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ROOT PARAMETERS OF BLACKGRAM (*VIGNA MUNGO* L.) IMPROVED BY SEED PELLETING WITH NUTRIENTS AND FOLIAR SPRAY OF NUTRIENTS AND PLANT GROWTH REGULATOR

Santosh Kumar Meena[1]* and V. Vengadessan[2]

[1]Department of Agronomy, PAJANCOA&RI, Karaikal – 609 603, Union Territory of Puducherry, India.

[2]Department of Plant Breeding and Genetics, PAJANCOA&RI, Karaikal – 609 603, Union Territory of Puducherry, India.

*Corresponding author E-mail: skmeenaagr@gmail.com

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ABSTRACT

The experiments were conducted at Agricultural College and Research Institute, Killikulam of Tamil Nadu Agricultural University, India. In the study, a treatment combination of DAP 40 g kg^{-1} seed, DAP 40 g + KCl 10 g kg^{-1} seed, DAP 40 g + KCl 10 g + Gypsum 20 g kg^{-1} seed and control in main plot and foliar spray treatments *i.e.*, DAP 2%, DAP 2% + KCl 1%, DAP 2% + NAA 40 ppm, DAP 2% + KCl 1% + NAA 40 ppm at two(30 & 45 DAS) and three (30,45 & 60 DAS) times totally eight treatment in sub plot were evaluated and found that a treatment combination of DAP 40 g + KCl 10 g + Gypsum 20 g kg^{-1} seed and DAP 2 % + KCl 1 % + NAA (40 ppm) at 30, 45 & 60 DAS registered higher root length, root nodule and nodule weight in blackgram crop in both the seasons.

Key words : Blackgram, Seed pelleting, DAP, KCl, NAA.

Introduction

Pulses are important food crop and well known for its nutritive value. Pulses contain approximately 21–25% protein, which is almost three times that of cereals; however have limiting amount of essential amino acids such as methionine, tryptophan and cystine (Tiwari and Singh, 2012). India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the world (FAO, 2017). Among various pulses blackgram (*Vigna mungo* L.) has its own importance. Blackgram (Urd bean) is the fourth most important pulse crop in India after chickpea, pigeon pea and green gram (Reddy *et al.*, 2022). Black gram supplies a major share of protein requirement of vegetarian population of the country (Sengar *et al.*, 2020). The per capita consumption of pulses in India is around 30-35 gm as against the recommendation of Indian Council of Medical Research (ICMR) at 45 gm and World Health Organisation (WHO) at 80 gm per day (Karthikeyan *et al.*, 2020). In order to meet the daily requirement of vegetable protein and to reduce the import of pulses there is need of hour to enhance the production of pulses.

Plant root play a crucial role in resource acquisition and crop performance (Lopez *et al.*, 2023). Among various approaches seed pelleting with nutrients is a technique which provides a secure and targeted way of applying nutrients directly to the seed and emerging seedlings (Baroni and Vieira, 2020). Pelleting of seeds with nutrients gives an initial boost for germinating seeds and growing seedlings. Hence, the seed pelleting as pre - sowing treatment is a boon to the black gram to have better germination, benefit the developing root system, establishment and early vigour of the seedlings for the effective utilization of resources (Kavitha *et al.*, 2003). Seed pelleting can play a role in promoting the development of root nodules in pulse crops, which are particularly important for nitrogen fixation (Vennila *et al.*, 2018). Nitrogen fixation is a biological process carried out by

certain bacteria called rhizobia, which form a symbiotic relationship with the roots of leguminous plants, including pulses**.** The nodules formed on the roots house these nitrogen-fixing bacteria, and the plants benefit from the nitrogen compounds produced by the bacteria (Kafeel *et al*., 2023; Iantcheva and Naydenova, 2021). Foliar spray with nutrients provides essential elements directly to the leaves of plants. While foliar nutrition primarily targets above-ground plant parts, it can indirectly influence root growth by supporting overall plant health and nutrient uptake. Foliar application of major nutrients like DAP and KCl was found to be as good as soil application and satisfy the needs at critical stages. Foliar spray of K provides support to the crop to withstand moisture stress conditions by maintaining proper water status in the plants. Foliar application of NAA reduced the flower drop and improved the growth, flower and fruit setting of chickpea (Upathyay, 2002). In a similar vein, the foliar spray application of DAP and NAA greatly enhanced the yield-attributing characteristics by decreasing flower shedding and increasing the number of pods per plant (Ravisankar *et al.,* 2003). In light of this context, field tests were carried out to evaluate the effects of foliar spray of nutrients and plant growth regulator as well as seed pelleting with nutrients on blackgram.

