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EFFECT OF DIFFERENT FORMS OF FERTILIZATION ON NUTRIENT UPTAKE AND PRODUCTIVITY OF CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

A field experiment was conducted during the *rabi* season of 2025–26 at the AICRP on Integrated Farming System, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, to evaluate the effect of different forms of fertilization on nutrient uptake and productivity of chickpea (*Cicer arietinum* L.). The experiment was laid out in a randomized block design with ten treatments and three replications using chickpea variety BDNGK-798. The treatments comprised different combinations of recommended and reduced doses of conventional fertilizers along with foliar application of potassium nitrate, monoammonium phosphate, nano urea, nano DAP, micronutrients and biofertilizers. Among the treatments, application of 75% recommended dose of nitrogen and phosphorus with 100% recommended dose of potassium along with one foliar spray of nano DAP @ 30 DAS (T_8) recorded superior performance for productivity and nutrient uptake. T_8 recorded the highest grain yield (1750.36 kg ha^{-1}) and straw yield (2800.00 kg ha^{-1}), while the corresponding values under the absolute control were 1385.91 and 2080.62 kg ha^{-1}, respectively. Nutrient uptake was also enhanced under T_8, with the highest nitrogen uptake by grain and straw (63.01 and 42.56 kg ha^{-1}, respectively) and phosphorus uptake by grain and straw (8.93 and 7.00 kg ha^{-1}, respectively). Similarly, sulphur uptake was highest under T_8, recording 4.03 kg ha^{-1} in grain and 4.48 kg ha^{-1} in straw. The higher nutrient uptake under T_8 was associated with improved nutrient concentration and greater grain and straw production. Treatments T_7 and T_{10} were generally statistically comparable with T_8 for several nutrient uptake and productivity parameters. The results indicated that integration of reduced basal N and P with full K and a foliar spray of nano DAP at 30 DAS improved nutrient acquisition and productivity of chickpea under the experimental conditions.

***Key words*:** Chickpea, fertilizer forms, nano DAP, nutrient uptake, productivity

Introduction

Chickpea (*Cicer arietinum* L.) is one of the most important pulse crops cultivated in India and plays a significant role in ensuring nutritional security, soil fertility and sustainable agricultural production. Being a major source of dietary protein, carbohydrates, minerals and other essential nutrients, chickpea has considerable importance in the Indian diet as well as in the agricultural economy (Jukanti *et al*., 2012). In addition to its nutritional importance, chickpea contributes to soil fertility through biological nitrogen fixation and therefore forms an important component of sustainable cropping systems. (Giri and Joshi, 2010).Productivity of chickpea is influenced by several factors, among which the availability and efficient utilization of plant nutrients are particularly important. Adequate and balanced fertilization is essential for optimum crop growth, development of yield attributes and production of quality seed. However, conventional

fertilizer application alone may not always ensure efficient nutrient acquisition by plants because nutrient availability and uptake are influenced by soil properties, crop demand and the method and timing of fertilizer application. Therefore, improving the efficiency of applied nutrients has become an important approach for increasing crop productivity while reducing unnecessary fertilizer inputs. Different forms and methods of fertilizer application provide opportunities for improving nutrient availability and uptake by crops. Foliar application can supplement nutrients directly through plant foliage during critical crop growth stages and may help overcome temporary limitations in nutrient availability through the soil. In recent years, nano-fertilizers have received considerable attention because of their potential to supply nutrients in small quantities with improved nutrient-use efficiency. (Raliya *et al.*, 2018; Kopittke *et al.*, 2019). Nano urea and nano DAP have been explored as alternatives or supplements to conventional fertilizers, particularly through foliar application (Fathima *et al.*, 2021; Toksha *et al.*, 2021). Similarly, the use of foliar potassium nitrate, monoammonium phosphate, micronutrients and biofertilizers offers alternative approaches for improving nutrient acquisition and crop performance.Nutrient uptake is an important indicator of the effectiveness of fertilizer management because it represents the quantity of nutrients absorbed and utilized by the crop. Improved nutrient uptake, together with greater biomass production, can contribute to enhanced grain and straw yield. Hence, evaluating different fertilizer forms and their combinations is necessary to identify suitable nutrient-management strategies for improving productivity and nutrient acquisition in chickpea.Keeping these considerations in view, the present investigation was undertaken to evaluate the effect of different forms of fertilization on nutrient uptake and productivity of chickpea (*Cicer arietinum* L.) under field conditions. The study specifically aimed to assess the performance of different combinations of conventional fertilizers, foliar-applied fertilizers, nano-fertilizers, micronutrients and biofertilizers in relation to nutrient uptake and grain and straw productivity of chickpea.

