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# Influence of potassium fulvate with iron and zinc foliar nutrition on nutrient uptake in chickpea

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**Abstract**
A field experiment was conducted during the Rabi season of 2024-25 at the Instructional Farm, College of Agriculture, Karad, to evaluate the effect of foliar application of potassium fulvate, iron, and zinc on total nutrient uptake in chickpea (*Cicer arietinum* L.). The experiment was laid out in a Randomized Block Design with nine treatments replicated thrice, consisting of foliar sprays of potassium fulvate at 200, 400, and 600 ppm applied singly or in combination with $FeSO_4$ and $ZnSO_4$ (0.5% each), along with the general recommended dose of fertilizers (GRDF). Results revealed that foliar application significantly enhanced total uptake of both macronutrients and micronutrients. The treatment with 400 ppm potassium fulvate + $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5%) recorded the highest total uptake of N (93.41 kg $ha^{-1}$), P (15.21 kg $ha^{-1}$), K (20.15 kg $ha^{-1}$), Fe (73.79 g $ha^{-1}$), Mn (63.42 g $ha^{-1}$), Zn (129.02 g $ha^{-1}$), and Cu (42.50 g $ha^{-1}$), compared to the control. The findings demonstrate that foliar sprays of potassium fulvate with Fe and Zn improve nutrient assimilation, mobility, and utilization efficiency in chickpea.

**Keywords:** Chickpea, potassium fulvate, foliar spray, nutrient uptake, Fe, Zn

## Introduction
Nutrient uptake efficiency is one of the most critical factors influencing productivity and nutritional value of pulses. Chickpea (*Cicer arietinum* L.), a major rabi pulse crop in India, is valued for its high protein content and contribution to soil fertility through biological nitrogen fixation. However, its productivity is constrained by poor nutrient use efficiency and widespread deficiencies of micronutrients such as iron and zinc in Indian soils (Ahmad *et al*., 2019) [1]. These deficiencies adversely affect nodulation, chlorophyll synthesis, enzymatic activity, and nutrient enrichment of grains, ultimately leading to reduced crop performance and lower nutritional quality (Rehman *et al*., 2022) [7]. Foliar application of nutrients is an efficient method for meeting plant nutrient requirements during critical growth stages. Unlike soil application, it ensures rapid absorption and effective translocation of nutrients into metabolic pathways. In pulses, Fe and Zn foliar sprays have been shown to improve nutrient assimilation, enhance nitrogen fixation, and enrich micronutrient concentration in grains (Rane *et al*., 2019; Kaur *et al*., 2020) [6, 3]. Humic substances, particularly fulvic acid and its potassium salts, have recently gained importance as biostimulants for enhancing nutrient uptake. Potassium fulvate is a low molecular weight, water-soluble fraction of humic substances that chelates nutrients, improves their solubility, and facilitates absorption and transport across plant membranes (Mora *et al*., 2019) [5]. Its combined application with Fe and Zn can synergistically improve nutrient uptake efficiency in legumes, but such studies in chickpea remain limited.

## Materials and Methods
The experiment was conducted during Rabi 2024-25 at the Instructional Farm, College of Agriculture, Karad (17°16′ N latitude, 74°12′ E longitude, altitude 576 m above mean sea level). The soil was an Inceptisol, clay loam in texture, slightly alkaline (pH 7.78), non-saline (EC 0.28 dS $m^{-1}$), low in available N (183.72 kg $ha^{-1}$), medium in P (13.60 kg $ha^{-1}$), and high in K (525.14 kg $ha^{-1}$), with 0.58% organic carbon. DTPA-extractable Fe and Zn (1.12 mg $kg^{-1}$) was near the critical limit, while other micronutrients were adequate.

The experiment was laid out in a Randomized Block Design (RBD) with nine treatments replicated thrice. Treatments consisted of foliar sprays of potassium fulvate at 200, 400, and 600 ppm, applied either alone or with $FeSO_4$ and $ZnSO_4$ (0.5% each), along with the general recommended dose of fertilizers (25:50:25 kg N:$P_2O_5$:$K_2O$ ha$^{-1}$). Chickpea variety (Phule digvijay) was sown at 30 × 10 cm spacing using a seed rate of 80 kg ha$^{-1}$. Seeds were treated with Rhizobium and Trichoderma cultures before sowing. Two foliar sprays were applied at 35 DAS (flower initiation) and 55 DAS (pod initiation). At harvest, grain and straw samples were collected, oven-dried, ground, and analyzed for nutrient content. Nitrogen was determined by the Kjeldahl method, phosphorus by the vanadomolybdate yellow color method, and potassium by flame photometry. Micronutrients (Fe, Zn, Mn, Cu) were estimated using atomic absorption spectrophotometry after di-acid digestion. Total nutrient uptake was calculated by multiplying concentration with grain and straw yield and depicated in table 1