Materials and Methods

Experimental site

The experiments were conducted at Agricultural College and Research Institute, Killikulam of Tamil Nadu Agricultural University, India. The college is located at the southern agroclimatic zone of Tamil Nadu, situated at 8° 46' North latitude and 77° 42' East longitude at an altitude of 40 m above MSL.

Technical programme

The experiments were laid out in Split Plot Design and replicated thrice. The experiments comprised of four seed pelleting treatments *viz*., DAP 40 g kg^{1} seed (M1), DAP 40 g + KCl 10 g kg^{-1} seed (M2), DAP 40 g + KCl 10 g + Gypsum 20 g kg^{-1} seed (M3) and Control (M4) in main plot and foliar spray treatments *i.e.*, DAP 2% at 30 & 45 DAS (S1), DAP 2% + KCl 1% at 30 & 45 DAS (S2), DAP 2% + NAA 40 ppm at 30 & 45 DAS (S3), DAP 2% + KCl 1% + NAA 40 ppm at 30 & 45 DAS (S4), DAP 2% at 30, 45 & 60 DAS (S5), DAP 2% + KCl 1% at 30, 45 & 60 DAS (S6), DAP 2% + NAA 40 ppm at 30, 45 & 60 DAS (S7), DAP 2% + KCl 1% + NAA 40 ppm at 30, 45 & 60 DAS (S8) totally eight treatment in sub plot.

Seed and sowing

Good viable seeds of blackgram Co.-5 having germination of 90 per cent were used. The seeds were pelleted as per the treatment schedule. Then the seeds were treated with *Trichoderma viride* @ 4 g kg^{-1} of seeds and *Rhizobium* @ 600 g ha^{-1} of seeds and sown in lines by adopting 30 x 10 cm spacing by dibbling at the depth of 4 cm.

Seed pelleting with DAP, KCl and Gypsum

Seed pelleting was done using the hand operated pelletizer designed at TNAU. Required quantities of seeds were placed in the rotating drum of the seed pelletizer. The seeds were treated with the respective treatment chemicals as per the treatment schedule. Then arappu (*Albizia amara*) powder (filler material) was slowly added by constantly rotating the drum at 20 rpm, to obtain uniform size pellet for easy handling of the seed.

Foliar application of nutrients and NAA

Foliar application of nutrients *viz*., DAP, KCl and plant growth hormone (NAA) were given on 30, 45 and 60 DAS as per the treatment schedule. The DAP spray solution was prepared by dissolving 20 g of DAP in one litre of water and KCl spray solution was prepared by dissolving 10 g of muriate of potash (MOP) in one litre. To prepare 40 ppm NAA solution, 0.89 ml of planofix was dissolved in one litre of water.

Observation on root length

Five plants at random from outside the net plot areas were carefully uprooted without damage to the roots using scoop at 30, 45 DAS and at harvest. Root length from the collar region to the tip of the root was measured in cm and mean value expressed as root length in cm.

Observation on nodules per plant

Five plants at random from outside the net plot area were uprooted carefully without damage to the roots, using scoop at 30, 45 DAS and at harvest. Roots were washed in running water and number of effective nodules per plant was counted.

Observation on weight of root nodule per plant

After counting root nodules, the nodules were carefully removed, dried, weighed and the mean value for five plants expressed in mg.

Statistical analysis

Statistical analysis of data was done by the analysis of variance method for split plot design as suggested by Gomez and Gomez (1984). Wherever treatment difference was significant, critical difference was worked out at five per cent probability level. Treatment differences

that were non-significant are denoted by 'NS'.

