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Effect of nano DAP on growth, yield and economics of green gram (*Vigna radiata* L.)

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Abstract
The field experiment was conducted during the *kharif* season of 2024 at the Instructional Farm, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, with a view to study the "Performance of green gram with foliar application of Nano DAP". The experiment was conducted in randomized block design with nine treatments of foliar nutrient applications and replicated thrice. Results revealed that application of 75% RDF + two foliar sprays of Nano DAP @ 4 ml L^{-1} at 30 and 40 DAS was recorded higher values of growth, yield contributing characters, yield and economics of green gram which was significantly superior over other treatments but was at par with application of RDF + Two water sprays and application of RDF only.

Keywords: Growth, yield, economics, nano DAP, 12:61:00 and green gram

Introduction
Green gram, commonly referred to as moog bean (*Vigna radiata* L.), is classified under the family *Leguminosae*. It is second most important pulse crop, accounting for 11% of all pulse food produced globally.
Green gram is highly responsive to phosphatic fertilization and is sensitive to insufficient phosphorous. Macro nutrients like N, P and K in sufficient quantity throughout the growing season are essential for optimum plant growth (Haque *et al*., 2001) [5]. Foliar feeding of fertilizer makes nutrient available for crop in adverse conditions. Nano fertilizer is a nutrient fertilizer that consists of Nanostructured formulations for effective uptake by plants due to the gradual release of nutrients. However, in traditional bulk fertilizers, the efficiency of plant uptake is low; therefore, larger amounts are necessary. In NPK based fertilizers, the efficiency of nutrient uptake is diminished primarily due to the drastic changes in chemical forms that plants are unable to absorb, resulting in runoff, leaching, and atmospheric losses. Foliar fertilizer application has been found to be the most effective method of applying plant nutrients in the form of foliar sprays because nutrients applied through the leaf penetrate the cuticle and stomata of the leaf and reach the cells very quickly, allowing rapid and effective nutrient utilization (Latha and Nadanassabady, 2003) [7].

Materials and Methods
A field investigation entitled "Performance of green gram (*Vigna radiata* L.) with foliar application of Nano DAP" was conducted at PGI Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri during *kharif* 2024.
The experiment consists of 9 treatments *viz*., T_1: Absolute control; T_2: RDF, (N:P2O5:K2O @ 20:40:00 kg ha^{-1}), T_3: RDF + Two water sprays, T_4: 75% RDF + Two foliar sprays of Nano DAP @ 2 ml L^{-1}, T_5: 50% RDF + Two foliar sprays of Nano DAP @ 2 ml L^{-1}, T_6: 75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1}, T_7: 50% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1}, T_8: 75% RDF + Two foliar sprays of 12:61:00 @ 1%, T_9: 50% RDF + Two foliar sprays of 12:61:00 @ 1%. FYM 5 t ha^{-1} applied to T_2 to T_9 treatments. Foliar spray was taken at 30 and 40 DAS. The experiment was laid out in randomized block design (RBD) with three replications.

The soil was clayey in texture, low in available nitrogen (191.10 kg ha^{-1}), medium in available phosphorus (17.56 kg ha^{-1}) and high in available potassium (380.05 kg ha^{-1}). The soil was alkaline in reaction (pH 8.05) with electrical conductivity of 0.38 dS m^{-1}.

The recommended dose of fertilizer (20:40:00 N:P_2O_5:K_2O kg ha^{-1} + 5 t ha^{-1} of FYM) was applied as a basal through DAP and urea in treatment T_2 to T_9. Thereafter, foliar application of Nano DAP was done at 30 and 40 days after sowing, respectively.

Results and Discussion

Growth attributing studies

Plant height

The plant height was significantly influenced due to foliar application of different nutrients to green gram.

The application of 75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1} at 30 and 40 DAS recorded significantly higher plant height (59.23 cm). It was statistically at par with application of RDF + Two water sprays (56.69 cm) and application of RDF (54.86 cm).

