENTS

Growth and yield response of black gram (*Vigna mungo* L) to foliar nutrition and growth regulator application

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ABSTRACT: A field experiment was conducted during *Kharif* season 2019-20 at the N. E. Bourlag Crop Research Centre of G. B. Pant University of Agriculture & Technology, Pantnagar (Uttarakhand) to find out growth and yield response of black gram(*Vigna mungo* L.) to foliar nutrition and growth regulator application. The black gram variety Pant U-31 was used for sowing. The experiment was consisted of 11 treatments *viz.*, absolute control, water spray at 40 and 55 DAS, foliar spray of 2% urea at 40 (flowering) and 55 DAS (grain filling), 2% SSP at 40 DAS, 2% SSP at 55 DAS, 2% SSP at 40 and 55 DAS, 100 ppm SA(salicylic acid) at 40 DAS, 100 ppm SA at 55 DAS, 100 ppm SA at 40 and 55 DAS, and 2% SSP at 40 DAS followed by 100 ppm SA at 55 DAS,100 ppm SA at 40 DAS fb2% SSP at 55 DAS. The experiment was laid out in Randomized Block Design with three replications. Foliar spray of 2% SSP at flowering and grain filling produced highest branches per plant and dry matter per plant which was at par with foliar spray of 2% urea at 40 and 55 and 100 ppm SA at 40 DAS followed by 2% SSP at 55 DAS. The grain yield was significantly influenced by the foliar application of 2% single super phosphate at flowering and 15 days later (36.2%), followed by 2% urea at flowering and 15 later (34.6%)and foliar spray of 100 ppm salicylic acid at 40 days after sowing followed by 2% single super phosphate at 55 days after sowing (28.9%). The number of pods per plant, grain weight per plant and 1000 seed weight were also significantly influenced by foliar nutrition and salicylic acid whereas number of grains per pod did not responded significantly in regards to foliar nutrition and salicylic acid. Therefore, it may be concluded that foliar spray of SSP @ 2% at flowering and grain filling was found significantly effective as foliar spray of 2% urea at flowering and grain filling and salicyclic acid @ 100 ppm at flowering followed by SSP @ 2% at grain filling to improve growth and grain yield of black gram

Key words: Black gram, foliar nutrition, growth, salicyclic acid, single super phosphate, yield

Black gram (*Vigna mungo* L. Hepper) is mainly grown as rainfed crop under diverse agro climatic situations round the year. There are various reasons of its low productivity *viz.*, poor management practices, various physiological and biochemical factors etc. Physiological constraints like flower drop and premature shedding of reproductive structures diminish the number of potential sinks (or) accumulation of assimilates which seems to be associated with nutrient deficiency and hormonal imbalance ultimately resulting in reduced translocation of dry matter to reproductive parts (Basavarajappa *et al.,* 2013).The requirement of primary nutrient like nitrogen and phosphorus is more at the time of flowering and grain filling as these elements are building block of amino acids. In addition, secondary elements like calcium and sulphur are also important for plant growth and development. The supplement of these nutrients through soil application is common practice. But soil applied nutrients may or may not be available to the plants due to several soil physic-chemical reactions and the soil applied fertilizer is not utilized by the crop within the season especially in short duration crops. Sulphur is a key component of essential amino acids *viz.*, methionine, cystine and cysteine needed for protein synthesis and also required in chlorophyll synthesis and enzymatic reactions. (Gajghane *et al.,* 2015). Calcium is also essential for cell elongation as well as cell division and preserves the structural integrity of plant membrane. The important role of calcium is nitrogen metabolism, thus it enhance nitrate uptake. Calcium as such or as a component of calmodulin increases the activity of many enzymes (Bush, 1995)

In addition to nutrients, growth regulators are also important factors used for yield and seed quality improvement in various crops. Salicylic acid (2-hydroxybenzoic acid), as a natural plant hormone, has many effects on physiological processes and growth of plants (Khan *et al*., 2010). Application of nutrients and growth regulators through foliar

spray at appropriate stages of growth is important for their efficient utilization and improved performance of the crop. This is considered to be an efficient and economical method of supplementing part of nutrients requirements at critical growth stages. Foliar nutrients usually penetrate the leaf cuticle or stomata and enter the cells facilitating easy and rapid utilization of nutrients. Foliar application of urea at critical growth stage has been found effective in increasing the nitrogen availability to developing seeds in pulses (Palta *et al.,* 2005). Therefore, the present study was conducted to find out the growth and yield response of black gram to foliar nutrition and salicylic acid application.