Results and Discussion

Root length

Data recorded on root length at 30, 45 DAS and at harvest indicated that the different seed pelleting treatments significantly influenced the root length (Table 1). At 30 DAS the maximum root length of 14.20 and 15.50 cm was recorded when the seeds were pelleted with DAP plus KCl and gypsum, whereas the minimum root length of 10.35 and 11.30 cm was recorded by without seed pelleting during both the seasons, respectively. On 45 DAS also the maximum root length of 16.86 and 19.29 cm was recorded by the same treatment as against the control, which recorded the minimum root length of 12.29 and 14.06 cm for both the seasons, respectively. The same trend was maintained at harvest stage with varying root length values. The increased root length under seed pelleting with nutrients might be due to supplying nutrient directly to seed for emerging seedlings at early growth stage. Shafi *et al* (2015) reported early germination, rapid seedling height and higher seedling vigour with DAP seed priming in Okra.

Foliar spray of nutrients and plant growth regulator had no significant effect on 30 DAS as it was applied only on that day onwards, but its influence was significant at subsequent stages of 45 DAS and at harvest. At 45 DAS, the maximum root length of 16.19, 16.72 and 18.09, 18.91 cm was recorded by the combined foliar spray of DAP plus KCl and NAA treatment combination at 30 DAS (S4 and S8) for the respective seasons. The foliar spray treatment of DAP alone at 30 DAS (S1 and S5) recorded the minimum root length and both were on par with S2 treatment. During the harvest stage, the highest root length was recorded by DAP plus KCl and NAA combined foliar spray at 30, 45 and 60 DAS (S8 – 20.68

Table 1 : Influence of seed pelleting with nutrients and foliar spray of nutrients and plant growth regulator on root length (cm).

Treatments	Season I						Season II					
	30 DAS		45 DAS		Harvest		30 DAS		45 DAS		Harvest	
Seed Pelleting												
M1	11.91		14.14		17.77		13.00		16.18		18.89	
M2	12.22		14.50		18.22		13.33		16.59		19.37	
M3	14.20		16.86		21.19		15.50		19.29		22.52	
M4	10.35		12.29		15.45		11.30		14.06		16.42	
SEd	**0.25**		**0.29**		**0.37**		**0.27**		**0.34**		**0.48**	
CD (0.05)	**0.61**		**0.72**		**0.91**		**0.66**		**0.83**		**1.17**	
Foliar Spray												
S1	11.48		12.81		15.68		12.65		14.48		17.00	
S2	12.53		13.46		17.03		13.01		15.41		17.83	
S3	12.32		14.79		18.29		13.70		16.66		19.71	
S4	11.99		16.19		19.82		13.77		18.09		20.72	
S5	12.67		13.05		16.68		13.04		15.18		18.05	
S6	12.48		13.82		17.89		13.74		16.17		19.32	
S7	11.70		14.75		19.17		13.32		17.35		20.10	
58	12.20		16.72		20.68		13.05		18.91		21.68	
SEd	**0.42**		**0.50**		**0.63**		**0.46**		**0.58**		**0.66**	
CD (0.05)	**NS**		**1.01**		**1.2**		**NS**		**1.15**		**1.31**	
	M × S	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**
SEd	0.83	0.85	0.99	1.01	1.24	1.26	0.90	0.92	1.13	1.15	1.31	1.32
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Note

(i) Seed Pelleting: DAP 40 g kg^{-1} seed **(M1),** DAP 40 g + KCl 10 kg^{-1} seed **(M2)**, DAP 40 g + KCl 10 g + Gypsum 20 g kg^{-1} seed **(M3),** Control **(M4)**

(ii) Foliar Spray: DAP 2 % at 30 & 45 DAS **(S1)**, DAP 2 % + KCl 1 % at 30 & 45 DAS **(S2)**, DAP 2 % + NAA 40 ppm at 30 & 45 DAS **(S3)**, DAP 2 % + KCl 1 % + NAA 40 ppm at 30 & 45 DAS **(S4)**, DAP 2 % at 30, 45 & 60 DAS **(S5)**, DAP 2 % + KCl 1 % at 30, 45 & 60 DAS **(S6)**, DAP 2 % + NAA 40 ppm at 30, 45 & 60 DAS **(S7)**, DAP 2 % + KCl 1 % + NAA 40 ppm at 30, 45 & 60 DAS **(S8)**.

