**Response of Chickpea to Potassium Fertilization in *Vertisols* under Rainfed Agro-ecosystems**

**ABSTRACT:** A field experiment was conducted during the *rabi* season of 2024–25 at the Regional Agricultural Research Station, Nandyal, to study the effect of different potassium levels and sources on the growth, yield, nutrient uptake and soil fertility in chickpea grown on *Vertisols* under rainfed conditions. The experiment included eight treatments involving combinations of recommended dose of fertilizers (RDF), soil-applied potassium at varying levels (20, 30, and 40 kg K/ha), foliar application of potassium nitrate (KNO₃ at 1%), and potassium solubilizing bacteria (KSB). The results indicated that the combined application of 30 kg K/ha with 1% KNO₃ foliar spray (T7) recorded the highest seed yield (2133 kg ha-1), 100-seed weight (29.7 g), and plant potassium content (1.51% at 45 DAS and 1.29% at harvest). This treatment also maintained higher residual soil potassium levels. Although individual potassium treatments improved plant and soil K content over the control, the integrated soil and foliar application significantly enhanced potassium uptake and yield performance. The study highlights the importance of potassium nutrition, often overlooked in pulse production, for sustainable chickpea cultivation under rainfed conditions.

**Key words**: chickpea, Agro-ecosystems, Potassium Fertilization and Rainfed agriculture

1. **INTRODUCTION**

 Chickpea (Cicer arietinum L.) is a major pulse crop cultivated extensively in the rainfed regions of Andhra Pradesh, particularly on *Vertisols*. It serves as an essential component of dryland cropping systems, contributing to both household nutrition and soil health through biological nitrogen fixation (Ali and Kumar, 2005; Gaur *et al*., 2010). Despite its significance, chickpea productivity in these regions remains suboptimal, often due to imbalanced nutrient management, limited input use, and erratic rainfall (Singh *et al.,* 2011).

In Andhra Pradesh, no potassium (K) fertilizer recommendation currently exists for chickpea cultivation, largely due to the traditional assumption that *Vertisols* are inherently rich in potassium (Tiwari 1996). However, with continuous cropping, nutrient mining and limited use of organic inputs, potassium depletion is becoming increasingly evident, particularly in long-term rainfed systems. Studies by Das *et al.* (2022) have highlighted emerging deficiencies of K in black soils, emphasizing the urgent need to revisit blanket fertilizer recommendations that exclude potassium for pulse crops.

To address this issue, periodic research trials conducted approximately every ten years have aimed to evaluate the response of chickpea to graded levels of potassium fertilization under rainfed conditions (Aulakh and Malhi, 2005; Pandian *et al*, 2024). These studies are vital for generating region-specific data to reassess nutrient recommendations and enhance productivity. However, variability in soil fertility status, rainfall distribution and genotypic response has made it challenging to derive consistent conclusions for long-term recommendations.

In recent years, the integration of potassium solubilizing bacteria (KSB) into nutrient management strategies has gained attention. KSB such as Frateuriaaurantia and Bacillus mucilaginosus have been reported to mobilize non-exchangeable and mineral forms of potassium, thereby improving potassium availability and uptake by crops (Meena *et al.,* 2014; Parmar and Sindhu, 2013). Studies on cabbage have demonstrated that the synergistic application of mineral potassium fertilization and potassium-solubilizing bacteria (KSB) inoculation enhances potassium use efficiency and improves plant resilience to drought stress (Choudhary *et al.,* 2024). Similar beneficial effects have also been observed in chickpea, leading to improved yield performance in *Vertisols* under rainfed conditions.

Despite repeated efforts to evaluate potassium responsiveness in chickpea, consistent and long-term fertilizer recommendations have not been developed, partly due to limited data on crop responses across varying soil fertility conditions and seasonal rainfall variability (Pawar *et al.,* 2021). This study was therefore undertaken to evaluate the impact of different levels of potassium, with and without KSB inoculation, on the growth, yield attributes, and yield of chickpea in *Vertisols* under rainfed conditions. The findings aim to provide updated insights for revising current nutrient management practices and developing site-specific potassium recommendations for chickpea in Andhra Pradesh.

1. **MATERIAL AND METHODS**

 A field experiment was conducted during the ***rabi* season of 2024–25**at the **Regional Agricultural Research Station (RARS), Nandyal** to investigate the effect of different levels of potassium on the growth and yield of chickpea (Cicer arietinum L.) under rainfed conditions. The experimental site is characterized by **clayey soil** with a **pH of 8.21** and was found to contain **146 kg ha-1 of available nitrogen**, **58.7 kg ha-1of available phosphorus, 275 kg ha-1of available potassium** and**0.34% organic carbon**.