Materials and Methods

Experimental site and soil characteristics

A field experiment was conducted during the *rabi* season of 2025–2026 at the All India Coordinated Research Project (AICRP) on Integrated Farming System, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani, Maharashtra, India. The experiment was conducted to evaluate the effect of different forms of fertilization on nutrient uptake and productivity of chickpea (*Cicer arietinum* L.). The experimental soil was slightly alkaline in reaction, with normal soluble salt concentration and calcareous nature. The soil was low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium, while available sulphur was in the medium range. Among the micronutrients, the soil had moderate zinc availability, slightly deficient iron availability, and adequate copper and manganese status.

Experimental design and treatments

The experiment was laid out in a randomized block design (RBD) with three replications. Ten fertilizer treatments were evaluated using chickpea variety BDNGK-798. The treatments consisted of different combinations of recommended and reduced doses of conventional fertilizers, foliar-applied fertilizers, nano-fertilizers, micronutrients and biofertilizers.

Crop and fertilizer management

Chickpea variety BDNGK-798 was used for the experiment. The crop was raised during the rabi season of 2025–2026 under field conditions following the recommended agronomic practices. The fertilizer treatments were imposed according to the respective treatment schedules. Conventional fertilizers were applied through soil application, while the respective foliar fertilizers were applied at the specified crop growth stages.

Foliar applications of potassium nitrate, monoammonium phosphate (MAP), nano urea and nano DAP were carried out at 30, 45 and/or 60 days after sowing (DAS), depending on the treatment. In T_9, foliar application of micronutrients comprising zinc and iron was carried out at 30 DAS. In T_{10}, Rhizobium and phosphate-solubilizing bacteria (PSB) were used as biofertilizers along with the recommended fertilizer dose. The crop was harvested at physiological maturity and grain and straw yields were recorded separately for each treatment. The recorded yields were expressed as kg ha^{-1}.

Nutrient uptake estimation

At harvest, representative plant samples from each treatment were collected and separated into grain and straw. The samples were processed and analysed for nutrient concentration following the analytical procedures adopted in the experiment. Nitrogen, phosphorus, potassium and sulphur concentrations in grain and straw were determined and expressed on a percentage basis, while micronutrient concentrations were expressed as mg kg^{-1}.Nutrient uptake by grain and straw was calculated from the respective nutrient concentration and dry matter yield of the corresponding plant component and expressed as kg ha^{-1}. The total nutrient uptake was obtained by summing the nutrient uptake by grain and straw.

Yield and productivity measurements

At maturity, the crop from each experimental plot was harvested separately and processed according to the treatment-wise plot layout. Grain yield was recorded after threshing and cleaning, while straw yield was recorded after separation of the grain. The yield of grain and straw was expressed in kg ha^{-1}.Productivity of chickpea was assessed based on grain and straw yield obtained under the different fertilizer treatments. The treatment effects were compared to determine the influence of different forms of fertilization on crop productivity.

Statistical analysis

The experimental data obtained for different growth, yield and nutrient uptake parameters were subjected to statistical analysis appropriate for a randomized block design (RBD). The analysis of variance was carried out to determine the significance of differences among the treatment means. The standard error of difference (SE±) and critical difference (CD) at the 5% level of significance were used for comparison of treatment means. The coefficient of variation (CV) was calculated to assess the experimental variability.