Table 2 : Influence of seed pelleting with nutrients and foliar spray of nutrients and plant growth regulator on number of nodules plant^{-1}.

Treatments	Season I						Season II					
	30 DAS		45 DAS		Harvest		30 DAS		45 DAS		Harvest	
Seed Pelleting												
M1	17.21		19.36		21.01		18.69		20.12		22.66	
M2	17.26		19.41		21.07		18.74		20.18		22.71	
M3	18.60		20.93		22.71		20.20		21.75		24.49	
M4	16.44		18.49		20.07		17.85		19.22		21.64	
SEd	**0.50**		**0.56**		**0.64**		**0.43**		**0.58**		**0.65**	
CD (0.05)	**1.22**		**1.36**		**1.48**		**1.06**		**1.41**		**1.59**	
Foliar Spray												
S1	16.40		19.14		20.75		18.06		19.87		22.28	
S2	17.89		19.53		20.96		18.58		20.05		22.56	
S3	17.59		19.68		21.46		18.75		20.49		23.09	
S4	17.12		19.79		21.60		19.67		20.76		23.42	
S5	18.10		19.19		20.79		18.61		19.91		22.34	
S6	17.82		19.54		21.01		19.61		20.09		22.62	
S7	16.71		19.71		21.51		19.02		20.55		23.16	
58	17.42		19.81		21.64		18.63		20.83		23.53	
SEd	**0.61**		**0.67**		**0.73**		**0.64**		**0.70**		**0.79**	
CD (0.05)	**NS**		**NS**		**NS**		**NS**		**NS**		**NS**	
	M × S	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**
SEd	**1.24**	**1.21**	**1.38**	**1.35**	**1.49**	**1.46**	**1.28**	**1.29**	**1.43**	**1.40**	**1.61**	**1.57**
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Note

(i) Seed Pelleting: DAP 40 g kg^{-1} seed **(M1),** DAP 40 g + KCl 10 kg^{-1} seed **(M2)**, DAP 40 g + KCl 10 g + Gypsum 20 g kg^{-1} seed **(M3),** Control **(M4)**

(ii) Foliar Spray: DAP 2 % at 30 & 45 DAS **(S1)**, DAP 2 % + KCl 1 % at 30 & 45 DAS **(S2)**, DAP 2 % + NAA 40 ppm at 30 & 45 DAS **(S3)**, DAP 2 % + KCl 1 % + NAA 40 ppm at 30 & 45 DAS **(S4)**, DAP 2 % at 30, 45 & 60 DAS **(S5)**, DAP 2 % + KCl 1 % at 30, 45 & 60 DAS **(S6)**, DAP 2 % + NAA 40 ppm at 30, 45 & 60 DAS **(S7)**, DAP 2 % + KCl 1 % + NAA 40 ppm at 30, 45 & 60 DAS **(S8)**.

and 21.68 cm for both the seasons, respectively). This was on par with the same combination of spray at 30 and 45 DAS (S4 - 19.82 and 20.72 cm respectively for both the seasons). The least root length was recorded by DAP spray alone at 30 and 45 DAS (S1 - 15.68 and 17.00 cm respectively) for both the seasons and was on par with S5 treatments. The interaction effect between seed pelleting and foliar spray was absent. The increased, root length at 45 DAS and at harvest were registered under foliar spray of DAP plus KCl and NAA at 30, 45 and 60 DAS. The increased root length might be due to higher shoot length, which was contributed by above mentioned treatmental spray might have resulted in proportionate root length in these treatments. These results are in line with the findings of Dixit and Elamathi, (2007), Khodadad and Mostafavi (2012) and Ramesh *et al*. (2016), who reported increased growth parameters in with DAP, KCl and NAA foliar spray.