The experiment was laid out in a **Randomized Complete Block Design (RCBD)** with **eight treatments** in three replications**.** The treatments were as follows: T1 – Recommended Dose of Fertilizers (RDF) at 20:40:0 kg N:P:K per hectare as basal; T2 – RDF + Potassium @ 20 **kg ha-1**; T3 – RDF + Potassium @ 30 **kg ha-1**; T4 – RDF + Potassium @ 40 **kg ha-1**; T5 – RDF + foliar spray of KNO₃ @ 1% at flowering stage; T6 – RDF + Potassium @ 20 **kg ha-1**+ foliar spray of KNO₃ @ 1% at flowering stage; T7 – RDF + Potassium @ 30 **kg ha-1**+ foliar spray of KNO₃ @ 1% at flowering stage; and T8 – RDF + Potassium Solubilizing Bacteria (KSB) @ 1000 ml/ha as a soil application.

 Chickpea was sown with recommended agronomic practices suitable for the region. Ten plants were randomly selected from each plot at maturity for recording **plant height, number of branches per plant, number of pods per plant, seed weight per plant,** and 100-seed weight, using a digital balance for precision. In addition, seed yield and biological yield were recorded on a per plot basis and converted to kilograms per hectare (**kg ha-1**) for statistical analysis.

1. **RESULTS AND DISCUSSION**

 The effect of different levels of potassium fertilization on growth and yield attributes of chickpea is presented in Table 1. Although the statistical analysis indicated non-significant differences for all parameters studied, noticeable numerical variations were observed among treatments for plant height, number of pods per plant, 100 seed weight, and seed yield.

**3.1 Plant height (cm):** Plant height ranged from 43.9 cm (T6) to 47.6 cm (T5). The maximum height was recorded in T5 (RDF + foliar spray of KNO₃ @ 1%), followed by T7 (46.5 cm) and T4 (45.8 cm). These results suggest a positive trend in plant height with foliar potassium application, likely due to enhanced nutrient translocation and improved physiological activity during the flowering stage (Shivakumar and Ahlawat*,* 2018). However, the differences were not statistically significant, indicating that potassium fertilization alone did not greatly influence vertical growth under rainfed conditions.

**3.2 Number of Pods per Plant:** The number of pods per plant ranged from 38 (T1) in the control (RDF without potassium) to 43 (T7) which included both soil-applied and foliar potassium. Treatments T2, T4, T6, and T8 also recorded 42 pods per plant, suggesting that potassium application, especially in combination with KNO₃ spray or KSB, might help in increasing pod-setting and retention, albeit marginally. Potassium is known to improve reproductive development and pod formation in legumes by enhancing photosynthate partitioning (Bansal and Trehan, 2011).

**3.3 100-Seed Weight:** The 100-seed weight varied between 28.3 g (T1) and 29.7 g (T7). Treatments receiving either foliar potassium (T5, T6, T7) and KSB (T8) showed slightly improved seed weight compared to the control. Potassium influences seed development by improving grain filling and enzyme activation during the reproductive phase (Neha *et al.,* 2017). However, the differences were again non-significant, and the improvements were only numerical.

**3.4 Seed Yield (kg ha-1):** Seed yield ranged from 1940 kg ha-1(T4) to 2133 kg ha-1 (T7). The highest yield was observed in T7 (RDF + 30 kg K/ha + 1% KNO₃ foliar spray), followed by T5 (2099 kg ha-1) and T3 (2079 kg ha-1). Interestingly, T4 (RDF + 40 kg K/ha) recorded the lowest yield, suggesting that higher doses of potassium may not always be beneficial under rainfed conditions and could lead to nutrient imbalance or reduced efficiency. The inclusion of foliar potassium and KSB (T8: 2071 kg ha-1) appeared more beneficial than higher soil application alone. Thus this dose performed better in the respect of growth, yield attributes and yield of chickpea. Similar finding have been reported by Kumar *et al.* (2005) and Ahmad *et al.* (2015). These findings align with earlier reports that balanced and appropriately timed potassium application enhances yield by improving root growth, drought tolerance and assimilate translocation (Kumar *et al.,* 2017).

### 3.5 Plant Potassium Content (%)

Potassium concentration in chickpea plants was significantly influenced by the different potassium treatments at both 45 days after sowing (DAS) and at harvest (table 2). At 45 DAS, the highest potassium content (1.51%) was observed in treatment T7 (RDF + 30 kg K/ha + 1% KNO₃ foliar spray), followed by T4 (1.42%), T6 (1.39%) and T3 (1.37%), all of which received potassium either through soil or a combination of soil and foliar applications. The lowest potassium content (0.83%) was recorded in T8 (RDF + potassium solubilizing bacteria), which was even lower than the control treatment T1 (0.87%).

A similar trend persisted at harvest, with T7 again showing the highest plant potassium content (1.29%), closely followed by T2 (1.26%) and T6 (1.26%). The control treatment (T1) exhibited the lowest potassium content at harvest (0.53%), indicating potassium deficiency in the absence of potassium fertilization. These findings confirm that potassium application, particularly when combined with foliar spray, enhances potassium uptake by plants, likely due to improved root absorption and nutrient translocation (Shivakumar and Ahlawat*,* 2018; Kumar *et al.,* 2017).