The increase in plant height of green gram with foliar application of Nano DAP may be due to enhanced nutrient uptake and utilization of particularly phosphorous. It stimulates cell elongation and division that promotes growth. The phosphorous helps in vigorous root growth which helps to absorb soil nutrients effectively resulting in optimum plant height of green gram. These results are in conformity with Benzon *et al.* (2015) [4] and Al-Juthery *et al.* (2018) [2].

Table 1: Growth and yield contributing characters of green gram as influenced by different treatments

Tr. No.	Treatment	Plant height (cm)	Dry matter accumulation (g)	Number of pods $plant^{-1}$	Seed yield $plant^{-1}$ (g)	Haulm yield $plant^{-1}$ (g)	(100 seeds) (g)
T_1	Absolute Control	41.33	19.74	13.73	9.02	11.73	2.25
T_2	RDF (20:40:00 kg ha^{-1} N:P_2O_5:K_2O)	54.86	27.52	24.00	13.56	17.63	3.39
T_3	RDF + Two water sprays	56.69	28.44	24.52	13.76	17.88	3.44
T_4	75% RDF + Two foliar sprays of Nano DAP @ 2 ml L^{-1}	50.96	25.39	22.19	12.15	15.80	3.04
T_5	50% RDF + Two foliar sprays of Nano DAP @ 2 ml L^{-1}	48.91	24.30	19.04	11.48	14.92	2.87
T_6	75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1}	59.23	29.94	25.69	14.87	19.33	3.72
T_7	50% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1}	50.40	24.88	21.03	11.66	15.15	2.91
T_8	75% RDF + Two foliar sprays of 12:61:00 @ 1%	47.64	22.96	18.51	11.39	14.81	2.85
T_9	50% RDF + Two foliar sprays of 12:61:00 @ 1%	45.52	21.87	17.28	10.77	14.00	2.69
	S.E. m. ±	2.70	1.19	0.98	0.74	0.97	0.18
	C.D. at 5%	6.98	4.04	2.97	2.25	2.92	0.56
	General mean	50.61	25.00	20.66	12.07	15.69	3.01
	C.V.	8.01	8.25	8.27	10.72	10.02	9.40

Dry Matter accumulation (g)

The highest dry matter production $plant^{-1}$ (29.94 g) was observed in application of RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1} at 30 and 40 DAS. It was at par with application of RDF + Two water sprays (28.44 g) and application of RDF (27.52 g).

When green gram is subjected with foliar application of Nano DAP, it results into higher dry matter $plant^{-1}$ because there is sufficient availability of nutrients to the green gram that results in increase in photosynthetic activities. Increased plant height, more number of leaves and higher leaf area due to application of foliar nutrients might have resulted in increase in dry matter $plant^{-1}$. These findings corroborate the earlier reports of Balachandrakumar *et al.* (2024) [3] and Maloth and Thatikunta (2024) [8], who observed the formulation encourages vegetative growth and biomass production allowing the plant to build up more dry matter.

Yield Contributing Characters

The number of pods $plant^{-1}$ was recorded significantly higher (25.69) at application of 75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1} at 30 and 40 DAS. While, it was at par with application of RDF + Two water sprays (24.52) and application of RDF (24.00). The highest seed yield $plant^{-1}$ (14.87 g) and haulm yield $plant^{-1}$ (19.33) was recorded in application of 75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1} at 30 and 40 DAS. It was at par with application of RDF + Two water sprays and application of RDF.

The foliar application of Nano DAP enhanced nutrient uptake efficiency, particularly nitrogen and phosphorus, which play a critical role in boosting photosynthetic activity, assimilate translocation, and sink development. Foliar feeding during reproductive stages supports pod filling and seed development by supplying nutrients directly to plant when root uptake is limited. This ensures increased seed yield $plant^{-1}$. These results are in collaboration with findings of Khemshetty *et al.* (2024) [6], Sachin *et al.* (2024) [10] and Shete *et al.* (2024) [12]. Foliar nutrients during active vegetative stages support efficient carbon assimilation and source-sink balance. These results agreed with findings of Adhikari *et al.* (2014) [1].