Number of root nodules and nodule weight per plant

The results revealed that the number of nodules per plant was significantly influenced by seed pelleting treatments at all the three stages (Table 2). The best treatment with regard to number of root nodules per plant was seed pelleting with DAP plus KCl and gypsum on the 30 DAS (18.60 and 20.20 nodules plant^{-1} for both the seasons, respectively). The minimum number of root nodules were recorded with the control (16.44 and 17.85 nodules plant^{-1} respectively for both the seasons).

On the 45 DAS the maximum number of nodules plant^{-1} was recorded with the same treatment (M3 - 20.93 and 21.75 nodules plant^{-1} for both the seasons, respectively). The minimum nodule numbers plant^{-1} was recorded by the control (18.49 and 19.22 nodules plant^{-1} for both the seasons, respectively).

Table 3 : Influence of seed pelleting with nutrients and foliar spray of nutrients and plant growth regulator on nodules weight plant^{-1} (mg).

Treatments	Season I						Season II					
	30 DAS		45 DAS		Harvest		30 DAS		45 DAS		Harvest	
Seed Pelleting												
M1	8.61		9.68		10.51		9.49		10.70		11.92	
M2	8.63		9.71		10.53		9.51		10.73		11.95	
M3	9.30		10.46		11.36		10.25		11.57		12.89	
M4	8.22		9.25		10.03		9.06		10.22		11.39	
SEd	**0.25**		**0.28**		**0.30**		**0.27**		**0.31**		**0.34**	
CD (0.05)	**0.61**		**0.68**		**0.74**		**0.67**		**0.75**		**0.84**	
Foliar Spray												
S1	8.20		9.57		10.38		9.46		10.57		11.73	
S2	8.95		9.76		10.48		9.63		10.67		11.87	
S3	8.79		9.84		10.73		9.37		10.90		12.15	
S4	8.56		9.90		10.80		9.83		11.04		12.32	
S5	9.05		9.59		10.39		9.69		10.59		11.76	
S6	8.91		9.77		10.50		9.81		10.69		11.90	
S7	9.35		9.86		10.75		9.51		10.93		12.19	
58	8.71		9.91		10.80		9.32		11.08		12.39	
SEd	**0.30**		**0.34**		**0.37**		**0.33**		**0.37**		**0.41**	
CD (0.05)	**NS**		**NS**		**NS**		**NS**		**NS**		**NS**	
	M × S	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**	**M × S**	**S × M**
SEd	**0.62**	**0.61**	**0.69**	**0.67**	**0.75**	**0.73**	**0.68**	**0.66**	**0.76**	**0.74**	**0.85**	**0.83**
CD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Note

(i) Seed Pelleting: DAP 40 g kg^{-1} seed **(M1),** DAP 40 g + KCl 10 kg^{-1} seed **(M2)**, DAP 40 g + KCl 10 g + Gypsum 20 g kg^{-1} seed **(M3),** Control **(M4)**

(ii) Foliar Spray: DAP 2 % at 30 & 45 DAS **(S1)**, DAP 2 % + KCl 1 % at 30 & 45 DAS **(S2)**, DAP 2 % + NAA 40 ppm at 30 & 45 DAS **(S3)**, DAP 2 % + KCl 1 % + NAA 40 ppm at 30 & 45 DAS **(S4)**, DAP 2 % at 30, 45 & 60 DAS **(S5)**, DAP 2 % + KCl 1% at 30, 45 & 60 DAS **(S6)**, DAP 2 % + NAA 40 ppm at 30, 45 & 60 DAS **(S7)**, DAP 2 % + KCl 1 % + NAA 40 ppm at 30, 45 & 60 DAS **(S8)**.

At harvest stage also similar trend of root nodules plant^{-1} was observed. The maximum of 22.71 and 24.49 nodules plant^{-1} was received with M3 and the minimum (20.07 and 21.64 nodules plant^{-1}) with the control (M4) for both the seasons, respectively. The results are in confirmation with previous findings in which seed pelleting with 50% bio digested slurry + 5% DAP resulted in highest values of no. of effective nodules/plant (Kuppuswamy *et al*., 1992).

