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Effect of Foliar Application of Nutrients and Plant Growth Regulators on Yield and Yield Attributing Characters of Greengram (*Vigna radiata* L.)

A. A. Prusty, A. K. Behura, A. M. Prusti, A. K. B. Mohapatra, P. K. Panda, I. O. P. Mishra, R. K. Panigrahi, T. R. Das

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ABSTRACT

A field experiment was conducted at Agricultural Research Station, Institute of Agricultural Sciences, Siksha "O" Anusandhan (DU), Bhubaneswar, under East and South-Eastern Coastal Plain Agro-climatic zone of Odisha during summer season of 2021 on sandy loam soil to evaluate the foliar spray (FS) once (30 days after sowing) or twice (30 and 45 DAS) of water soluble nutrients (NPK 19:19:19), micronutrient (boron), growth regulators such as salicylic acid (SA), naphthalene acetic acid (NAA) and brassinolide (BR) on yield and yield attributing characters of greengram. Application of RDF (20:40:20:20 Kg $N:P_2O_5:K_2O:S$/ha) + 2 FS NPK (19:19:19) spray recorded the highest seed yield (1201 kg/ha) which was at par with RDF + 2FS of B, RDF + 2FS BR, RDF +1FS of B, and RDF + 1FS NPK but significantly superior than other treatments. All foliar treatments were significantly superior over RDF and control for grain, stover and biological yield and production efficiency reflecting importance of foliar nutrition in enhancing productivity of greengram. The increase in seed yield of RDF + 2 FS NPK was 42.6 and 93.4 %, over RDF and control respectively. Treatment RDF + 2 FS NPK produced maximum flowers / plant (31.57). Minimum flower drop (32.0%) recorded with (RDF + 2FSB) which was at par with RDF + 2 FS BR (33.2%), RDF + 2FS NPK (34.3%) and RDF + 2 FS SA (35.8%). The effect of twice foliar spray of NPK (19:19:19), NAA and BR was significant over their corresponding one spray on pod setting percentage. Application of RDF+ 2FS NPK registered maximum number of pods / plant (19.0), clusters/plant (7.7), pod length (10.2 cm), seeds/pod (12.2) and production efficiency (16.02 kg seed/ha/day).

Keywords Greengram, Foliar nutrition, Growth regulators, Yield, yield attributing characters,

A. A. Prusty*, A. K. Behura
Department of Agronomy, Institute of Agricultural Sciences , Siksha "O" Anusandhan Deemed to be University, Bhubaneswar, Odisha 751030.

A. M. Prusti, P. K. Panda, I. O. P. Mishra, R. K. Panigrahi
Center for Pulses Research, OUAT, Berhampur, Odisha 761001

A. K. B. Mohapatra
Department of Agrometeorology, College of Agriculture, Bhubaneswar 751003, India

T. R. Das
Division of Genetics, IARI, New Delhi 110012
Email : prustyanyesha@gmail.com
*Corresponding author

INTRODUCTION

Pulses are the second most important food crop, next to cereals in terms of production and consumption. They are rich source of dietary proteins, fibers, energy, minerals particularly calcium, iron and vitamins. In Odisha, greengram (*Vigna radiata* L.) is the predominant pulse crop grown in 8.37 lakh ha area with 4.11 lakh tonnes production and productivity of 491 kg/ha (Odisha Agricultural Statistics 2018-19), while at the national level, it occupies third position (4.58 million ha area, 2.509 million tonnes production and productivity of 548 kg/ha) next to chickpea and arhar (DES 2019-20).

Low yield of pulses in general and greengram in particular are because of its cultivation as a catch crop in acidic rainfed marginal lands under residual soil moisture and poor agronomic management. Besides, some technological constraints like lack of suitable varieties resistant to biotic and abiotic stresses with good yield potential, physiological factors such as low partitioning of assimilates, low pod setting due to flower abscission and non-availability of required nutrients at critical stages are the major constraints for low yield in greengram. Flower drop in pulses is a common phenomenon which reduces the pod setting percentage thereby causing low yield. During the process of evolution and adaptation, pulse crops acquired characters like indeterminate and compact growth, excessive flowering, flower drop, shattering, non- synchronous maturity for their survival rather than high yield (Kunta *et al.* 2013).