### 3.6 Soil Available Potassium (K₂O kg ha-1)

 Soil available potassium levels also varied significantly across treatments. At 45 DAS, the highest available potassium (301 kgha-1) was recorded in T4 (RDF + 40 kg K/ha), followed by T7 (296 kg ha-1) and T2 (293 kg ha-1), reflecting the direct impact of higher potassium application rates. The lowest soil potassium level (259 kg ha-1) was found in the control (T1), suggesting depletion of soil potassium due to crop uptake without replenishment.

 This trend continued at harvest, with T7 maintaining the highest soil potassium level (288 kg ha-1), followed by T4 (284 kg ha-1) and T3 (281 kg ha-1). The control plot (T1) again had the lowest potassium content in soil (236 kg ha-1). Statistically significant differences were observed at both sampling stages, with critical differences of 28.84 kg ha-1 at 45 DAS and 24.19 kg ha-1 at harvest. These results indicate that integrated potassium application not only improved potassium uptake by chickpea plants but also helped sustain higher residual soil potassium levels, particularly when soil and foliar potassium were applied together (Bansal and Trehan, 2011).

1. **CONCLUSION:** The study confirms that integrated potassium management significantly improves chickpea yield and soil fertility under rainfed *vertisol* conditions. The combination of 30 kg K/ha with a 1% KNO₃ foliar spray was the most effective, enhancing yield, potassium uptake, and residual soil K. These results highlight the importance of including potassium in nutrient strategies for sustainable chickpea production.

**Table:1 Effect of different levels of Potassium on Chickpea yield and yield attributing characters in *vertisols* under rainfed conditions**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Plant height (cm)** | **No. of pods/plant** | **100 seed wt. (g)** | **Seed yield****(kg ha-1)** |
| **T1:** RDF (20-40-0 kg N, P and K per ha) as basal | 45.6 | 38 | 28.3 | 1983 |
| **T2:** RDF + Potassium @ 20 kg ha-1 | 44.3 | 42 | 29.5 |  |
| **T3:** RDF + Potassium @ 30 kg ha-1 | 45.3 | 40 | 29.0 | 2079 |
| **T4:** RDF + Potassium @ 40 kg ha-1 | 45.8 | 42 | 29.3 | 1940 |
| **T5:** RDF + KNO3 @ 1% as foliar application at flowering stage | 47.6 | 40 | 29.5 | 2099 |
| **T6:**RDF+ Potassium @ 20 kg ha-1 + KNO3 @ 1% as foliar application at flowering stage | 43.9 | 42 | 28.9 | 2039 |
| **T7:** RDF + Potassium @ 30 kg ha-1 + KNO3 @ 1% as foliar application at flowering stage | 46.5 | 43 | 29.7 | **2133** |
| **T8:** RDF + Potassium Solubilizing Bacteria (KSB) 1000 ml per ha as soil application | 45.6 | 42 | 28.8 | 2071 |
| **SE.m** ± | **1.3** | **1.3** | **0.9** | **95.8** |
| **C.D @ 5%** | **NS** | **NS** | **NS** | **NS** |
| **C.V (%)** | **4.9** | **5.3** | **5.1** | **8.1** |

**Table: 2 Percent of Potassium concentrations in chickpea plant and available potassium in soil**

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Plant analysis for K (%)** | **Soil available K20** **(kg ha-1)** |
|  | **At 45 DAS** | **At Harvest**  | **At 45 DAS** | **At Harvest**  |
| **T1:** RDF (20-40-0 kg N, P and K per ha) as basal | 0.87 | 0.53 | 259 | 236 |
| **T2:** RDF + Potassium @ 20 kg ha-1 | 1.35 | 1.26 | 293 | 275 |
| **T3:** RDF + Potassium @ 30 kg ha-1 | 1.37 | 1.17 | 290 | 281 |
| **T4:** RDF + Potassium @ 40 kg ha-1 | 1.42 | 1.24 | 301 | 284 |
| **T5:** RDF + KNO3 @ 1% as foliar application at flowering stage | 1.30 | 1.09 | 263 | 258 |
| **T6:**RDF+ Potassium @ 20 kg ha-1 + KNO3 @ 1% as foliar application at flowering stage | 1.39 | 1.26 | 279 | 271 |
| **T7:** RDF + Potassium @ 30 kg ha-1 + KNO3 @ 1% as foliar application at flowering stage | 1.51 | 1.29 | 296 | 288 |
| **T8:** RDF + Potassium Solubilizing Bacteria (KSB) 1000 ml per ha as soil application | 0.83 | 0.59 | 263 | 254 |
| **SE.m** ± | 0.03 | 0.05 | 9.51 | 7.97 |
| **C.D @ 5%** | 0.10 | 0.14 | 28.84 | 24.19 |
| **C.V (%)** | 4.60 | 7.81 | 5.87 | 5.15 |

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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