Results and Discussion

Effect of different forms of fertilization on grain and straw yield of chickpea

The grain and straw yield of chickpea were significantly influenced by different forms of fertilization. The grain yield ranged from 1385.91 to 1750.36 kg ha^{-1}, while straw yield ranged from 2080.62 to 2800.00 kg ha^{-1}. Treatment T_8, comprising 75% recommended dose of N and P + 100% recommended dose of K along with one foliar spray of nano DAP at 30 DAS, recorded the highest grain yield of 1750.36 kg ha^{-1}. It was followed by T_7 (1720.54 kg ha^{-1}) and T_{10} (1670.42 kg ha^{-1}). The absolute control (T_1) recorded the lowest grain yield of 1385.91 kg ha^{-1}.Similarly, the highest straw yield of 2800.00 kg ha^{-1} was recorded under T8, which was statistically at par with T_7 and T_{10}. The lowest straw yield (2080.62 kg ha^{-1}) was recorded under the absolute control. The superior productivity under T_8 may be attributed to the combined effect of adequate basal N and P, full K supply and foliar application of nano DAP. The additional foliar supply of nutrients during crop growth may have supported nutrient acquisition, photosynthetic activity and assimilate translocation towards reproductive organs, resulting in improved pod development, seed filling and overall biomass production. The greater productivity under T_8 was also associated with improved growth and yield attributes; for example, T_8 recorded the highest number of branches at 60 DAS (8.59 $plant^{-1}$) and the highest number of pods at 80 DAS (78.80 $plant^{-1}$). The present findings indicate that partial substitution/reduction of conventional N and P through integration with foliar nano DAP, while maintaining full K application, improved chickpea productivity under the experimental conditions. Similar improvements in chickpea yield with nano DAP application were reported by Khemshetty *et al*., 2024; Drostkar *et al*., 2016.

Table 1: Details of fertilizer treatments imposed on chickpea.

Treatment No.	Treatments detail
T_1	Control without fertilizers
T_2	RDF 25:50:25 (N: P_2O_5: K_2O kg ha^{-1})
T_3	100% RDP + Three Foliar sprays of Potassium nitrate. 30,45,60 DAS.
T_4	50% RDNP+100% RDK+One foliar spray of Monoammonium phosphate at 30 DAS.
T_5	50% RDN + 100 % RDPK + Two foliar spray of Nano Urea at 30 and 45 DAS.
T_6	75%RDN + 100%RDPK + One foliar spray of Nano urea at 30 DAS.
T_7	50% RDNP + 100%RDK+ 2 foliar spray of of Nano DAP at 30 and 45 DAS.
T_8	75%RDNP +100%RDK + One foliar spray of Nano DAP at 30 DAS.
T_9	100%RDF + One foliar spray of micro nutrients (Zn,Fe) at 30 DAS.
T_{10}	100%RDF + Biofertilizers (Rhizobium) + PSB as seed treatment.

DAS: Days after sowing; RDF: Recommended dose of fertilizer; RDP: Recommended dose of phosphorus; MAP: Monoammonium phosphate; PSB: Phosphate-solubilizing bacteria.

Effect of different forms of fertilization on nitrogen uptake

Nitrogen uptake by grain and straw of chickpea was significantly influenced by different forms of fertilization. The highest nitrogen uptake was recorded under T_8 (75% RDNP + 100% RDK + one foliar spray of nano DAP @ 30 DAS). T_8 recorded 63.01 kg N ha^{-1} in grain and 42.56 kg N ha^{-1} in straw, giving a total nitrogen uptake of 105.57 kg ha^{-1}.The nitrogen uptake under T_8 was statistically at par with the superior treatments, particularly T_7 and T_6, while the absolute control (T_1) recorded the lowest uptake, with 45.46 kg ha^{-1} in grain, 28.71 kg ha^{-1} in straw and 74.17 kg ha^{-1} total uptake. The greater nitrogen uptake under T_8 may be attributed to the combined effect of improved nitrogen concentration and higher grain and straw production. The treatment provided adequate basal nutrition along with foliar nano DAP, which may have supported nutrient acquisition and translocation during crop growth. The thesis also associates the improved nitrogen accumulation with enhanced nutrient-use efficiency and

Table 2: Effect of different forms of fertilization on grain and straw yield of chickpea.

