Plant Archives Vol. 25, No. 2, 2025 pp. 1059-1064 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.no.2.152

RESPONSE OF NANO DAP ON NUTRIENT CONTENT, UPTAKE AND QUALITY OF COWPEA (*VIGNA UNGUICULATA* L.)

S.N. Goplani[1*], A. M. Polara[2], M. P. Dobariya[1] and N. H. Solanki[1]

[1]Department of Agronomy, Junagadh Agricultural University, Junagadh, Gujarat, India.

[2]Cotton Research Station, J.A.U., Junagadh, Gujarat, India

*Corresponding author E-mail: shivamgoplani0@gmail.com

(Date of Receiving-04-06-2025; Date of Acceptance-06-08-2025)

ABSTRACT

At the Cotton Research Station, Junagadh Agricultural University, Junagadh, in the South Saurashtra Agro-climatic Zone of Gujarat, a field experiment entitled "Response of nano DAP on nutrient content, uptake, and quality of cowpea (*Vigna unguiculata* L.)" was carried out during the summer season of 2024. The experiment was laid out in randomized block design with three replications. The experiment comprised 10 treatments in combination of soil application, seed treatment and foliar application with conventional fertilizer and nano DAP. Among these treatments the application of 100% RDF recorded significantly higher protein (21.19%) content was recorded under the application of treatment T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS). Similarly, chemical analysis of plant and soil revealed that significantly higher nutrient content in seed (3.39 and 0.53 per cent of N and P) and stover (1.14 and 0.26 per cent of N and P) furthermore higher uptake of nutrient by seed (45.46, 7.11 and 15.02 kg/ha of N, P and K) and stover (30.32, 6.91 and 37.77 kg/ha of N, P and K) as well as by crop (75.78, 14.02 and 52.79 kg/ha of N, P and K) was recorded under the treatment T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS). While, significantly the maximum available N (287.69 kg/ha) and P_2O_5 (35.56 kg/ha) in soil after harvest of crop was recorded with the application of treatment T_2 (100% RDF).

***Key words*:** Nano DAP, Cowpea, Quality and Nutrient

Introduction

Pulses are considered as an important part of food crop occupying a unique position in agriculture and also an important component of food grain crops because of their high nutritive value. Pulses are the important sources of proteins, vitamins and minerals for the predominantly vegetarian population and are popularly known as "Poor man's meat" and "Rich man's vegetable" (Singh and Singh, 1992). Among various pulses cowpea (*Vigna unguiculata* L.) belongs to family Papilonacaeae (Fabaceae or Leguminosae) is very important pulse crop.

Legume crops are P loving plants and need more P for growth, seed development and most especially in nitrogen fixing which is energy driving process (Sanginga *et al*., 2000). Phosphorus plays important role to cowpea yields as it stimulates growth, initiates nodule formation for biological nitrogen fixation through increasing the efficiency of the *rhizobium*-legume symbiosis.

These bacteria convert atmospheric nitrogen (N_2) into a form that the plant can use, such as ammonia (NH_3). This symbiotic relationship not only benefits the cowpea plant by providing it with essential nitrogen but also enriches the soil with nitrogen, making it available for subsequent crops.

The formulation of nano DAP includes phosphorus (16.0% P_2O_5 w/v) and nitrogen (8.0% N w/v). Since its particles are smaller than 100 nanometers (nm), Nano DAP (Liquid) has an advantage in terms of surface area to volume. It can easily enter through stomata and other plant openings or inside the seed surface because to its special characteristic.

Using nano fertilizer topically leads to higher nutrient use efficiency (NUE) and a quicker reaction to plant growth. Because of their high reactivity and ease of

Table 1: Effect of different treatments on protein content of cowpea.

	Treatments	Protein content (%)
T_1	Absolute control	19.25
T_2	100% RDF (20:40:00 kg N-P_2O_5-K_2O /ha)	21.00
T_3	75% RDF + seed treatment with nano DAP at 5 ml/kg seed	19.50
T_4	50% RDF + seed treatment with nano DAP at 5 ml/kg seed	19.31
T_5	T_3 + foliar spray of nano DAP at 2 ml/lit at 30 DAS	19.69
T_6	T_3 + foliar spray of nano DAP at 4 ml/lit at 30 DAS	19.75
T_7	75% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS and 40 DAS	21.06
T_8	50% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS, 40 DAS and 50 DAS	19.38
T_9	75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS	21.19
T_{10}	50% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS, 40 DAS and 50 DAS	19.63
	S.Em.±	0.47
	C.D. at 5%	1.41
	C.V.%	4.10

penetration through the leaf cuticle, nano fertilizers provide controlled release and precise dispersion. (Mahil and Kumar, 2019).

