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Nutrient uptake of pigeonpea as influenced by foliar spray of Nano-DAP

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Abstract
A field experiment was conducted during *kharif* 2022 at KVK, Kalaburagi to study the Nutrient Management with Nano-DAP in Pigeonpea. There were eight treatments consisting of different doses of RDF (Two treatments with 100% RDF, two treatment with 75% RDF, Two treatment with 50% RDF along 100% RDF and absolute control) with different doses of Nano-DAP sprayed at 45 & 60 DAS. Results revealed that application of 100% RDF as basal + Nano-DAP spray @ 4 ml l^{-1} each at 45 and 60 DAS has produced significantly higher nutrient content and uptake. It has resulted in enhanced nutrient content in seed (2.46%, 1.07% and 1.63% at N, P and K, respectively). and stalk (0.55%, 0.58% and 0.78% at N, P, and K, respectively) further higher uptake in grain (36.31, 15.83, 24.19 kg/ha of N, P and K, respectively) and in stalk (25.41, 26.66, 34.84 kg/ha of N, P, and K respectively) Results confirmed that reduced rate of conventional fertilizer can be substituted by foliar application of nano fertilizers to enhance nutrient use efficiency.

Keywords: Nano-DAP, nutrient uptake, nutrient content

1. Introduction
Pulses are gaining more important position in Indian agriculture. After the green revolution, India has become self-sufficient in case of food grain production. However, India is still lagging in pulses production and is dependent on imports for domestic consumption particularly in recent years. Therefore, there is an immediate need for another revolution in the case of pulse production. Pigeonpea (*Cajanus cajan* L. Mill sp.) is an important legume crop, plays a vital role in the daily diet, and belongs to the family *Leguminosae*. It is also known as red gram, tur, and arhar. It is often cross-pollinated crop (20 to 70%). The food values of pigeonpea are 22.3% protein, 1.7% fat, 3.5% mineral, 1.5% fiber, and 57.5% carbohydrates in 100 g edible portions. Globally, pigeonpea is grown in an area of 63.57 lakh hectares with a production of 54.75 lakh tonnes and productivity of 861.25 kg/ha (FAO STAT, 2021). India ranks first in pigeonpea production globally with 43.4 lakh tonnes cultivated under 49.8 lakh hectares with a productivity of 871 kg/hectare in 2021-22 (agricoop.nic.in). In *Kharif* 2022, pigeonpea production was 38.9 lakh tonnes in an area of 46.2 lakh hectares (Agricoop.nic).
Nano fertilizers are important tools in agriculture to improve crop growth, yield and increase nutrient use efficiency and reducing the wastage of fertilizers as well as cost of cultivation. Nano-fertilizers are very effective for precise nutrient management in precision agriculture matching the crop growth stage for nutrients and may provide nutrients throughout the crop growth period. Nano-fertilizers provide more surface area for different metabolic reactions in the plant which increases the rate of photosynthesis and produces more dry matter and yield of the plants also incresase nutrient concentration and uptake of crops. To address these challenges, we should think of an alternate technology such as nanotechnology to precisely detect and deliver correct quantity of nutrients and other inputs required by crops in suitable proportion that promote productivity while ensuring environmental safety. Farmers are using urea and DAP fertilizers for soil as well as foliar application to crops. However, the efficacy is lower. In view of the above facts, the present investigation was carried out to study the "Nutrient uptake of Pigeonpea as influenced by foliar spray of Nano-DAP''.

2. Materials and Methods
A field experiment was conducted during *Kharif*, 2022 at Krishi Vigyan Kendra, Kalaburagi, on *Vertisol* having pH 8.23 and EC 0.21 dSm^{-1}. The experimental site was located at a 17º 34' N latitude and 76º 79' E longitude. of 478 meters above mean sea level in North Eastern Dry Zone of Karnataka (Zone 2).