Foliar application is a preferred option when quick supply of nutrients is hindered under unfavorable soil conditions. It increases photosynthetic rate and nutrient transportation from leaves to the developing seeds. Water soluble fertilizer NPK 19:19:19 boosts the productivity of crops by providing immediate nutrient availability during adverse condition and by increasing number of flowers and pods. Positive effect of supplying legume plants with supplementary nitrogen or a balanced dose of nutrients particularly at pre flowering stage was found to have beneficial effect on increasing seed yield (Das and Jana 2015, Jadhav and Kulkarni 2016, AICRP on MULLaRP 2017-18 and NituKumari *et al.* 2019).

Boron (B) is the second most deficient micronutrient worldwide after zinc. It has a key role in regulating plants hormone levels, maintaining a balance between sugar and starch and helps in the translocation of sugar and carbohydrates, effective nitrogen fixation and nodulation in legumes promoting proper growth, nitrogen metabolism and protein formation, flower production, fertilization, seed and fruit development. Economic yield of legumes decreases with inadequate supply of boron. Adequate supply of boron enhances essential amino acid content. Application of boron @ 2 kg per ha enhanced the yield attributes, nodulation and yield of the summer green gram (Movalia *et al.* 2018). Foliar applied boron has more influence on grain yield in greengram than soil application and soil applied boron was at the par with foliar applied boron (Padbhusan and Kumar 2014).

Plant growth regulators are known to influence growth and yield attributes right from seed germination to senescence. Naphthalene acetic acid (NAA) is a synthetic plant hormone in the auxin family helps in efficient transport of sugars from parts of plants (source) to developing grains (sinks). It also prevents premature dropping of fruits. Foliar spray of 40 ppm NAA increases flower production, reduces flower drop and increases seed yield in pulses (TNAU 2013). NAA ensures greater dry matter partitioning and yield in pulses (Vishnu and Brar 2020). Sharma *et al.* (2020) reported foliar spraying of NAA in greengram brought significantly higher harvest index and seed yield than control.

Salicylic acid (2 hydroxy-benzoic acid) is a natural plant hormone which has a role in plant development, photosynthesis, transpiration, ion uptake and transport (Dempsey et al. 2011). Salicylic acid has been reported to induce flowering in a number of plants. Foliar spray of salicylic acid in greengram increased seed yield (Maity and Bera 2009, Kuttimani and Velayutham, 2011 and Ali and Mahmoud 2013). Sharma *et al.* (2020) reported foliar spraying of SA brought significantly higher pods per plant, biological yield, harvest index and seed yield than control in greengram.

Brassinolide 6th plant hormone play crucial roles in diverse aspects of plant biology, including cell

elongation, cell division, root growth, photo-morphogenesis, stomatal and vascular differentiation, seed germination, immunity and reproduction (Gudesblat and Russinova 2011). It increases growth and uptake of nutrients, imparts resistance to abiotic stresses and increases flowering, pod set and yield. Foliar spray of brassinolide increased pods per m^2 and seed yield in greengram (Sengupta and Tamang 2015, Maity and Bera 2009).

Research results about beneficial role of foliar applied nutrients like NPK 19:19:19, boron and growth regulators like salicylic acid, brassinolide and naphthalene acetic acid on greengram under the agro climatic conditions of Odisha are very scanty. Therefore, a field experiment was conducted to evaluate the foliar spray of water soluble nutrients like NPK 19:19:19, micronutrient like boron, growth regulators like salicylic acid (SA), naphthalene acetic acid (NAA) and brassinolide (BR) on yield and yield attributing characters of greengram grown in the summer season