Materials and Methods

At the Cotton Research Station, Junagadh Agricultural University, Junagadh (21.5°N latitude and 70.5°E longitude with an elevation of 60 m above mean sea level), in the South Saurashtra Agro-climatic Zone of Gujarat, a field experiment entitled "Response of nano dap on nutrient content, uptake and quality of cowpea (*Vigna unguiculata* L.)" was carried out during the summer of 2024. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction with pH 8.08 and EC 0.33 dS/m. The soil was medium in available nitrogen (282.34 kg/ha), available phosphorus (42.65 kg/ha) and in available potash (278.11 kg/ha). The experiment was laid out in randomized block design with three replications. The experiment comprised 10 treatments in combination of soil application, seed treatment and foliar application with conventional fertilizer and nano DAP *viz.*, T_1 (Absolute control), T_2 (100% RDF (20-40-00 N-P_2O_5-K_2O kg/ha)), T_3 (75% RDF + seed treatment with nano DAP at 5 ml/kg seed), T_4 (50% RDF + seed treatment with nano DAP at 5 ml/kg seed), T_5 (T_3 + foliar spray of nano DAP at 2 ml/lit at 30 DAS), T_6 (T_3 + foliar spray of nano DAP at 4 ml/lit at 30 DAS) T_7 (75% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS and 40 DAS), T_8 (50% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS and 40 DAS), T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS) and T_{10} (50% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS, 40 DAS and 50 DAS). The cowpea (*cv.* Gujarat Cowpea-6) was sown on 21th February 2024 at a spacing of 45 × 15 cm using seed rate of 25 kg/ha with RDF (20-40-00 N-P_2O_5-K_2O kg/ha) applied as basal.

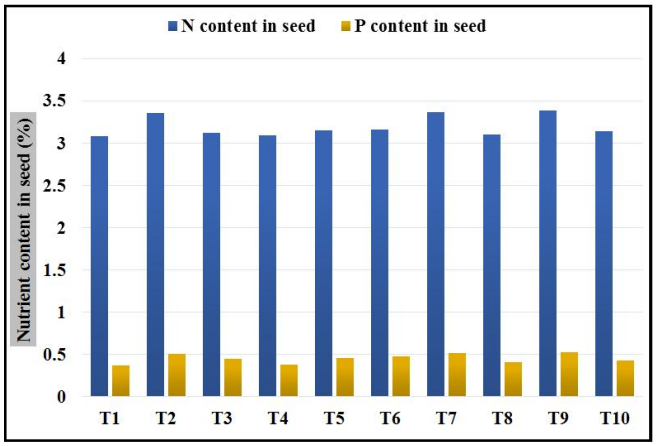

Fig. 1: Effect of different treatments on nutrient content in seed of cowpea.

Methods followed for determination of nutrient content in seed and stover *viz.*, modified Kjeldahl's method for nitrogen content, Vando-molybdo phosphoric acid yellow colour method for phosphorus content and flame photometer method for potassium content (Jackson 1974).

Soil analysis for available NPK nutrients was carried out before sowing and after harvest of crop. Representative sample from 0-30 cm depth was taken from each plot and methods adopted were alkaline permanganate method for nitrogen (Subbiah and Asija 1956), olsen's method for phosphorus (Olsen *et al.*, 1954) and flame photometer method for potassium.

Results and Discussion

Quality parameters

Protein content (%)

Highest protein content (21.19%) was recorded under the treatment T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS). The higher protein content recorded due to better uptake of nitrogen and converted into amino acids. The observations are in

Table 2: Effect of different treatments on nutrient content in seed and stover of cowpea.