Tr. No.	Treatment details	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	Control without fertilizers (Absolute control)	1385.91	2080.62
T_2	RDF 25:50:25 (N: P_2O_5: K_2O kg ha^{-1})	1485.67	2228.50
T_3	100% RDP + Three Foliar sprays of Potassium nitrate. 30, 45, 60 DAS.	1434.79	2281.32
T_4	50% RDNP + 100% RDK + One foliar spray of Monoammonium phosphate @ 30 DAS.	1500.62	2355.97
T_5	50% RDN + 100 % RDPK + Two foliar spray of Nano Urea at 30, 45 DAS.	1600.56	2512.88
T_6	75%RDN + 100%RDPK + One foliar spray of Nano urea@ 30 DAS.	1660.28	2621.24
T_7	50% RDNP + 100%RDK+ 2 foliar spray of Nano DAP @ 30& 45 DAS.	1720.54	2770.07
T_8	75%RDNP +100%RDK + One foliar spray of Nano DAP @ 30 DAS.	1750.36	2800.00
T_9	100%RDF + One foliar spray of micro nutrients (Zn,Fe) @ 30 DAS.	1634.50	2451.21
T_{10}	100%RDF + Biofertilizers (Rhizobium) + PSB.	1670.42	2649.98

favourable physiological responses under nano-fertilizer application. The nitrogen concentration itself was also highest under T_8, with 3.60% in grain and 1.52% in straw, and was statistically at par with T_7 and T_{10}. Thus, the results demonstrate that integrating reduced N and P fertilization with full K application and foliar nano DAP improved nitrogen acquisition and accumulation in chickpea, ultimately contributing to higher productivity. Similar findings on improved nitrogen uptake under nano-fertilizer application were reported by Raliya *et al*., (2018), Chinnappa *et al*., (2023) and Akansha Singh *et al*., (2021).

Effect of different forms of fertilization on phosphorus uptake

Different forms of fertilization significantly influenced phosphorus concentration and uptake in both grain and straw of chickpea. Phosphorus concentration in grain ranged from 0.39 to 0.51%, while that in straw ranged from 0.18 to 0.25%. The highest phosphorus concentration in both grain (0.51%) and straw (0.25%) was recorded under T_8 (75% RDNP + 100% RDK + one foliar spray of nano DAP @ 30 DAS), which was statistically at par with T_7 and T_{10}. The lowest phosphorus concentration was recorded under the absolute control (T_1). Phosphorus uptake by grain ranged from 5.41 to 8.93 kg ha^{-1}. The maximum grain phosphorus uptake (8.93 kg ha^{-1}) was recorded under T_8 and was at par with T_7 and T_{10}, whereas the minimum (5.41 kg ha^{-1}) was recorded under T_1. Similarly, phosphorus uptake by straw was highest under T_8 (7.00 kg ha^{-1}), followed by T_7 and T_{10}, while the absolute control recorded the lowest uptake (3.74 kg ha^{-1}). The higher phosphorus uptake under T_8 may be attributed to the combined effect of balanced basal fertilization and foliar application of nano DAP. Improved phosphorus nutrition may have promoted root development and nutrient acquisition, while foliar application provided an additional source of phosphorus during crop growth. The greater grain and straw production under T_8 also contributed to the higher total nutrient uptake. The findings are in agreement with Pandao *et al*., (2024), Dhansil *et al*., (2018) and Lynch and Brown (2008).

Table 3: Effect of different forms of fertilization on phosphorus concentration and uptake in chickpea.