MATERIALS AND METHODS

The field experiment was conducted at G.B. Pant University of Agriculture and Technology, Pantnagar to find out the growth and yield response of black gram to foliar nutrients and salicylic acid. The climate of experimental site is humid sub-tropical with hot summers and cold winter. The maximum temperature during the hot summer exceeds up to 45° C while the minimum temperature during winter seldom drops to 1° C. The mean rainfall received during the crop growth season (July- November, 2019) was 628.7 mm. The mean maximum weekly temperature during the crop season ranged from 33.8°C during 35th standard meteorological week (Aug-Sep, 2019) to 29.2°C during 44th standard meteorological week (Oct-Nov, 2019). The mean minimum weekly temperature during the crop season ranged from 26°C during 31th standard meteorological weeks (July-Aug, 2019) to 16.2°C during 43th standard meteorological week (Oct, 2019).The soil of experimental field was well drained and has been classified as 'mollisols' (Deshpande *et al.,* 1971). The soil of experimental field was high in organic carbon, low in available nitrogen and medium in available phosphorus and medium in available potassium. Black gram variety PU-31 was used for sowing. The crop was sown in the last week of July. The experiment was conducted in Randomized Block Design with three replications. The treatment details are as follows, T_1-absolute control (no foliar spray),T_2-water spray at 40 (flowering) and 55 days after sowing (grain filling stage),T_3-Urea@2% at 40 and 55 DAS,T_4 -SSP @ 2% at 40 DAS,T_5 -SSP @ 2% at 55 DAS,T_6-SSP@ 2% at 40 and 55 DAS,T_7 -Salicylic acid @100 ppm at 40 DAS,T_8-Salicylic acid@ 100 ppm at 55 DAS,T_9 -Salicylic acid@100 ppm at 40 and 55 DAS,T_{10} -SSP @ 2% at 40 DAS followed by Salicylic acid@100 ppm at 55 DAS and T_{11} -Salicylic acid@100 ppm at 40 DAS followed by SSP @ 2% at 55 DAS. Foliar application of nutrients and growth regulator *viz.*, urea, SSP and salicylic acid were sprayed as per treatment. Appropriate need base plant protection measures were taken up to control the pest and diseases as per the recommended cultural practices. The growth parameters *viz.*, number of branches per plant and plant dry matter were recorded at 40, 55and 70 DAS and yield attributes were recorded after harvesting of the crop. For recording growth parameters and yield attributing characters 5 plants were selected randomly and mean value were reported. The data collected for black gram was statically analyzed in Randomised Block Design following the procedure given by Cochran and Cox (1959). Whenever significant difference existed, critical differences were used at five per cent probability level.

RESULTS AND DISCUSSION

Growth parameters

The foliar nutrition and salicylic acid application improved growth parameters of black gram. The foliar application of 2% urea at flowering and grain filling stage significantly increased number of branches per plant and dry matter in black gram which was statically *at par* with foliar spray of single super phosphate @ 2% at flowering and grain filling stage (Table 1). This might be due to quick availability of foliar applied nutrients resulted in better vegetative growth as observed by more number of branches and more dry matter produced with the advancement of growth stages. At 70 days after sowing, the significant increase in number of branches was observed with foliar application of 2% urea flowering and grain filling stage (32.4%) followed by foliar spray of single super phosphate

@ 2% at flowering and grain filling stage (29.7%) and foliar spray of salicylic acid @ 100 ppm at 40 days after sowing followed by single super phosphate @ 2% at 55 days after sowing (21.6%) over absolute control treatment.

Foliar application of single super phosphate at flowering and grain filling stage might have helped in acceleration of various metabolic process *viz.*, photosynthesis and energy transfer reaction, as it contains calcium, phosphorus and sulphur content as Bohra *et al.* (2006) also reported that foliar application of sulphur @ 0.5 % at branching and flowering stage of *Vigna aconitifolia* the increased the leaf chlorophyll content. These elements help in cell elongation and as well as cell division. It is also known that sulphur is important for meristematic tissue activity and development of shoots and resulting into increased number of branches per plant. In the present investigation, foliar application of salicylic acid also increased number of branches per plant. It may be because of stimulating effect of salicylic on physiological and biochemical aspects of plant via increasing assimilation rate which increases chlorophyll content in leaf (Maity and Bera, 2009) and also increased activity of antioxidant enzymes and glutathione content (Khan *et al*., 2010). The stimulation effect of salicylic acid on plant growth was also reported by El-Shraiy and Hegazi (2009) on pea. Ali and Mahmoud (2013) also registered the maximum number of branches plant per plant with foliar spray of 150 ppm salicylic acid.

Presence of nitrogen, phosphorus and salicylic acid has governed the various physiological characters that ultimately increased the dry matter production at various stages of crop growth. The production of dry matter increased with the advancement of crop growth age. At 55 and 70 days after sowing, the dry matter production was significantly higher with 2% urea spray at flowering and grain filling which was *at par* with foliar application of single super phosphate @2% at 40 and 55 days after sowing. At 55 days after sowing, the maximum increase in dry matter production 21.3% was observed with 2% foliar spray of urea followed by foliar spray of single super phosphate @ 2% at 40 and 55 days after sowing (19.9%) whereas at 70 days after sowing this increase was 23.8% and 23.4% respectively. Similar results were reported by Thakur *et al.* (2017). Absolute control treatment produced minimum dry matter (27.3 g/plant) which was *at par* with all the treatments except foliar application of urea @ 2% (33.8 g/plant), single super phosphate@ 2% at 40 and 55 days after (33.7 g/plant) sowing and salicylic acid @ 100 ppm at 40 days after sowing followed by single super phosphate @ 2% at 55 days after sowing (31.8 g/plant).

Foliar spray of urea increased chlorophyll content

Table 1: Number of branches per plant and dry matter production of black gram as influenced by foliar nutrition and salicylic acid application

Treatments	Number of branches per plant			Dry matter production (g/plant)		
	40 DAS	55 DAS	70 DAS	40 DAS	55 DAS	70 DAS
T_1: absolute control (no foliar spray)	2.7	3.1	3.7	15.0	22.1	27.3
T_2: water spray at 40 and 55 DAS	2.6	3.2	3.8	15.1	22.3	27.5
T_3: 2% urea at 40 and 55 DAS	3.2	4.2	4.9	16.2	26.8	33.8
T_4: 2% SSP at 40 DAS	2.8	3.3	4.0	16.1	24.3	30.1
T_5: 2% SSP at 55 DAS	3.0	3.4	3.9	16.2	24.3	29.5
T_6: 2% SSP at 40 and 55 DAS	3.2	4.1	4.8	16.3	26.5	33.7
T_7: 100 ppm SA at 40 DAS	3.2	3.5	3.9	15.8	23.7	29.2
T_8: 100 ppm SA at 55 DAS	3.0	3.3	3.7	15.3	22.8	28.1
T_9: 100 ppm SA at 40 and 55 DAS	2.9	3.4	4.1	16.0	24.5	30.5
T_{10}: 2% SSP at 40 DAS *fb* 100 ppm SA at 55 DAS	2.8	3.5	4.1	15.9	24.7	30.9
T_{11}: 100 ppm SA at 40 DAS *fb* 2% SSP at 55 DAS	3.1	3.8	4.5	15.6	24.9	31.8
SEm±	0.2	0.2	0.3	0.8	1.0	1.4
CD at 5%	NS	0.7	0.8	NS	2.8	4.2

SSP: Single super phosphate; SA: salicylic acid; DAS: days after sowing

in plants may be due to the fact that nitrogen is a constituent of chlorophyll molecule. The increase in chlorophyll content reflects increased PS II photochemistry, photosynthates production and dry matter accumulation. The combination of nitrogen, phosphors and brassinolide combined with micronutrient favored better translocation of assimilates to sink resulted in improvement in growth and dry matter accumulation (Bera *et al.,*2008).Sulphur application greatly influences chlorophyll synthesis, carbohydrate as well as protein metabolism and finally results in improvement of growth characters contributing to higher dry matter accumulation in plants. These results are in agreement with the findings of Kumar and Sarlach (2015). Maity and Bera (2009) reported that foliar application of salicylic acid influences different physiological and biochemical aspects of green gram plant via increasing assimilation rate, chlorophyll content and hill reaction activity in the leaf. Better utilization and translocation of photosynthates in plant and metabolites leading to improved dry matter accumulation.

Yield and yield attributes

In the present experiment, the crop was supplied with an additional dose of 2% urea, 2% single super phosphate and 100 ppm salicylic acid as foliar spray in different combination at flowering and grain filling period along with soil application of fertilizers. The seed yield was significantly influenced by the foliar application of 2% single super phosphate at flowering and grain filling followed by 2% urea at flowering and grain filling and foliar spray of 100 ppm salicylic acid at 40 days after sowing followed by 2% single super phosphate at 55 days after sowing. The per cent increase in yield of black gram in above treatments was 36.2%, 34.6% and 28.9% respectively over absolute control (Table 2). The stimulating effect of nutrients and salicylic acid on crop might be due to easy availability and translocation of nutrient in plant without any loses. It also observed that foliar application improved the yield attributes because of complete utilization of the additional foliar nutrients by the plants and improved efficiency of nutrient because foliar feeding of nutrient penetrate the cuticle of leaf or stomata and then enter the cell (Ravisankar *et al.,*2003 and Jeyakumar *et al.* 2008). Additional application of nitrogen, phosphorus, calcium and sulphur as foliar spray increased yield attributing characters like number of pods per plant, grain weight per plant and 1000 seed weight and ultimately increased the grain yield. It might be due to the fact that immediate and adequate availability of nutrients which might be taken up by plants for accelerating various physiological processes like cell division, enlargement of cell and photosynthesis (Sujatha, 2001 and Bera *et al*., 2008). The significant result of foliar feeding of salicylic acid to soybean crop had also been reported by Deotale *et al.* (1998). Narayanan *et al.* (2015) reported that foliar application of salicylic acid at the beginning of flowering may lead to branching and increased photosynthetic efficiency. It may lead to the proper distribution of stored material and partitioning on nutrient in the plant at its peak requirement.

The number of pods per plant, grain weight per plant and 1000 seed weight were significantly influenced by spraying schedule of nutrients and salicylic acid whereas number of grains per pod did not responded significantly in regards to spraying schedule of nutrients and salicylic acid. In the present study, the maximum increment in number of pods was recorded with foliar spray of urea 2% at flowering and 15 days later (25.6%) followed by foliar spay of single super phosphate @2% at flowering and 15 days later (24.8%) , foliar spray of salicylic acid @100ppm at 40 days after sowing followed by 2% SSP at 55 days after sowing(20.8%), single super phosphate @ 2% at 40 days after sowing followed by salicylic acid @100 ppm at 55 days after sowing(19.6%) and foliar spray of salicylic acid @ 100 ppm at flowering and 15 days later (17.4%) over absolute control treatment (Table 2). The significant increase in number of pods per plant may be attributed to better growth and development attained by crop due to additional application of nutrients known to be involved in photosynthesis, protein metabolism and energy transfer reactions. Further, the foliage applied nitrogen, phosphorus and secondary nutrients *viz.*, calcium and sulphur at the initial stages enhance the dry matter accumulation as well as favored the partitioning of carbohydrates to the development of sink

and effectively absorbed and translocation to the pods resulting in more number of pods per plant. These results are in agreement with the finding of Ganapathy *et al*. (2008) and Dandge *et al.* (2018).The beneficial effect of additional foliar feeding of nutrients and growth regulator on grain yield can be very well explained in the light of the fact that foliar feeding of nutrients increases the grain weight per plant and 1000 seed weight probably because of high photosynthetic rate caused by better radiant energy utilization as indicated by increase in dry matter production. The maximum increase in grain weight per plant was observed with foliar application of single super phosphate @ 2% at flowering and grain filling (50%) followed by 2% urea spray (44.8%), salicylic acid @ 100 ppm at 40 days after sowing followed by single super phosphate @ 2% at 55 days after sowing (37.9%), foliar spray of single super phosphate @ 2%at 40 days after sowing followed by salicylic acid @ 100 ppm at 55 days after sowing (34.4%) and salicylic acid @100 ppm at 40 and 55 days after sowing(29.3%). Foliar application of nutrients and growth regulator at later stages ensure better crop nutrition at flower initiation and grain filling stage, increased the nutrient content in grain which might resulted into increased grain weight per plant. Foliar application of salicylic acid might have enhanced the CO_2 fixation, induced activity of carbohydrate synthesizing enzymes coupled with effective partitioning of dry matters into reproductive sink. These results are in line with those of Bera *et al.* (2008). Sujatha (2001) also reported that foliar application of salicylic acid @ 100 ppm concentration increased number of pods per plant, number of seeds per pod and seed weight per plant.

Grain weight is also considered an important component contributing to grain yield. The maximum increase in grain weight was recorded with foliar spray of 2% single super phosphate at flowering and grain filling stage (21.6%)followed by 2% urea spray (20.8%) and foliar spray of 100 ppm salicylic acid at 40 days after sowing followed by single super phosphate @2% at 55 days after sowing (18.9%) These results are in conformity with Maheshwari and Karthik (2017). They reported that the foliar spray of nitrogen and phosphorus @ 2% at 30 and 45 days after sowing significantly increased the test weight. Rawat *et al. (*2019) also concluded that maximum increase in 1000 seed weight (g), was recorded under the foliar treatment of salicylic acid @ 150 ppm at 20, 40 and 60 days after sowing stage followed by 100 and 50 ppm of salicylic acid over control. Foilar spray of salicylic acid improved grain size in terms of weight may be weight due to mobilization of reserve food materials to the sink for grain filling process through increase of hydrolyzing and oxidizing enzyme activities (Uma, 1998).

CONCLUSION

Based on the result of above study, it is concluded that foliar spray of single super phosphate @ 2% at flowering and grain filling stage was significantly

Table 2: Yield and yield attributes of black gram as influenced by foliar nutrition and salicylic acid application

Treatments	Number of pods per plant	Number of grains per pod	Grain weight per plant (g)	Thousand seed weight (g)	Grain yield (kg/ha)
T_1: absolute control (no foliar spray)	32.7	5.8	5.8	31.8	919
T_2: Water spray at 40 and 55 DAS	33.0	5.9	6.0	32.7	930
T_3: 2% urea at 40 and 55 DAS	41.1	6.7	8.4	38.4	1237
T_4: 2% SSP at 40 DAS	37.0	6.3	7.1	35.1	1009
T_5: 2% SSP at 55 DAS	36.1	6.2	6.2	33.6	963
T_6: 2% SSP at 40 and 55 DAS	40.8	6.8	8.7	38.7	1252
T_7: 100 ppm SA at 40 DAS	36.4	6.2	6.6	33.7	981
T_8: 100 ppm SA at 55 DAS	35.2	6.0	6.3	33.1	939
T_9: 100 ppm SA at 40 and 55 DAS	38.4	6.4	7.5	34.5	1014
T_{10}: 2% SSP at 40 DAS*fb*100 ppm SA at 55 DAS	39.1	6.6	7.8	36.4	1123
T_{11}: 100 ppm SA at 40 DAS *fb* 2% SSP at 55 DAS	39.5	6.6	8.0	37.8	1185
SEm±	1.6	0.3	0.5	2.2	39
CD at 5%	4.6	NS	1.4	4.6	115

SSP: Single super phosphate; SA: salicylic acid; DAS: days after sowing

as effective as foliar spay of urea @ 2% at flowering and grain filling stage and salicylic acid @ 100 ppm at flowering followed by single super phosphate @ 2% at grain filling for improving growth and yield of black gram.

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