## Results and Discussion

### Total Macronutrient Uptake (N, P, K)

The data presented in Table 1 showed that total macronutrient uptake by chickpea was significantly improved with foliar application of potassium fulvate, iron, and zinc. The highest total nitrogen uptake (93.41 kg ha$^{-1}$) was recorded in $T_8$ (400 ppm potassium fulvate + $FeSO_4$ 0.5% + $ZnSO_4$ 0.5%), followed by $T_9$ (92.70 kg ha$^{-1}$), while the lowest was observed in control (50.51 kg ha$^{-1}$). The increase in nitrogen uptake may be attributed to the improved chelation and transport of nutrients by fulvate and the catalytic role of Fe and Zn in nitrogen metabolism (Kaur *et al*., 2020; Mora *et al*., 2019) [3, 5]. Similar increases in nitrogen uptake due to Fe and Zn sprays have been reported in chickpea and lentil (Rane *et al*., 2019; Rehman *et al*., 2022) [6, 7].

Total phosphorus uptake also varied significantly among treatments. The maximum uptake was recorded in $T_9$ (15.34 kg ha$^{-1}$), followed closely by $T_8$ (15.21 kg ha$^{-1}$), whereas control recorded only 9.32 kg ha$^{-1}$. The enhancement may be due to fulvate improving phosphorus solubility and root permeability, while Zn facilitates the enzymatic activity associated with phosphorus metabolism (Ahmad *et al*., 2019) [1].

Potassium uptake showed a similar trend. The highest total potassium uptake (20.15 kg ha$^{-1}$) was observed in $T_8$, compared to only 12.01 kg ha$^{-1}$ in control. Fulvic substances are known to enhance ion transport and membrane permeability, which likely improved K absorption and translocation (Mora *et al*., 2019) [5]. These findings corroborate earlier studies in legumes where humic substances enhanced K uptake efficiency (Kolape *et al*., 2023) [4].

### Total Micronutrient Uptake (Fe, Zn, Mn, Cu)

The effect of treatments on total micronutrient uptake is presented in Table 2. The maximum Fe uptake (73.79 g ha$^{-1}$) was recorded in $T_8$, followed by $T_9$ (72.95 g ha$^{-1}$), whereas the lowest was in control (40.22 g ha$^{-1}$). The improvement in Fe uptake may be due to fulvate preventing Fe precipitation and enhancing its mobility within the plant (El-Sayed *et al*., 2024) [2].

Zinc uptake exhibited the most pronounced response. $T_8$ recorded 129.02 g ha$^{-1}$, which was more than double the uptake in control (63.12 g ha$^{-1}$). This is attributed to fulvate's chelating property and Zn's role in seed development and auxin metabolism (Ahmad *et al*., 2019) [1]. Rehman *et al*. (2022) [7] also reported similar increases in Zn uptake with foliar Zn sprays in lentil.

Manganese uptake increased from 35.12 g ha$^{-1}$ in control to 63.42 g ha$^{-1}$ in $T_8$, while copper uptake increased from 27.01 g ha$^{-1}$ in control to 42.50 g ha$^{-1}$ in $T_8$. The enhancement of Mn and Cu uptake may be attributed to fulvate's role in mobilizing divalent cations and increasing their bioavailability (Mora *et al*., 2019; Kaur *et al*., 2020) [5, 3].

Overall, the treatment with 400 ppm potassium fulvate + $FeSO_4$ 0.5% + $ZnSO_4$ 0.5% ($T_8$) consistently recorded the highest total uptake of both macronutrients and micronutrients. The next best treatment was $T_9$ (600 ppm fulvate + Fe + Zn), which was at par with $T_8$, suggesting that 400 ppm fulvate is the optimum dose. These results demonstrate the synergistic role of fulvate, Fe, and Zn in enhancing nutrient absorption, assimilation, and translocation efficiency in chickpea (Mora *et al*., 2019; Kolape *et al*., 2023) [5, 4].