Tr No.	Treatment details	Phosphorus				
		Content (%)		Uptake(kg/ha)		
		Grain	Straw	Grain	Straw	Total
T_1	Control without fertilizers (Absolute control)	0.39	0.18	5.41	3.74	9.15
T_2	RDF 25:50:25 (N: P_2O_5: K_2O kg ha^{-1})	0.46	0.22	6.83	4.90	11.73
T_3	100% RDP + Three Foliar sprays of Potassium nitrate. 30, 45, 60 DAS.	0.47	0.22	6.74	5.01	11.75
T_4	50% RDNP + 100% RDK + One foliar spray of Monoammonium phosphate @ 30 DAS.	0.45	0.21	6.75	4.95	11.7
T_5	50% RDN + 100 % RDPK + Two foliar spray of Nano Urea at 30, 45 DAS.	0.42	0.19	6.72	4.77	11.49
T_6	75%RDN + 100%RDPK + One foliar spray of Nano urea@ 30 DAS.	0.43	0.20	7.14	5.24	12.38
T_7	50% RDNP + 100%RDK+ 2 foliar spray of Nano DAP @ 30& 45 DAS.	0.49	0.23	8.43	6.65	15.08
T_8	75%RDNP +100%RDK + One foliar spray of Nano DAP @ 30 DAS.	0.51	0.25	8.93	7.00	15.93
T_9	100%RDF + One foliar spray of micro nutrients (Zn,Fe) @ 30 DAS.	0.46	0.22	7.52	5.39	12.91
T_{10}	100%RDF + Biofertilizers (Rhizobium) + PSB.	0.50	0.24	8.35	6.35	14.70

Table 4: Potassium concentration and uptake in grain and straw of chickpea.

Tr No.	Treatment details	Potassium				
		Content (%)		Uptake(g/ha)		
		Grain	Straw	Grain	Straw	Total
T_1	Control without fertilizers (Absolute control)	0.52	1.28	7.21	26.63	33.84
T_2	RDF 25:50:25 (N: P_2O_5: K_2O kg ha^{-1})	0.62	1.50	9.21	33.42	42.63
T_3	100% RDP + Three Foliar sprays of Potassium nitrate. 30, 45, 60 DAS.	0.64	1.56	9.18	35.82	44.99
T_4	50% RDNP + 100% RDK + One foliar spray of Monoammonium phosphate @ 30 DAS.	0.63	1.54	9.60	36.28	45.88
T_5	50% RDN + 100 % RDPK + Two foliar spray of Nano Urea at 30, 45 DAS.	0.64	1.57	10.24	39.45	49.69
T_6	75%RDN + 100%RDPK + One foliar spray of Nano urea@ 30 DAS.	0.65	1.60	10.79	41.94	52.73
T_7	50% RDNP + 100%RDK+ 2 foliar spray of Nano DAP @ 30& 45 DAS.	0.66	1.62	11.35	44.87	56.22
T_8	75%RDNP +100%RDK + One foliar spray of Nano DAP @ 30 DAS.	0.69	1.68	12.07	47.04	59.11
T_9	100%RDF + One foliar spray of micro nutrients (Zn,Fe) @ 30 DAS.	0.63	1.55	10.29	37.99	48.28
T_{10}	100%RDF + Biofertilizers (Rhizobium) + PSB.	0.65	1.60	10.85	42.39	53.25

Potassium concentration and uptake

Different forms of fertilization significantly influenced potassium concentration and uptake by chickpea grain and straw. The potassium concentration in grain ranged from 0.52 to 0.69%, while that in straw ranged from 1.28 to 1.68%. Treatment T_8 (75% RDNP + 100% RDK + one foliar spray of nano DAP @ 30 DAS) recorded the highest potassium concentration in both grain (0.69%) and straw (1.68%). The grain potassium concentration under T_8 was statistically at par with T_7, T_6, T_5, T_3 and T_{10}, whereas the lowest concentration was recorded under the absolute control (T_1). Potassium uptake by both grain and straw was also significantly affected by the fertilizer treatments. The highest potassium uptake by grain (12.07 kg ha^{-1}) was recorded under T_8, which was statistically at par with T_7, T_{10} and T_6. The corresponding potassium uptake by straw under T_8 was 47.04 kg ha^{-1}, resulting in the highest total potassium uptake of 59.11 kg ha^{-1}. In comparison, the absolute control recorded only 7.21 kg ha^{-1} potassium uptake in grain, 26.63 kg ha^{-1} in straw and 33.84 kg ha^{-1} in total. The higher potassium concentration and uptake under T_8 may be attributed to the combined application of 75% recommended N and P, 100% recommended K and foliar nano DAP. The improved nutrient supply may have supported physiological processes and nutrient acquisition, while the higher biomass and grain production under T_8 also contributed to greater potassium uptake. Similar observations regarding improved nutrient-use efficiency and nutrient accumulation with nano-fertilizers have been reported by Raliya *et al*., (2018), Tarafdar *et al*., (2020), Dey *et al*., (2017).