The soil was low in organic carbon content (4.32 g kg^{-1}) and available P_2O_5 (26.2 kg ha^{-1}), and low in available N (203 kg ha^{-1}) with high available K_2O content 362 kg ha^{-1}).
The experiment was laid out in randomized complete block design (RCBD) with three replications. There were eight treatments consisting of different doses of RDF which include T_1: 100% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS, T_2: 100% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS, T_3: 75% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS, T_4: 75% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS, T_5: 50% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS, T_6: 50% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS, T_7: Recommended dose of fertilizer (25:50:0 N: P_2O_5: K_2O) and T_8: Absolute control.
Biometric observations were recorded from randomly tagged five plants, at 30 days interval. Harvesting was done at physiological maturity of the crop. The pods were harvested from the net plot area and stalks were sun dried in the field, further cleaned and yield parameters were recorded. The samples were collected during harvest and dried at 65 ^{0}C in a hot air oven, powdered using a grinder, fitted with stainless steel bladders and preserved in polythene bags for further analysis of uptake of N, P and K as suggested by Jackson (1973) [2]. Data analysis and interpretation was done using Fisher's method of analysis and variance technique as given by Gomez and Gomez (1984) [3].

3. Results and Discussion

3.1 Effect of nano fertilizers on nutrient content (Fig. 1 and 2): Significantly higher N, P and K concentration in seed recoerded in treatment recieving 100% RDF with Nano-DAP spray @ 4 ml l^{-1} at 45 and 60 DAS. (2.46%, 1.07% and 1.63% N, P and K, respectively) and in stalk (0.55%, 0.58% and 0.78% stalk N, P and K respectively). However it is on par with 100% RDF with Nano-DAP spray @ 2 ml l^{-1} at 45 and 60 DAS(2.40%, 0.98% and1.61% N, P and K respectively) and in stalk (0.52%, 0.52% and 0.76% stalk N, P and K respectively) (Table 1). The increase in nitrogen content due to Nano-DAP foliar application, which contains nitrogen and reduces nitrogen loss, with potential synergistic interactions between nitrogen and phosphorus further enhancing nitrogen concentration. Nanoparticles might have absorbed through pigeonpea leaf stomata and distributed throughout the plant. Nano-DAP mainly helps overcome limitation leaching, immobilization, low nutrient availability. Nano-DAP made directly nutrient available to plant as supply in nitrogen and phosphorus. Similar result were found by Sharma *et al.* (2022) [4]. The increase in phosphorus concentration due to application of Nano-DAP may be due to diameter of 25-50 nm helps to retain phosphorus as a result of increased total surface area and protect phosphorus from fixtation resulting in control release of nutrient, making phosphorus available for a longer time due to increased concentration of phosphorus. Similar result were found by Satyashraya *et al.* (2022) [5]. Potassium content increase due to synergistic interaction between N and P, increased in concentration of potassium in grains and stalk. Similar result were found by Merghanya *et al* (2019) [6].

3.2 Effect of Nutrient uptake (Fig. 3 and 4)

Significantly higher N, P and K uptake in seed was recorded in treatment receiving 100% RDF with Nano-DAP spray @ 4 ml l^{-1} at 45 and 60 DAS. (36.31, 15.83, 24.19 Kg/ha N, P and K respectively) and in stalk (25.41, 26.66, 34.84 Kg/ha stalk N, P and K respectively). However, it is on par with 100% RDF with Nano-DAP spray @ 2 ml l^{-1} at 45 and 60 DAS (32.33, 13.19 and 21.65 kg/ha N, P and K respectively) and in stalk (23.28, 23.25 and 34.01 Kg/ha stalk N, P and K respectively). The grain had higher nitrogen (N) content compared to the stalk after harvest, in line with findings by Sharma *et al*. (2022) [3] on pearl millet with nano-urea foliar application. The treatment with 100% recommended dose of nitrogen (RDN) recorded the highest N content in both grain and stalk, significantly outperforming the 50% and 75% RDN treatments, consistent with studies by Krishna (2014) [7], Sankalp (2013) [8], and Chandel *et al.* (2010) [9] Gupta *et al.* (2022) [10].
The higher P content in grain and stalk recorded under the treatment of 100% RDN which was significantly higher over 50% RDN and 75% RDN. Similarly, Tarafdar *et al.* (2015) [11] recorded the application of Nano-P also helps in improving the organic acid concentration in the rhizosphere and P uptake by the plants compared to other conventional sources of P fertilizers. Similar to N and P, K uptake increased as N and P levels increased, which may be explained by a larger loss of soil nutrients during the growth stages and increased dry matter formation in the presence of high N and P levels. Pande *et al.* (1985) [12], nutrient uptake was regulated by the application of nitrogen (N), which in turn was influenced by trends in dry matter production. Similarly, Kumar *et al.* (2007) [13], the greater dry matter yields at higher levels of N have led to noticeably larger uptakes of N, P, K. Burhan and Hassan (2019) [14] and Rashmi *et al.* (2022) [15]. Shankaralingappa *et al.* (2000) [16].