**Table 1:** Effect of foliar application of potassium fulvate, Fe and Zn on total uptake (kg ha$^{-1}$) of macronutrients by chickpea.

| Tr. No | Treatment | Macronutrients (kg ha$^{-1}$) | | |
|---|---|---|---|---|
| | | N | P | K |
| $T_1$ | Absolute control | 46.77 | 7.66 | 27.17 |
| $T_2$ | GRDF (FYM 5 t ha$^{-1}$ + 25:50:30 kg ha$^{-1}$N: $P_2O_5$:$K_2O$) | 67.61 | 11.86 | 41.92 |
| $T_3$ | GRDF and Fe & Zn @ 0.5% each as foliar spray | 71.87 | 12.87 | 44.49 |
| $T_4$ | GRDF + 200 ppm foliar spray of potassium fulvate | 75.90 | 14.11 | 47.16 |
| $T_5$ | GRDF + 400 ppm foliar spray of potassium fulvate | 79.64 | 15.51 | 51.1 |
| $T_6$ | GRDF + 600 ppm foliar spray of potassium fulvate | 81.25 | 16.14 | 52.64 |
| $T_7$ | GRDF + 200 ppm foliar spray potassium fulvate with Fe & Zn@ 0.5% each | 86.69 | 17.55 | 55.08 |
| $T_8$ | GRDF + 400 ppm foliar spray potassium fulvate with Fe & Zn @ 0.5% each | 93.40 | 20.13 | 58.87 |
| $T_9$ | GRDF + 600 ppm foliar spray potassium fulvate with Fe & Zn @ 0.5% each | 92.43 | 20.73 | 59.26 |
| | S.Em.± | 4.05 | 0.69 | 1.25 |
| | C.D. at 5% | 12.15 | 2.09 | 3.75 |

**Table 2:** Effect of foliar application of potassium fulvate, Fe and Zn on total uptake (kg $ha^{-1}$) of micronutrients by chickpea.

| Tr. No | Treatment | Micronutrients(g $ha^{-1}$) | | | |
|---|---|---|---|---|---|
| | | Fe | Mn | Zn | Cu |
| $T_1$ | Absolute control | 118.39 | 97.05 | 114.99 | 49.28 |
| $T_2$ | GRDF (FYM 5 t $ha^{-1}$ + 25:50:30 kg $ha^{-1}$N: $P_2O_5$:$K_2O$) | 177.50 | 146.77 | 176.73 | 73.88 |
| $T_3$ | GRDF and Fe & Zn @ 0.5% each as foliar spray | 183.70 | 154.41 | 187.92 | 76.47 |
| $T_4$ | GRDF + 200 ppm foliar spray of potassium fulvate | 190.69 | 162.92 | 197.09 | 79.48 |
| $T_5$ | GRDF + 400 ppm foliar spray of potassium fulvate | 201.57 | 176.27 | 210.33 | 83.78 |
| $T_6$ | GRDF + 600 ppm foliar spray of potassium fulvate | 204.77 | 182.18 | 217.04 | 85.44 |
| $T_7$ | GRDF + 200 ppm foliar spray potassium fulvate with Fe & Zn @ 0.5% each | 210.38 | 186.88 | 223.86 | 88.57 |
| $T_8$ | GRDF + 400 ppm foliar spray potassium fulvate with Fe & Zn @ 0.5% each | 220.44 | 196.23 | 236.25 | 93.61 |
| $T_9$ | GRDF + 600 ppm foliar spray potassium fulvate with Fe & Zn @ 0.5% each | 218.82 | 194.94 | 232.52 | 93.16 |
| | S.Em.± | 4.35 | 3.75 | 5.09 | 2.03 |
| | C.D. at 5% | 13.06 | 11.25 | 15.27 | 6.09 |

## Conclusion

Foliar application of 400 ppm potassium fulvate along with $FeSO_4$ (0.5%) and $ZnSO_4$ (0.5%) along with GRDF significantly improved total uptake of N, P, K, Fe, Zn, Mn, and Cu in chickpea. The study highlights the importance of fulvate as a natural chelator that enhances nutrient absorption and utilization efficiency when combined with micronutrient sprays. This integrated foliar nutrition approach found to be to improve nutrient uptake efficiency leads to increased productivity and protein content in chickpea.

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