Treatments		A			B		
		N	P	K	N	P	K
T_1	Absolute control	3.08	0.37	0.97	0.94	0.16	1.24
T_2	100% RDF (20:40:00 kg N-P_2O_5-K_2O /ha)	3.36	0.51	1.09	1.11	0.25	1.38
T_3	75% RDF + seed treatment with nano DAP at 5 ml/kg seed	3.12	0.45	1.03	1.02	0.21	1.32
T_4	50% RDF + seed treatment with nano DAP at 5 ml/kg seed	3.09	0.38	0.98	0.96	0.18	1.26
T_5	T_3 + foliar spray of nano DAP at 2 ml/lit at 30 DAS	3.15	0.46	1.06	1.05	0.22	1.34
T_6	T_3 + foliar spray of nano DAP at 4 ml/lit at 30 DAS	3.16	0.48	1.07	1.06	0.23	1.35
T_7	75% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS and 40 DAS	3.37	0.52	1.11	1.12	0.25	1.41
T_8	50% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS, 40 DAS and 50 DAS	3.10	0.41	1.00	0.99	0.19	1.28
T_9	75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS	3.39	0.53	1.12	1.14	0.26	1.42
T_{10}	50% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS, 40 DAS and 50 DAS	3.14	0.43	1.01	1.00	0.21	1.29
	S.Em.±	0.08	0.01	0.04	0.03	0.01	0.04
	C.D. at 5%	0.22	0.04	NS	0.08	0.02	NS
	C.V.%	4.10	5.57	5.91	4.24	5.15	5.26

A: Nutrient content in seed (%); **B:** Nutrient content in stover (%)

agreement with those of Dhansil *et al*., (2018), Rathore (2022), Gurjar (2023), Prakash *et al*., (2023b), Borana (2024) and Khemshetty *et al*., (2024).

Nutrient content

Nitrogen content in seed (%)

Treatment T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS) gave the highest nitrogen content (3.39%) in seed. The positive influence of conventional and nano fertilizer application on nutrient content in cowpea appears to be due to improved nutritional level both in the root zone and plant system. The increased availability of nitrogen in root zone coupled with increased metabolic activity at cellular level might have increased nutrient uptake and their accumulation in vegetative plant parts. Increased accumulation of nutrients in vegetative plant parts with improved metabolism led to greater translocation of nutrients to reproductive organs of the crop and ultimately increased the contents in seed. These results are in conformity with the findings of El-Azizy *et al*., (2021), Gurjar (2023) and Poudel *et al*., (2023).

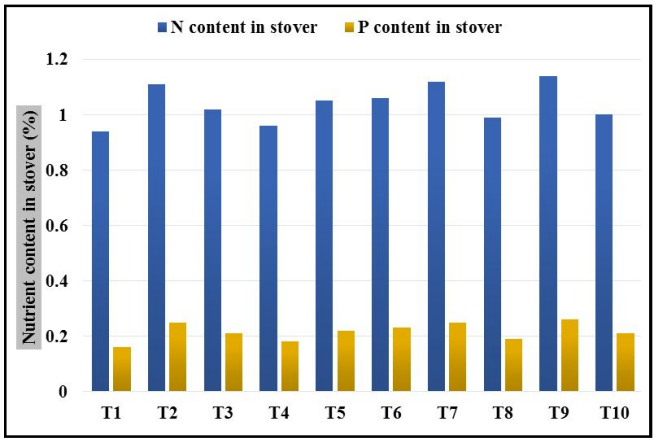

Fig. 2: Effect of different treatments on nutrient content in stover of cowpea.

Phosphorus content in seed (%)

Highest phosphorus content (0.53%) in seed found with T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS). This may be because applying nano DAP to the leaves of plants covers a greater surface area, allowing particles smaller than plant pores to enter the plant more deeply and enhance nutrient absorption. These results are in accordance with the findings of El-Azizy *et al*., (2021), Gurjar (2023) and Poudel *et al*., (2023).

Potassium content in seed (%)

The data unveiled that employment of different treatments in this experiment did not exert any significant effect on potassium content of cowpea.

Nitrogen content in stover (%)

Treatment T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS) gave significantly higher nitrogen content (1.14) of the stover. This may be due to nano DAP, due to its smaller particle size and higher surface area, facilitates more efficient nutrient absorption at the cellular level, allowing for better uptake of nitrogen to the plant. Similar findings were also reported by El- Azizy *et al*., (2021), Gurjar (2023) and Poudel *et al*., (2023).

Phosphorus content in stover (%)

Improved phosphorus content (0.26) in stover found with T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS). This may be because applying nano DAP to the leaves of plants covers a greater surface area, allowing particles smaller than plant pores to enter

Table 3: Effect of different treatments on nutrient uptake by cowpea.