Table 1: Nutrients content in Pigeonpea as influenced by foliar spray of Nano-DAP

Treatment	N (%)		P (%)		K (%)	
	Seed	Stalk	Seed	Stalk	Seed	Stalk
T_1: 100% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	2.40	0.52	0.98	0.52	1.61	0.76
T_2: 100% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	2.46	0.55	1.07	0.58	1.63	0.78
T_3: 75% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	2.30	0.47	0.79	0.41	1.54	0.73
T_4: 75% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	2.34	0.49	0.84	0.45	1.55	0.74
T_5: 50% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	2.22	0.40	0.65	0.33	1.45	0.64
T_6: 50% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	2.24	0.43	0.71	0.36	1.46	0.67
T_7: Recommended dose of fertilizer (25:50:0 N: P_2O_5: K_2O Kg/ha)	2.27	0.46	0.81	0.42	1.52	0.72
T_8: Absolute control	2.07	0.30	0.32	0.21	1.31	0.51
S.Em±	0.02	0.01	0.031	0.021	0.01	0.009
CD@5%	0.08	0.03	0.094	0.064	0.05	0.02

Note: FYM @ 5 tonnes ha^{-1} & Zinc Sulphate @15kg ha^{-1} for all the treatments except T_8
DAS: Days after sowing

Table 2: Nutrients uptake by Pigeonpea after harvest of crop as influenced by foliar spray of Nano-DAP

Treatment	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})	
	seed	stalk	seed	stalk	seed	stalk
T_1: 100% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	32.33	23.28	13.19	23.25	21.65	34.01
T_2: 100% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	36.31	25.41	15.83	26.66	24.19	34.84
T_3: 75% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	27.48	18.71	9.43	16.36	18.38	32.47
T_4: 75% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	29.19	20.50	10.51	18.77	19.47	33.06
T_5: 50% RDF + 2 ml Nano-DAP foliar application @ 45 and 60 DAS	21.27	12.84	6.23	10.58	13.90	28.65
T_6: 50% RDF + 4 ml Nano-DAP foliar application @ 45 and 60 DAS	22.89	14.52	7.25	12.12	15.01	29.95
T_7: Recommended dose of fertilizer (25:50:0 N: P_2O_5: K_2O Kg/ha)	25.80	17.51	9.22	16.04	17.32	32.13
T_8: Absolute control	15.45	7.52	2.39	5.23	9.85	22.83
S.Em±	1.34	1.01	1.22	1.77	1.30	0.47
CD@5%	4.09	3.08	3.72	5.37	3.96	1.44

Note: FYM @ 5 tonnes ha^{-1} & Zinc Sulphate @15kg ha^{-1} for all the treatments except T_8
DAS: Days after sowing

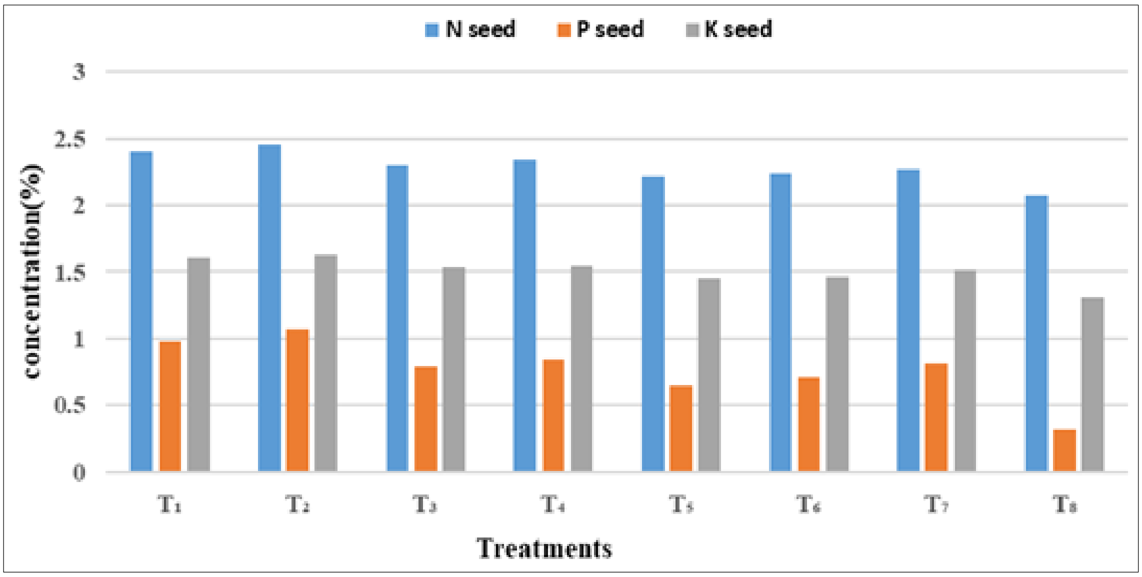

Fig 1: Nutrients content in Pigeonpea seed as influenced by foliar application of Nano-DAP

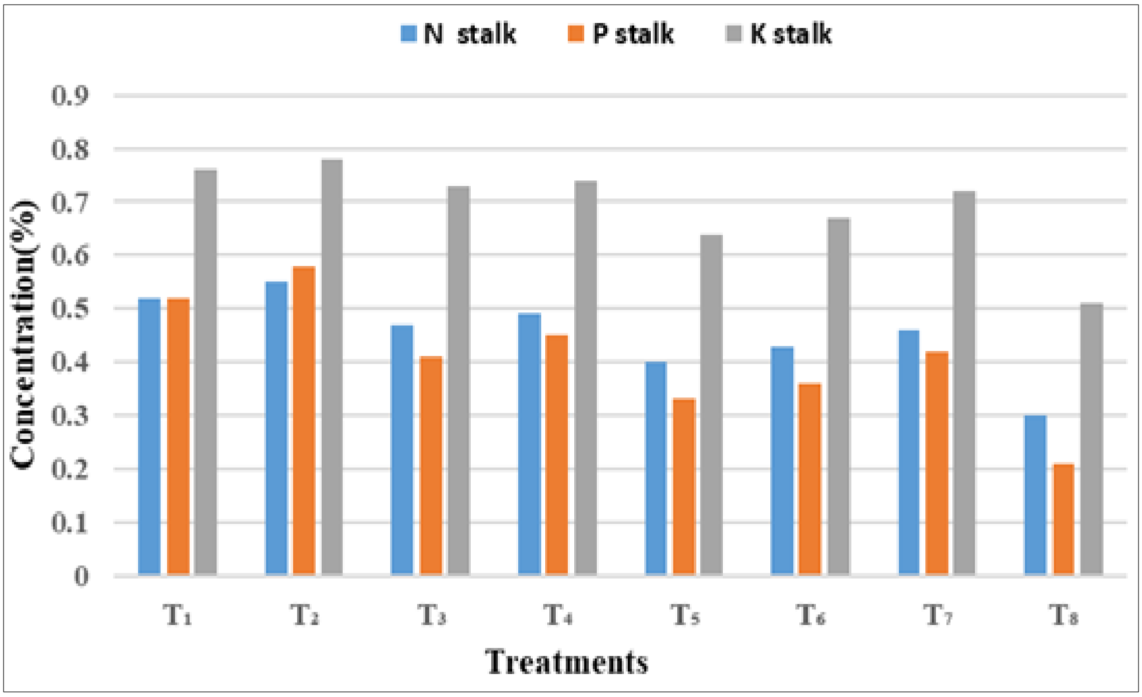

Fig 2: Nutrients content in Pigeonpea stalk as influenced by foliar application of Nano-DAP

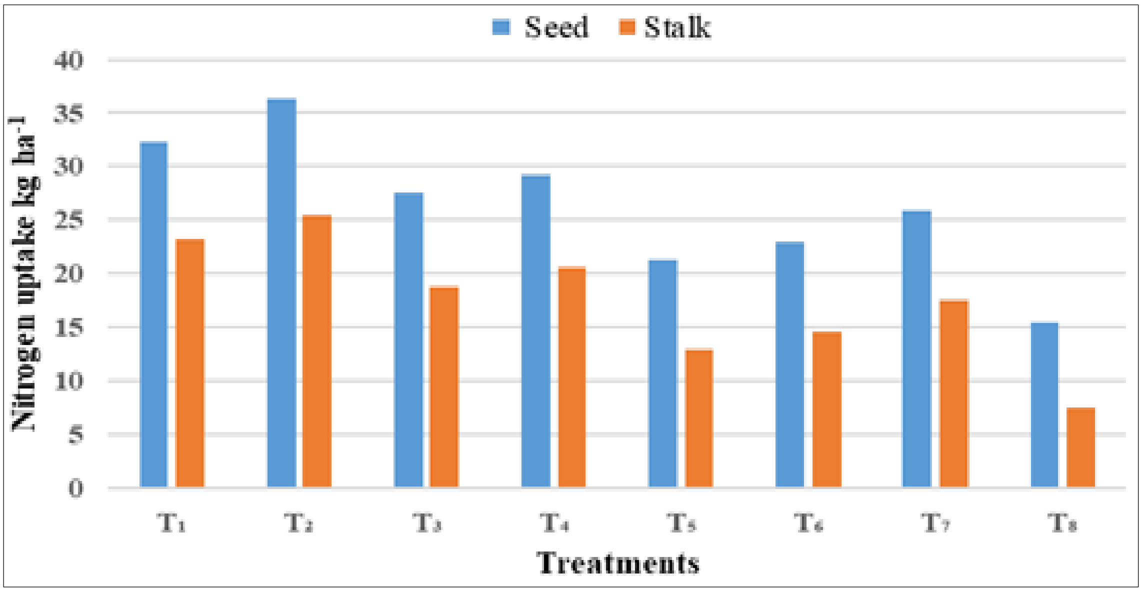

Fig 4: Phosphorus uptake by Pigeonpea after harvest as influenced by foliar spray of Nano-DAP

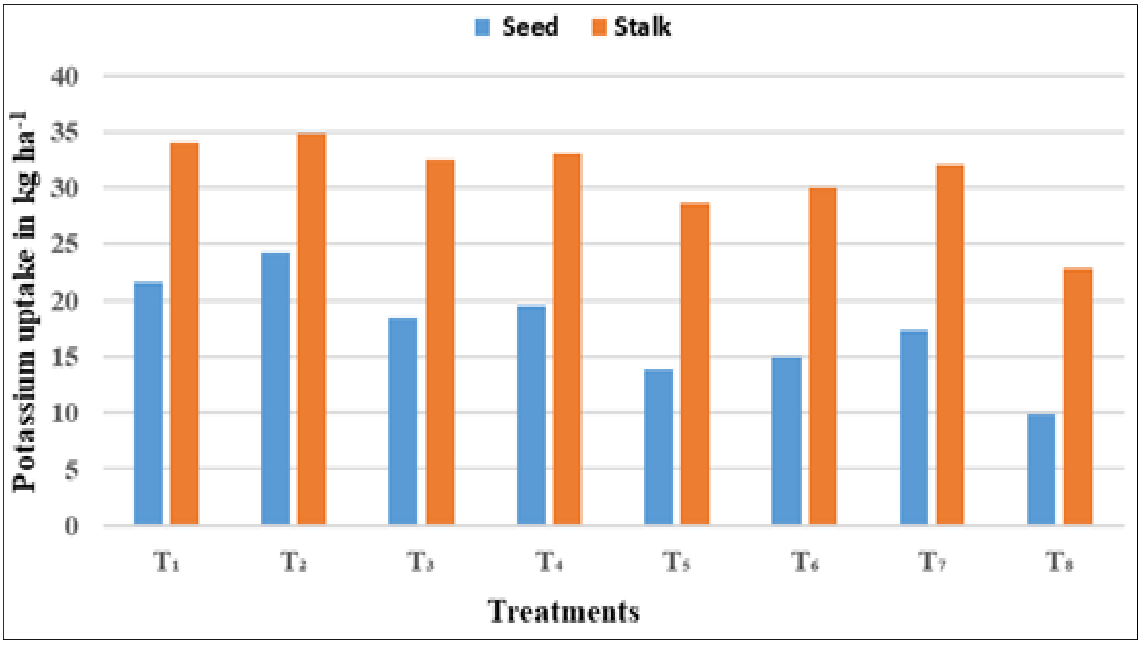

Fig 5: Potassium uptake by Pigeonpea after harvest as influenced by foliar spray of Nano-DAP

4. Conclusion

Combined application of conventional and nano fertilizers i.e., 100% RDF as basal + Nano-DAP spray @ 4 ml l^{-1} each at 45 and 60 DAS helped to increase nutrient content and nutrient uptake of pigeonpea plants. as compared to other treatment. However, it was par with 100% RDF with Nano-DAP spray @ 2 ml l^{-1} at 45 and 60 DAS. This information can be valuable for optimizing fertilizer application practices in pigeonpea cultivation, providing a cost-effective and sustainable approach to ensure the crop's nutrient requirements are met without excessive fertilizer use.

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