The significantly higher weight of 100 seeds (3.72 g) was recorded with application of 75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1} at 30 and 40 DAS. It was at par with application of RDF + Two water sprays (3.44 g) and application of RDF (3.39 g). Adequate phosphorus is critical for energy transfer and seed development, while nitrogen improves protein synthesis and translocation of assimilates into the developing seeds, leading to bolder and denser seeds. The results are in comparison with Sanjayakumar *et al.* (2024) [11].

Yield studies

Table 2: Seed, haulm and economics of green gram as influenced by different foliar nutrient application

Tr. No.	Treatment	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Gross monetary returns (₹ ha^{-1})	Cost of cultivation (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})	B:C ratio
T_1	Absolute Control	612	963	53788	40078	13710	1.34
T_2	RDF (20:40:00 kg ha^{-1} N:P_2O_5:K_2O)	1262	1703	110576	55246	55330	2.00
T_3	RDF + Two water sprays	1280	1742	112170	55774	56396	2.01
T_4	75% RDF + Two foliar sprays of Nano DAP @ 2 ml L^{-1}	1168	1626	102399	56718	45681	1.80
T_5	50% RDF + Two foliar sprays of Nano DAP @ 2 ml L^{-1}	1001	1410	87778	55338	32440	1.59
T_6	75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1}	1388	1820	121552	58838	62714	2.07
T_7	50% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1}	1100	1545	96454	57034	39420	1.69
T_8	75% RDF + Two foliar sprays of 12:61:00 @ 1%	928	1310	81380	56983	24397	1.42
T_9	50% RDF + Two foliar sprays of 12:61:00 @ 1%	867	1237	76046	55603	20443	1.36
	S.E. m. ±	53	61	4430	--	4430	-
	C.D. at 5%	158	182	13338	--	13338	-
	General mean	1067	1484	93571	54623	38948	1.70
	C.V.	8.51	8.01	8.20	-	8.20	-

Seed and haulm yield

The application of 75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1} at 30 and 40 DAS produced significantly the highest seed yield (1388 kg ha^{-1}) and haulm yield (1820 kg ha^{-1}) of green gram among all treatments, but remained at par with the application of RDF + Two water sprays at 30 and 40 DAS and application of RDF.

The significant increase in haulm yield in green gram due to foliar application of Nano DAP is due to enhanced vegetative growth resulting from better nitrogen and phosphorus availability. Nitrogen supports rapid cell division and expansion, increasing leaf and stem biomass, while phosphorus contributes to root development and energy transfer processes. These physiological effects promote a more robust plant structure with increased biomass accumulation in vegetative parts leads to increase in the seed and haulm yield. Similar results are in confirmation with Singh *et al.* (2023) [13] and Balachandrakumar *et al.* (2024) [3].

Economics

Gross Monetary Returns

The significantly higher gross monetary returns (₹ 1,21,552 ha^{-1}), net monetary returns (₹ 62,714 ha^{-1}) and B:C ratio (2.07) were obtained in the application of 75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1} at 30 and 40 DAS. It was followed by and at par with application of RDF + Two water sprays at 30 and 40 DAS and application of RDF. Higher seed and haulm yields due to effective foliar nutrition, particularly with Nano DAP, were responsible for the higher gross monetary returns. Foliar-applied Nano DAP improved photosynthesis and nutrient uptake, ultimately enhancing yield and marketable output. Similar outcomes were reported by Pratihar and Banerjee (2023) [9], Sachin *et al.* (2024) [10].

Conclusion

The application of 75% RDF + Two foliar sprays of Nano DAP @ 4 ml L^{-1} at 30 and 40 DAS to green gram found beneficial for higher growth and yield of green gram with higher profitability.

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Conflict of Interest

The authors declare there are no conflict of interest relevant to this article.

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