Treatments		A			B			C		
		N	P	K	N	P	K	N	P	K
T_1	Absolute control	24.30	2.92	7.65	15.11	2.57	19.94	39.41	5.49	27.59
T_2	100% RDF (20:40:00 kg N-P_2O_5-K_2O /ha)	38.71	5.88	12.56	25.41	5.72	31.59	64.11	11.60	44.14
T_3	75% RDF + seed treatment with nano DAP at 5 ml/kg seed	32.29	4.66	10.66	21.19	4.36	27.43	53.49	9.02	38.09
T_4	50% RDF + seed treatment with nano DAP at 5 ml/kg seed	25.96	3.19	8.23	16.39	3.07	21.51	42.34	6.26	29.74
T_5	T_3 + foliar spray of nano DAP at 2 ml/lit at 30 DAS	34.68	5.06	11.67	23.13	4.85	29.52	57.82	9.91	41.20
T_6	T_3 + foliar spray of nano DAP at 4 ml/lit at 30 DAS	36.28	5.51	12.28	24.19	5.25	30.81	60.47	10.76	43.09
T_7	75% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS and 40 DAS	41.99	6.48	13.83	27.70	6.18	34.87	69.69	12.66	48.71
T_8	50% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS, 40 DAS and 50 DAS	30.13	3.99	9.72	19.45	3.73	25.15	49.58	7.72	34.87
T_9	75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS	45.46	7.11	15.02	30.32	6.91	37.77	75.78	14.02	52.79
T_{10}	50% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS, 40 DAS and 50 DAS	33.50	4.59	10.78	21.48	4.51	27.71	54.98	9.10	38.48
	S.Em.±	2.46	0.42	0.85	1.80	0.40	2.12	4.13	0.82	2.93
	C.D. at 5%	7.31	1.24	2.53	5.35	1.20	6.31	12.27	2.44	8.72
	C.V.%	12.42	14.67	13.13	13.90	14.87	12.84	12.60	14.72	12.75

A: Nutrient uptake by seed (kg/ha); **B:** Nutrient uptake by stover (kg/ha); **C:** Total nutrient uptake by cowpea (kg/ha)

the plant more deeply and enhance nutrient absorption. The results were in line with the findings of El- Azizy *et al*., (2021), Gurjar (2023) and Poudel *et al*., (2023).

Potassium content in stover (%)

It is evident from the data that application of various treatment shows no significant influence on potassium content in stover of cowpea.

Nutrient uptake

Nitrogen uptake of seed (kg/ha)

The increased nitrogen uptake (45.46 kg/ha) by seed in T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS) may be attributed to the higher surface area and better absorption efficiency of nano-fertilizers. Moreover, repeated foliar application at critical growth stages may have improved the translocation of N from vegetative parts to the developing seed, thus boosting uptake. The present findings are closely associated with Deo *et al*., (2022), Rathore (2022), Girigoud *et al*., (2023b) and Borana (2024).

Phosphorus uptake by seed (kg/ha)

Phosphorus being relatively immobile in the soil, its uptake is often restricted under conventional fertilization, especially in low P-fixing soils. Nano-sized phosphorus particles in nano DAP have been reported to enhance solubility and root absorption due to their smaller size and higher reactivity. In T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS) foliar application of nano fertilizer also help bypass soil-related constraints and deliver nutrients directly to the plant system (7.11 kg/ha). Similar results were found by Deo *et al*., (2022), Rathore (2022), Girigoud *et al*., (2023b), Borana (2024) and Varghese (2024).

Potassium uptake by seed (kg/ha)

Higher potassium uptake (15.02 kg/ha) by seed was noted with the treatment T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS). Although nano DAP is primarily a source of nitrogen and phosphorus, the improved physiological vigour due to nano fertilizer application may enhance root growth and uptake of other essential nutrients like potassium. Similar results observed by Deo *et al*., (2022), Rathore (2022) and Girigoud *et al*., (2023b).

Nitrogen uptake by stover (kg/ha)

The increase in nitrogen uptake (30.32 kg/ha) by stover in treatment T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS) was due to nano fertilizers which have higher surface area and smaller particle size, less than the pore size of root and leaves of the plant which can increase their penetration into the plant from applied surface and improve nutrient uptake. These results are in confirmation with the findings of Deo *et al*., (2022), Rathore (2022), Girigoud *et al*., (2023b) and Borana (2024).

Phosphorus uptake by stover (kg/ha)

The highest phosphorus (6.91 kg/ha) uptake by stover was reported under the treatment T_9 (75% RDF + foliar

Table 4: Effect of different treatments on soil available nutrients after harvest of cowpea.