Sulphur concentration and uptake

Different forms of fertilization significantly influenced sulphur concentration and uptake in chickpea grain and straw. The highest sulphur concentration was recorded under T8 (75% RDNP + 100% RDK + one foliar spray of nano DAP @ 30 DAS), with 0.23% in grain and 0.16% in straw. These values were statistically at par with T_7 and T_{10}, whereas the lowest sulphur concentration was recorded under the absolute control (T_1), with 0.14% in grain and 0.08% in straw. Sulphur uptake by grain, straw

Table 5: Sulphur concentration and uptake in grain and straw of chickpea.

Tr No.	Treatment details	Sulphur				
		Content (%)		Uptake(g/ha)		
		Grain	Straw	Grain	Straw	Total
T_1	Control without fertilizers (Absolute control)	0.14	0.08	1.94	1.66	3.6
T_2	RDF 25:50:25 (N: P_2O_5: K_2O kg ha^{-1})	0.16	0.10	2.37	2.22	4.59
T_3	100% RDP + Three Foliar sprays of Potassium nitrate. 30, 45, 60 DAS.	0.17	0.11	2.44	2.51	4.95
T_4	50% RDNP + 100% RDK + One foliar spray of Monoammonium phosphate @ 30 DAS.	0.18	0.12	2.70	2.83	5.53
T_5	50% RDN + 100 % RDPK + Two foliar spray of Nano Urea at 30, 45 DAS.	0.19	0.13	3.04	3.26	6.31
T_6	75%RDN + 100%RDPK + One foliar spray of Nano urea@ 30 DAS.	0.20	0.14	3.32	3.67	6.99
T_7	50% RDNP + 100%RDK+ 2 foliar spray of Nano DAP @ 30& 45 DAS.	0.22	0.15	3.78	4.15	7.93
T_8	75%RDNP +100%RDK + One foliar spray of Nano DAP @ 30 DAS.	0.23	0.16	4.03	4.48	8.51
T_9	100%RDF + One foliar spray of micro nutrients (Zn,Fe) @ 30 DAS.	0.18	0.12	2.94	2.94	5.88
T_{10}	100%RDF + Biofertilizers (Rhizobium) + PSB.	0.22	0.15	3.67	3.97	7.64

and total plant uptake was also significantly influenced by the fertilizer treatments. Treatment T_8 recorded the highest sulphur uptake of 4.03 kg ha^{-1} in grain and 4.48 kg ha^{-1} in straw, and was statistically at par with T_7 and T_{10}. In comparison, the absolute control recorded 1.94 kg ha^{-1} in grain and 1.66 kg ha^{-1} in straw. The higher sulphur uptake under T_8 may be attributed mainly to its higher sulphur concentration together with greater grain and straw production. The improved sulphur accumulation under T_8 may also be associated with the balanced supply of major nutrients and improved nutrient acquisition under the treatment. Since nano DAP does not directly supply sulphur, its possible contribution should be interpreted indirectly through improved crop growth and nutrient-use efficiency rather than as a direct source of sulphur. The findings are consistent with the observations reported by Toksha *et al*., (2021), Tarafdar *et al*., (2020), Fathima *et al*., (2021) and Jyothi and Hebsur (2017).

Conclusion

The present study demonstrated that different forms and methods of fertilization significantly influenced nutrient concentration, nutrient uptake and productivity of chickpea. Among the treatments, T_8 (75% recommended dose of N and P + 100% recommended dose of K + one foliar spray of nano DAP @ 30 DAS) recorded superior performance, with the highest grain yield (1750.36 kg ha^{-1}) and straw yield (2800.00 kg ha^{-1}). The treatment also recorded the highest uptake of nitrogen, phosphorus, potassium and sulphur, indicating improved nutrient acquisition and utilization by the crop.

Treatments T_7 and T_{10} were statistically comparable with T_8 for several important parameters. Overall, the results indicate that integration of reduced N and P application with full K supply and foliar nano DAP can be an effective nutrient-management approach for improving chickpea productivity and nutrient uptake under the experimental conditions.

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