With regard to the foliar spray, the number of root nodules plant^{-1} had not influenced significantly but numerically higher number of root nodules plant^{-1} at 45 DAS and harvest stage were recorded under foliar spray of DAP plus KCl and NAA at 30, 45 and 60 DAS (S8). The interaction between foliar spray and seed pelleting was not significant. Increased number of root nodules and nodule weight per plant registered higher under foliar spray of DAP plus KCl and NAA at 30, 45 and 60 DAS. The increased root growth might have provided better source for the symbiotics to act upon and developed more number of nodules and the resultant nodule weight. Increased number of nodule per plant and nodule weight by foliar spray of 2 % DAP in blackgram was recorded by Karthikeyan *et al.* (2020).

The trend of the data on nodule weight plant^{-1} was similar to that of nodule number plant^{-1} (Table 3). At 30 DAS, seed pelleting with DAP plus KCl and gypsum (M3) ranked first with the nodule weight of 9.30 and 10.25 mg plant^{-1} for first and second season respectively. The minimum nodule weight was obtained with control (M4 – 8.22 and 9.06 mg plant^{-1} for both seasons, respectively).

The seed pelleting influence observed at 30 DAS on nodule weight was extended to 45 DAS also and the maximum nodule weight of 10.46 and 11.57 mg plant^{-1}

for both the seasons respectively was recorded with the same treatment as that of 30 DAS (M3). The lowest nodule weight was recorded with the control (M4 – 9.25 and 10.22 mg plant^{-1} respectively for both the seasons). At harvest stage also the M3 treatment ranked first with a nodule weight of 11.36 and 12.89 mg plant^{-1} for both the seasons, respectively. The lowest nodule weight was observed under control (M4 – 10.03 and 11.39 mg plant^{-1} during both the season, respectively). In the case of foliar spray, the nodule weight was not influenced significantly by the different combinations of spray. DAP plus KCl and NAA foliar spray at 30, 45 and 60 DAS spray (S8) registered higher numerical value of nodule weight plant^{-1} at 45 DAS and at harvest stage. The interaction between seed pelleting and foliar spray treatments was not found significant at any of the growth stage of blackgram. The increased root growth might have provided better source for the symbiotics to act upon and developed more number of nodules and the resultant nodule weight. The findings are in accordance with the findings of Arun Raj *et al.* (2018), Devaraju and Senthilvel (2018) and Karthikeyan *et al.* (2020).

Conclusion

The study concluded that adoption of various seed pelleting and foliar spray treatments had significant impact on root length, number of root nodules plant^{-1} and nodule weight plant^{-1}of irrigated blackgram. The treatment combination of DAP 40 g + KCl 10 g + Gypsum 20 g kg^{-1} seed and DAP 2% + KCl 1% + NAA (40 ppm) at 30, 45 & 60 DAS registered higher root length, root nodule and nodule weight in blackgram crop in both the seasons.

Author contributions

S K Meena contributed to the conception, design, execution and interpretation of the work. Vengadessan V contributed to the search in scientific databases. Both the authors contributed to the manuscript and approved the submitted version.

References

Arun Raj, M., Sathya P. and Vignesh S. (2018). Effect of Foliar Nutrition for Maximizing the Productivity of Blackgram (*Vigna mungo* L.). *Int. J. Sci., Environ. Tech.*, **7(6)**, 2026 – 2032.

Baroni, D.F. and Vieira H.D. (2020). Coating seeds with fertilizer: A promising technique for forage crop seeds. *Agricultural Sciences*.

Devaraju, B. and Sethivel T. (2018). Effect of foliar application of different source of nutrients in growth and yield of blackgram under Irrigated condition. *Int. J. Curr. Microbiol. App. Sci*., **7(1)**, 3205-3109.

Dixit, P.M., Elamathi S., Kishor K.Z. and Neeta C. (2008). Effect of foliar application of nutrients and NAA in mungbean. *J Food Legume*, **21**, 277-278.