Treatments		Soil available nutrients (kg/ha)		
		N	P_2O_5	K_2O
T_1	Absolute control	228.46	24.11	252.25
T_2	100% RDF (20:40:00 kg N-P_2O_5-K_2O /ha)	287.69	35.56	273.95
T_3	75% RDF + seed treatment with nano DAP at 5 ml/kg seed	262.73	31.97	262.38
T_4	50% RDF + seed treatment with nano DAP at 5 ml/kg seed	239.55	25.85	255.36
T_5	T_3 + foliar spray of nano DAP at 2 ml/lit at 30 DAS	266.41	32.65	267.20
T_6	T_3 + foliar spray of nano DAP at 4 ml/lit at 30 DAS	271.28	32.81	268.29
T_7	75% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS and 40 DAS	278.88	34.52	270.23
T_8	50% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS, 40 DAS and 50 DAS	241.37	26.28	255.97
T_9	75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS	282.52	34.74	277.36
T_{10}	50% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS, 40 DAS and 50 DAS	246.11	26.94	258.05
	S.Em.±	9.83	1.22	8.84
	C.D. at 5%	29.21	3.63	NS
	C.V.%	6.54	6.94	5.80

spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS). This might be due to foliar delivery of nano DAP ensures direct entry of phosphorus into mesophyll tissues, bypassing soil - induced limitations, and thereby significantly contributing to stover phosphorus accumulation. These findings are in close conformity with those reported by Deo *et al*., (2022), Rathore (2022), Girigoud *et al*., (2023b) and Borana (2024).

Potassium uptake by stover (kg/ha)

Enhanced nitrogen and phosphorus availability under nano fertilizer treatment T_9 (75% RDF + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS) may have indirectly supported potassium (37.77 kg/ha) uptake by stover. Similar results were found by Deo *et al*., (2022), Rathore (2022) and Girigoud *et al*., (2023b).

Post harvest nutrient status of soil

Available nitrogen (kg/ha)

Higher available soil nitrogen (287.69 kg/ha) was noticed in T_2 (100% RDF) due to higher amount of fertilizers (100%) were applied in this treatment as compared to others. Similarly, least was noticed in T_1 (Absolute control) as no fertilizers (0%) were applied. Similar results were found by Prakash *et al*., (2023a) and Borana (2024).

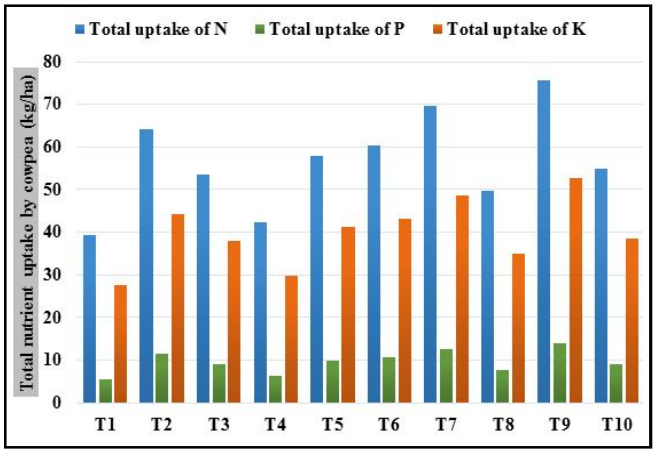

Fig. 3: Effect of different treatments on total nutrient uptake by cowpea.

Available phosphorus (kg/ha)

T_2 (100% RDF) gave higher available soil phosphorus (35.56 kg/ha) due to higher amount of fertilizers (100%) were applied in this treatment as compared to others. Likewise, least was noticed in T_1 (Absolute control) as no fertilizers (0%) were applied. Similar results were also reported by Prakash *et al*., (2023a) and Borana (2024).

Available potassium (kg/ha)

An exploration of data stipulated that there is no significant effect on the available potassium in soil after harvest of cowpea by the application of various treatments during the course of investigation.

Conclusion

Based on one year's experimentation, it seems quite logical to conclude that for getting higher nutrient content, uptake and quality of summer cowpea, crop should be fertilized with 75% RDF (20: 40: 00 kg N: P_2O_5: K_2O / ha) + foliar spray of nano DAP at 4 ml/lit at 30 DAS and 40 DAS under the medium black calcareous soil of South Saurashtra Agro-climatic Zone. This treatment was closely followed by 75% RDF + foliar spray of nano DAP at 2 ml/lit at 30 DAS and 40 DAS and 100% RDF.