MATERIALS AND METHODS

The experiment was conducted at Agricultural Research Station, Institute of Agricultural Sciences, Siksha "O" Anusandhan, (Deemed to be University), Bhubaneswar, located at 28.4' N latitude, 27.12' E longitude at an altitude of 45 m above msl in East and South-Eastern Coastal Plain Agro-climatic zone of Odisha during summer season of 2021. The soil was sandy loam in texture and moderately acidic. The pH (1:2.5), EC, organic carbon, available N, P, K and B were 5.6, 0.22 ds/m at 25°C, 0.45 %, 214 kg/ha, 13.65 kg/ha, 185 kg/ha, 0.4 mg/kg respectively. The experiment comprising of twelve treatments T_1: RDF (20:40:20:20 Kg N:P_2O_5:K_2O:S/ha) + water spray at 30 DAS, T_2: RDF+ N:P:K (19:19:19) @ 2 % spray at 30 DAS (1FS), T_3: RDF + Salicylic Acid @ 100 ppm spray at 30 DAS (1FS), T_4: RDF + Napthalene Acetic Acid @ 50 ppm spray at 30 DAS (1FS), T_5: RDF + Boron @ 0.02 % spray at 30 DAS (1FS), T_6: RDF + Brassinolides @ 0.25 ppm spray at 30 DAS (1FS), T_7 : RDF + N:P:K (19:19:19) @ 2 % spray at 30 DAS and 45 DAS (2FS), T_8: RDF + Salicylic Acid @ 100 ppm spray at 30 DAS and 45 DAS (2FS), T_9: RDF+ Napthalene Acetic Acid @ 50 ppm spray at 30 DAS and 45 DAS (2FS), T_{10}: RDF + Boron @ 0.02 % spray at 30 DAS and 45 DAS (2FS), T_{11}: RDF + Brassinolides @ 0.25 ppm spray at 30 DAS and 45 DAS (2FS), T_{12}: Control, was laid out in Randomized Block Design (RBD) with three replications. Greengram cv. IPM 02-14 was sown on 17 February 2021 with a spacing of 25 cm × 10cm in a plot size of 5 m × 3 m . A uniform dose of 20 kg nitrogen 40kg P_2O_5, 20 kg K_2O and 20 kg S per hectare were applied as basal in furrows except in the control plot. Urea (46%N) and muriate of potash (60% K_2O) were used as sources of nitrogen and potassium respectively, whereas DAP (18% N, 46% P_2O_5) as source of nitrogen and phosphorus and SSP (16 % P_2O_5, 11 % S) as source of phosphorus and sulfur respectively. Recommended agronomic management including plant protection measures were adopted for all treatments.

The data recorded for different characteristics were statistically analysed as described by Gomez and Gomez (1984). Whenever significant difference existed, critical difference was constructed at five per cent probability level. The non-significant treatment differences were denoted as NS.

RESULTS AND DISCUSSION

Effect of nutrients and growth regulators on number of flowers per plant, flower drop percentage, pod setting percentage

Flower drop is a major concern of low productivity in green gram. Present study revealed that foliar spray of nutrients and growth regulators enhanced the numbers of flowers per plant and reduced flower drop significantly over RDF and control (Table 1) indicating that all foliar spray of nutrient and growth regulator had positive effect on increasing flowers/ plant and also reducing the flower drop percentage. Application of RDF + NPK 1 FS was found significantly superior in increasing number of flowers / plant (30.39) than all other nutrients and growth regulators sprayed once and also at par with all other nutrients and growth regulators sprayed twice. Treatment RDF + 2 FS NPK produced maximum flowers/ plant (31.57) which was significantly superior over other treatments except RDF + NPK 1FS. Foliar spray of nutrients and growth regulators either once or twice did not significantly

Table 1. Effect of foliar application of nutrients and PGRs on pod setting percentage of summer greengram.

Treatments	Number of flowers/plant	Flower drop (%)	Pod setting (%)
T_1: RDF	23.39	48.0	52.0
T_2: RDF + NPK (1 FS)	30.39	43.5	56.5
T_3: RDF + SA (1 FS)	27.08	40.8	59.2
T_4: RDF + NAA (1 FS)	27.04	43.5	56.5
T_5: RDF + B (1 FS)	26.58	36.3	63.7
T_6: RDF + BR (1 FS)	27.49	39.3	60.7
T_7: RDF + NPK (2 FS)	31.57	34.3	65.7
T_8: RDF + SA (2 FS)	27.19	35.8	64.2
T_9: RDF + NAA (2 FS)	27.31	38.0	62.0
T_{10}: RDF + B (2 FS)	27.58	32.0	68.0
T_{11}: RDF + BR (2 FS)	27.84	33.2	66.8
T_{12}: CONTROL	19.92	57.5	43.5
SE (m) ±	0.8	1.4	1.8
CD (p=0.05)	2.4	4.2	5.3

influence the flower numbers but were significantly superior over RDF and control.

It was also revealed from the study that twice foliar application of nutrients and growth regulators had significantly reduced flower drop than corresponding one spray. Among foliar treatments, minimum flower drop (32.0 %) was noticed by (RDF + 2 FS B) which was at par with RDF + 2FS BR (33.2 %) and RDF + 2 FS NPK (34.3%). Minimum flower drop with foliar spray of B may be ascribed to its role in regulating plant hormone levels which promotes flower production and retention.

The results revealed that all the nutrients and growth regulators applied once or twice significantly increased the pod setting percentage over control. One time foliar application of SA, BR and B significantly increased the pod setting percentage (59.2, 60.7 and 63.7 %,) respectively as compared to RDF (52.0%). Twice foliar application invariably significantly increased the pod setting percentage in all the treatments over RDF. The effect of twice foliar spray of NPK (19:19:19), NAA and BR was significant over their one spray. Foliar feeding of nutrients and growth regulators were aimed to provide balanced nutrition that can help to stimulate better growth, nodulation of roots and effective partitioning of assimilates for higher pod setting thereby enhancing yield.

Ganapathy *et al.* (2008) observed that foliar spray of NAA @ 40 ppm at pre flowering and flowering stage in rice fallow greengram and blackgram resulted in significant increase in flower number per plant, number of pods per plant, fruit setting and grain yield and simultaneously significantly reduced flower drop percentage over control. Reduction of flower drop percentage was due to prevention of abcission layer formation. Marimutthu and Surrendran (2015) reported that twice foliar application of BR @ 0.25 ppm as well as SA @100ppm at 30 and 45 DAS significantly enhanced flower number per plant, number of pods per plant and fruit setting in blackgram.

The results of this study corroborates with the findings of Ganapathy *et al.* (2008) with respect to NAA, Marimutthu and Surrendran (2015) with respect to SA and BR, Matwa *et al.* (2017) with respect to B, SA and BR on production of more flowers per plant, less flower drop percentage and higher pod setting percentage.

Effect of nutrients and growth regulators on yield and yield attributing characters

Number of pods per plant and number of clusters per plant are important yield attributing characters that determine grain yield in greengram. All foliar treatments exhibited significant increase in all yield attributing characters over control and RDF (Table 2) explaining their importance in enhancing yield in greengram. However, there was no significant difference between twice and corresponding one foliar application of nutrients and growth regulators for all yield attributing characters except pod length. Application of RDF was significantly enhanced all yield attributing characters over control in greengram reflecting the positive influence of major nutrients on improving yield attributing characters. Among foliar treatments, RDF + 2FS NPK (19:19:19) recorded maximum number of pods per plant (19.0), seeds per pod (12.2), pod length (10.2 cm), clusters per plant (7.7), 100seed weight (3.9 g) which was significantly superior over one spray of SA (T_3) and NAA (T_4) for number of pods per plant, one spray of all nutrients and growth regulators for pod length, one spray of all nutrients and growth regulators except NPK(T_2) and twice spray of NAA (T_9) for number of seeds per pod,

Table 2. Effect of foliar application of nutrients and PGRs on yield and yield attributes in greengram.

Treatments	Number of pods/ plant	Number of seeds pod	Pod length (cm)	Number of clusters/ plant	100 seed weight	Seed weight (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Production efficiency (kg seed/ day)	Harvest index (%)
T_1: RDF	12.2	8.3	7.3	3.7	3.3	842	2215	3057	11.23	27.5
T_2: RDF + NPK (1 FS)	17.1	11.1	8.7	6.6	3.7	1119	2723	3843	14.93	29.1
T_3: RDF + SA (1 FS)	15.8	10.3	8.9	5.4	3.7	993	2561	3554	13.24	27.9
T_4: RDF + NAA (1 FS)	15.2	10.2	8.5	5.1	3.7	978	2556	3534	13.04	27.7
T_5: RDF + B (1 FS)	16.9	10.5	8.6	6.0	3.6	1122	2715	3837	14.95	29.2
T_6: RDF + BR (1 FS)	16.6	10.2	9.0	5.8	3.7	1055	2577	3631	14.06	29.1
T_7: RDF + NPK (2 FS)	19.0	12.2	10.2	7.7	3.9	1201	2790	3991	16.02	30.1
T_8: RDF + SA (2 FS)	17.4	10.9	9.9	6.1	3.8	1066	2644	3709	14.21	28.7
T_9: RDF + NAA (2 FS)	16.8	10.6	10.0	5.4	3.9	1056	2605	3661	14.08	28.8
T_{10}: RDF + B (2 FS)	18.6	11.1	9.5	6.7	3.8	1180	2860	4040	15.73	29.2
T_{11}: RDF + BR (2 FS)	18.4	11.0	9.5	6.6	3.9	1125	2684	3809	15.00	29.5
T_{12}: Control	8.4	6.6	6.0	2.0	3.1	621	1870	2491	8.28	24.9
SE (m) ±	0.8	0.4	0.3	0.4	0.1	45	107	128	0.60	1.19
CD (p=0.05)	2.5	1.4	1.0	1.2	0.3	13	315	378	1.77	NS

one spray of all nutrients and growth regulators except NPK (T_2) and twice spray of SA (T_8) and NAA (T_9) for number of clusters per plant. Sharifi *et al*. (2018) reported that significantly higher yield attributing characters like number of pods per plant higher seed weight per plant and 100 grain weight were finally led to increased yield in soybean explaining importance of yield attributing characters in enhancing productivity. Foliar application of nutrients and growth regulators at flower initiation and pod development stage might have resulted in sufficient availability of nutrients at critical stages of crop growth, higher uptake of nutrients, enhanced photosynthetic activity and efficient translocation of more assimilates to reproductive organs and thereby increased plant dry matter production in the pod setting phase which reduced the flower drop and resulted in more number of pods per plant, longer pods, increasing number size and weight of seed. Foliar treatment of NPK (20:20:20) increased grain yield in common bean as NPK enhances the plants vegetative growth and improve the ability of the plant for the synthesis, storage and translocation of nutrient from one part to other parts of the plant (Rahman *et al.* 2014).

The present study revealed that grain, stover and biological yield and production efficiency in grengram was significantly influenced by various treatments of foliar nutrition. All foliar treatments were significantly superior over RDF and control for grain, stover and biological yield and production efficiency reflecting importance of foliar nutrition in enhancing productivity of greengram. Significantly superiority of RDF over control for grain, stover and biological yield and production efficiency exhibits the important role of RDF in enhancing productivity in greengram. Application of RDF + 2 FS NPK recorded the highest seed yield (1201 kg / ha) and production efficiency (16.02 kg seed/ha/day). This treatment was at par with RDF + 2FS of B, RDF + 2FS BR, RDF +1FS of B and RDF + 1FS NPK for seed yield, at par with RDF + 2FS of B and RDF + 2FS BR for production efficiency.The increase in seed yield of the best treatment RDF + 2 FS NPK over RDF and control was to the tune of 42.6 and 93.4 %, respectively. The highest seed yield of RDF + 2 FS NPK (19:19:19) treatment can be attributed to higher number of flower per plant (31.57), pod setting percentage (65.7%), reduced flower drop (34.3%), more number of pods per plant (19.0), seeds per pod (12.2) and 100 seed weight (3.9 g) as compared to other treatments. Maximum stover (2860 kg/ha) and biological (4040 kg/ha) yield were registered with foliar spraying of RDF + 2 FS B. Treatment RDF + 2 FS B was significantly superior over T_3, T_4, T_6, and T_9 for biological yield and at par with all foliar application treatments for stover yield. Harvest index is an important character and is a measure of reproductive

efficiency and successful partitioning of assimilates. In the present study there was no significant difference between treatments for harvest index though there was significant difference among the treatments for grain yield explaining that the increase in the yield was due to increase in the total dry matter rather than harvest index. Similar results on harvest index were also reported by Matwa *et al.* (2017) Application of nutrients and PGRs might have increased the process of photosynthesis and efficient translocation of photosynthates to sinks thus making favorable influence on yield parameters, grain, stover and biological yield and production efficiency of greengram. The present results were in accordance with findings of Ali and Mahmoud (2013) with respect to SA for number of pods per plant, seedsper pod, 1000 seed weight and seed yield, Marimuthu and Surendran (2015) with respect to B and BR for number of pods per plant, Jadhav and Kulkarni (2016) with respect to NPK for number of pods per plant, 1000 seed weight and seed yield, Matwa *et al.* (2017) with respect to B, BR and SA for number of pods per plant, pod length and biological yield, Praveena *et al.* (2018) with respect to B for number of pods per plant, seeds per pod, seed yield and stover yield, Kunjammal and Sukumar (2019) with respect to NAA for number of pods per plant and seed yield, Nitukumari *et al*. (2019) with respect to NPK for number of pods per plant, seeds per pod grain yield and stover yield, Sharma *et al.* (2020) with respect to NAA for grain yield and harvest index and with respect to SA for pods per plant, seed yield, biological yield and harvest index.

In general, there is a continuous competition for available assimilates between vegetative and reproductive sinks in greengram due to indeterminate flowering and fruiting habit. As the source is highly limited, translocation of assimilates to the growing reproductive sinks is reduced. Under such situation external application of water soluble nutrients and growth regulators play an important role for enhanced photosynthesis and efficient translocation of photosynthates to reproductive organs to achieve higher productivity. Spraying of nutrients and growth regulators are effective, more efficient, and requires less amount in comparison with soil application. Foliar application of nutrients like NPK (19:19:19) and boron and growth regulator brassinolide have distinct advantage over other treatment. Spraying of either NPK (19:19:19) or boron or brassinolide in combination with RDF is a good management practice to obtain a higher grain yield in summer greengram.

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