Gomez, K.A. and Gomez A.A. (1984). *Statistical Procedures for Agricultural Research*. 2nd Edition, John Wiley and Sons, New York, 680 p.

https://www.fao.org/india/fao-in-india/india-at-a-glance/en/ (Accessed on 14.01.2024)

Iantcheva, A. and Naydenova G. (2021). Biological nitrogen fixation in legumes understanding the process. *Legume hub* (https://www.legumehub.eu)

Kafeel, U., Jahan U. and Khan F.A. (2023). Role of mineral nutrients in biological nitrogen fixation. *Sust. Plant Nutr.*, 87-106

Karthikeyan, A., Vanathi J., Babu S. and Ravikumar C. (2020). Studies on the effect of Foliar Application of organic and Inorganic Nutrients on the Phenotypic enhancement of Blackgram cv. Vamban-6. *Plant Archives*, **20(2)**, 1161-1164.

Kavitha, S., Vanangamudi K. and Sabir-Ahamed A. (2003). Vigour and viability of hardened and pelleted seeds of blackgram (*Vigna mungo* (L.) Hepper). *Madras Agric. J*., **90 (4-6)**, 304-309.

Khodadad and Mostafavi (2012). Grain yield and yield components of soybean upon application of different micronutrient foliar fertilizer at different growth stages. *Int. J Agric Res*., **2(4)**, 389-394.

Kuppuswamy, G., Lakshamanan A.R. and Jeyabal A. (1992). Effect of seed pelleting with biodigested slurry and macro nutrients on rice fallow greengram cv. Co-2. *Madras Agricult. J.*, **79(4)**, 183-187.

Lopez, G., Ahmadi S.H., Amelung W., Athmann M., Ewert F., Gaiser T., Gocke M.I., Kautz T., Postma J., Rachmilevitch S., Schaaf G., Schnepf A., Stoschus A., Watt M., Yu P. and Seidel S.J. (2023). Nutrient deficiency effects on root architecture and root-to-shoot ratio in arable crops. *Front. Plant Sci.*, **13**, 1067498.

Ramesh, T., Ravi V., Parthipan T. and Rathika S. (2016). Productivity enhancement in rice fallow black gram through refinement of nutrient management. *Legume Res*., **39(1)**, 106- 109.

Ravisankar, N., Chandrasekharan B., Sathiyamoorthi K. and Balasubramanian T.N. (2003) Effect of agronomic practices for multi-blooming in greengram (*Vigna radiata* L.) (cv. Pusa bold). *Madras Agric. J*., **90(1-3)**, 166-169.

Reddy, P.R.K., Tzudir L., Kumari S., Nongmaithem D., Singh A.P. and Yadav R. (2022). Response of Blackgram (*Vigna mungo* L.) to Integrated Weed Management and its effect on Weed Dynamics. *Plant Archives*, **22(2)**, 397-402.

Sengar, V.S., Singh K.K., Singh A.K., Srivastava A. and Chaudhary B. (2020). Economic Analysis of Production, Marketing and Constraints of Black Gram in Auraiya District of Uttar Pradesh. *Int. J. Curr. Microbiol. App. Sci.*, **Special Issue-11**, 2972-2979.

Shafi, G., Ara N., Khan F.U., Jamal U. and Basir A. (2015). Influence of DAP seed priming and soaking durations on yield and yield associated traits in Okra. *Pure Appl. Biol*., **4(3)**, 389-397.

Tiwari, B.K. and Singh N. (2012). Pulse chemistry and technology. *Cambridge: Royal Society of Chemistry.*

Upadhyay, R.G. (2002). Response of growth regulators on flower drop, fruit setting, biochemical constituents and yield of chickpea (*Cicer artietinum* L.) under mid hill conditions of H.P. *Legume Res*., **25(3)**, 211-214.

Vennila, S., Pushpakaran M. and Palaniraja K. (2018). Effect of presowing seed pelleting treatment using botanical leaf powders and biofertilizers on growth and yield characters in blackgram (*Vigna mungo* [L.] Hepper) variety VBN 5. *J. Pharmacog. Phytochem*., **7(4)**, 2923-2925.