References

Borana, H. (2024). Effect of nano fertilizers on productivity of wheat (*Triticum aestivum* L.). M. Sc. (Agri) Thesis (Unpublished). Agriculture University, Jodhpur, Rajasthan.

Deo, H.R., Chandrakar T., Srivastava L.K., Nag N.K., Singh

D.P. and Thakur A. (2022). Effect of nano DAP on yield, nutrient uptake and nutrient use efficiency by rice under Bastar plateau. *The Pharma Innovation Journal*, **11(9)**, 1463-1465.

Dhansil, A., Zalawadia N., Prajapat B.S. and Yadav K. (2018). Effect of nano phosphatic fertilizer on nutrient content and uptake by pearl millet (*Pennisetum glaucum* L.) crop. *International Journal of Current Microbiology and Applied Sciences*, **7(12)**, 2327-2337.

El-Azizy, F.A., Habib A.A.M. and Abd-El Baset A.M. (2021). Effect of nano phosphorus and potassium fertilizers on productivity and mineral content of broad bean in North Sinai. *Journal of Soil Sciences and Agricultural Engineering*, **12(4)**, 239-246.

Girigoud, A., Naik A., Siddaram B.S. and Bellakki M.A. (2023b). Nutrient uptake of pigeon pea as influenced by foliar spray of nano DAP. *The Pharma Innovation Journal*, **12(12)**, 1552-1556.

Gurjar, T. (2023). effect of efficient phosphorus management on black gram (*Vigna mungo* L. Hepper). M.Sc. (Agri.) Thesis (Unpublished). Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh.

Jackson, M.L. (1974). Soil Chemical Analysis. *Printice Hall of India Pvt. Ltd., New Delhi.*

Khemshetty, A., Patil D.H., Rathod P.S., Patil A.S. and Basavaraj K. (2024). Studies on Nano DAP on Growth, Yield and Quality of Chickpeas under Rainfed Conditions of Northeastern Dry Zone of Karnataka. *Journal of Experimental Agriculture International*, **46(3)**, 139-145.

Mahil, E. and Kumar B. (2019). Foliar application of nano fertilizers in agricultural crops- A review. *Journal of Farm Science*, **32(3)**, 239-249.

Olsen, S.R., Cole C.V., Watanabe F.S. and Dean L.A. (1954). Estimation of available phosphorus in soils by extraction with NaHCO, *Circular USDA*, 939.

Poudel, A., Singh S.K., Jiménez-Ballesta R., Jatav S.S., Patra A. and Pandey A. (2023). Effect of nano-phosphorus formulation on growth, yield and nutritional quality of wheat under semi-arid climate. *Agronomy*, **13(3)**, 768.

Prakash, A.N., Siddaram R. and Bellakki M.A. (2023a). Effect of nano DAP on nutrient uptake and available nutrients status of soil after harvest of soybean (*Glycine max* L.). *The Pharma Innovation Journal*, **12(12)**, 1990-1994.

Prakash, A.N., Siddaram R. and Bellakki M.A. (2023b). Response of nano DAP on growth, yield and quality of soybean. *The Pharma Innovation Journal*, **12(12)**, 2002-2005.

Rathore, A. (2022). Response of nano fertilizer (DAP) on growth and yield of Soybean [*Glycine max* (L.) Merrill] under Malwa condition of Madhya Pradesh. M. Sc. (Agri) Thesis (Unpublished). Rajmata Vijyaraje Scindia Krishi Vishwa Vidyalaya, Indore, Madhya Pradesh.

Sanginga, N., Lyasse O. and Singh B.B. (2000). Phosphorus use efficiency and nitrogen balance of cowpea breeding lines in a low P soil of the derived savanna zone in West Africa. Plant and Soil **220**, 119-128.

Singh, V. and Singh B. (1992). Tropical grain legume as important human food. Economic botany, **16(48)**, 310-321.

Subbiah, B.V. and Asija G.L. (1956). A rapid procedure for estimation of available nitrogen in soils. *Current Science*, **25(8)**, 259-260.

Varghese R.A. (2024). Substitution of molecular phosphorus with nano DAP and phosphorus nano particle on the performance of black gram (*Vigna mungo* L.). M. Sc. (Agri) Thesis (Unpublished). Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal.