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Effect of foliar application of potassium on yield and quality of Groundnut (*Arachis hypogaea* L.) in vertisol

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Abstract
A field experiment was conducted during summer 2017 at Agricultural Research Station, Nipani, University of Agricultural Sciences, Dharwad to evaluate the effect of foliar application of different potassium sources, doses and timing on yield and quality of groundnut in Vertisol. The experiment was laid out in randomized block design with fourteen treatments replicated thrice. The treatments consisted of three potassium sources (KCl, K_2SO_4 and KNO_3), two concentrations (1% and 2%), two application times (30 DAS and 60 DAS), water spray control and recommended dose of fertilizer (RDF) alone. Foliar application of 2% K_2SO_4 at 60 DAS along with RDF recorded significantly higher kernel yield (2469 kg ha^{-1}) and pod yield (3417 kg ha^{-1}) compared to water spray with RDF (1616 kg ha^{-1} kernel yield and 2361 kg ha^{-1} pod yield) and RDF alone (1559 kg ha^{-1} kernel yield and 2361 kg ha^{-1} pod yield). This treatment also resulted in higher oil content (48.37%), oil yield (1194 kg ha^{-1}), protein content (25.38%) and protein yield (627 kg ha^{-1}) with maximum net returns (₹1,14,490 ha^{-1}) and benefit-cost ratio (3.73). The study concluded that foliar application of 2% K_2SO_4 at 60 DAS supplemented with basal RDF is effective for enhancing groundnut productivity and profitability in Vertisol.

Keywords: Groundnut, foliar nutrition, potassium sources, vertisol and yield quality

Introduction
Groundnut (*Arachis hypogaea* L.) is an important oilseed crop cultivated globally for its edible oil and protein-rich kernels. In India, groundnut occupies a significant position among oilseed crops, contributing substantially to the country's vegetable oil production. The crop requires adequate nutrition throughout its growth period, with potassium playing a crucial role in various physiological processes including photosynthesis, protein synthesis, enzyme activation, and maintenance of cellular turgor pressure. Vertisols, characterized by high clay content and dominated by smectite group of minerals, are known for their capacity to fix applied potassium, making it unavailable to crops during critical growth stages. This fixation phenomenon often results in potassium deficiency symptoms despite adequate soil application, necessitating alternative approaches for potassium nutrition. Foliar application of nutrients has emerged as an effective strategy to overcome soil-related nutrient availability issues and provide timely nutrition to crops. Previous studies have demonstrated the effectiveness of foliar potassium application in various crops, but limited research exists on optimizing potassium sources, concentrations, and application timing specifically for groundnut in vertisols. The present investigation was undertaken to evaluate the effect of foliar application of different potassium sources at varying concentrations and application times on yield and quality parameters of groundnut in vertisol conditions.

Materials and Methods
The field experiment was conducted during summer 2017 at Agricultural Research Station, Nipani, University of Agricultural Sciences, Dharwad, Karnataka, India. The experimental site is located in the Northern Transitional Zone (Zone 8) of Karnataka with Vertisol soil type. The soil was analyzed for physico-chemical properties following standard procedures. The experiment was laid out in randomized block design with fourteen treatments replicated thrice. The treatments included three potassium sources (Potassium Chloride - KCl, Potassium Sulphate

- K_2SO_4 and Potassium Nitrate - KNO_3), two concentrations (1% and 2%), two application timings (30 days after sowing - DAS and 60 DAS), water spray control along with recommended dose of fertilizer (RDF) and RDF alone. The RDF consisted of 25:50:25 kg ha^{-1} of N:P_2O_5: K_2O applied as basal dose. Groundnut variety suitable for the region was sown with a spacing of 30 cm × 10 cm. Foliar sprays were applied using a knapsack sprayer during evening hours to minimize evaporation losses. The crop was grown under irrigated conditions with uniform agronomic practices followed for all treatments. The observations recorded were plant height, number of branches per plant, number of pods per plant, kernel weight, shelling percentage, pod yield, kernel yield, oil content, protein content, oil yield, protein yield, and nutrient uptake (N, P, K) were recorded following standard procedures. Economic analysis was conducted based on prevailing market prices. The data collected were analyzed using analysis of variance (ANOVA) technique and treatment means were compared using least significant difference (LSD) at 5% probability level.

Results

The results of growth parameter in foliar application of 2% K_2SO_4 at 60 DAS along with RDF significantly enhanced plant height (29.53 cm), number of branches per plant (7.53) and number of nodules per plant (17.33) compared to control treatments. These improvements in growth parameters were attributed to the beneficial effect of potassium on photosynthetic activity and enzyme functions. Similarly, yield parameters showed the results as follows. The treatment receiving foliar application of 2% K_2SO_4 at 60 DAS along with RDF produced significantly higher number of pods per plant (21.00), kernel weight (41.65 g), and shelling percentage (72.00%) compared to water spray with RDF (18.47 pods per plant, 35.85 g kernel weight, and 67.00% shelling percentage) and RDF alone (14.73 pods per plant, 37.45 g kernel weight and 65.83% shelling percentage). Foliar application of 2% K_2SO_4 at 60 DAS along with RDF recorded significantly higher kernel yield (2469 kg ha^{-1}) and pod yield (3417 kg ha^{-1}) compared to all other treatments. This represented a yield increase of 52.8% in kernel yield and 44.7% in pod yield over RDF alone. The treatment was statistically at par with 1% KCl at 60 DAS along with RDF for pod yield (3148 kg ha^{-1}) and kernel yield (2234 kg ha^{-1}).

Interestingly, the oil content in kernels was significantly enhanced with foliar application of 2% K_2SO_4 at 60 DAS (48.37%) compared to water spray with RDF (44.27%) and RDF alone (45.33%). Similarly, protein content was higher in treatments receiving foliar potassium application, with 2% K_2SO_4 at 60 DAS recording 25.38% protein content compared to 22.31% in water spray control and 22.75% in RDF alone. Consequently, oil yield and protein yield were substantially higher in the best treatment (1194 kg ha^{-1} and 627 kg ha^{-1}, respectively) compared to controls (714-705 kg ha^{-1} oil yield and 354-361 kg ha^{-1} protein yield).Total uptake of nitrogen (177.45 kg ha^{-1}), phosphorus (32.02 kg ha^{-1}), and potassium (107.99 kg ha^{-1}) was significantly higher in the treatment receiving foliar application of 2% K_2SO_4 at 60 DAS along with RDF. This enhanced uptake was attributed to the synergistic effect of potassium on nutrient absorption and utilization. The treatment involving foliar application of 2% K_2SO_4 at 60 DAS along with RDF recorded the highest net monetary returns (₹1,14,490 ha^{-1}) and benefit-cost ratio (3.73), followed by 1% KCl at 60 DAS along with RDF (₹1,03,949 ha^{-1} net returns and 3.55 B:C ratio).

Discussion

The virtual way of appreciating the superiority of any technology lies in the evaluation of yields. Assessing the performance of a crop in terms of economic yield provides a clear and unambiguous picture of yield potential of that crop under defined set of conditions. In the present investigation, foliar application of 2 per cent K_2SO_4 at 60 days after sowing (DAS) along with the recommended dose of fertilizers (T11) resulted in significantly higher kernel yield (2469 kg ha^{-1}) and pod yield (3417 kg ha^{-1}) and it was on par with 1 per cent KCl at 60 DAS along with RDF for pod yield and followed by for kernel yield (2234 kg ha-1and 3148 kg ha^{-1} respectively) as compared to water spray along with RDF (T13, 1616 kg ha-1 and 2361 kg ha^{-1} respectively) and RDF alone (T14, 1559 and 2361 kg ha-1 respectively) (Fig 1).This depicts that soil application of recommended dose of potassium at the time of sowing results in considerable loss of potassium because of its fixation in soil dominated by smectite group of clays in Vertisol, that results in lower availability of potassium at the later stages of crop which might reduce the uptake of nutrients by the groundnut crop (Madkour *et al.*, 1992) [8]. It indicates that foliar application of 2 per K_2SO_4 at 60 DAS apart from basal dose of potassium application to soil supplements the crop nutrient requirement that could arise at later stage and resulted in higher yield than that of RDF alone. Foliar spray of potassium sulphate to the crop resulted in timely supply of optimum quantity of nutrients to the plant and their subsequent absorption by groundnut leaves resulting in better assimilation and translocation of nutrients. The similar conclusions are also drawn in the observations made by Der *et al.* (2015) [3] and Rathore *et al.* (2014) [4]. Pod yield is governed by a number of factors having direct or indirect impact. The main factors which have direct bearing on pod yield are total number of pods $plant^{-1}$, kernel weight and shelling percentage. The growth attributes like dry matter production $plant^{-1}$ and its distribution in to various plant parts had indirect influence on dry pod yield.

Similarly, shelling per cent, kernel weight and number of pods per plant were more closely associated with the kernel yield. The treatment receiving foliar application of 2 per cent K2SO4 at 60 DAS along with the RDF (T11) produced higher shelling per cent (72.00%), kernel weight (41.65 g) and number of pods per plant (21.00) and it was on par with 1 per cent KCl at 60 DAS along with RDF (T7 *i.e.*, 71.17%, 37.53 g. and 19.73, respectively) as compared to water spray along with RDF (67.00%, 35.85 g. and 18.47, respectively) and RDF alone (65.83%, 37.45 g. and 14.73, respectively). Such differences with respect to yield components in T11 were due to increase in kernel weight which might be due to accelerated mobility of photosynthates from source to sink as influenced by potassium and it's accumulation in kernels. The present findings are akin to the observations of Mekki (2015) [2] and Der *et al.* (2015) [3]. Further, foliar spray of sulphate of potassic containing potassium and sulphur might have resulted in quick and spot availability of optimum quantity of these nutrients in required form to the groundnut crop. This also resulted in better absorption of nutrients by groundnut leaves which inturn might have helped in the production of more number of flowers and more number of pods per plant, better kernel development in pods, more number of developed pods and ultimately higher pod weight and shelling percentage. Thus, owing to the integration of all the favourable yield components such as number of pods plant-1, kernel weight (g) and shelling percentage (%) in treatments which received foliar application of 2 per cent K2SO4 along with RDF (25 kg

N, 50 kg P2O5 and 25 kg K2O ha^{-1}) at 60 DAS and 1 per cent KCl at 60 DAS along with RDF resulted in significantly higher pod yield and kernel yield over water spray along with RDF (T13, 1616 kg ha-1 and 2361 kg ha^{-1}) and RDF alone (T14, 1559 and 2361 kg ha^{-1}). The lower pod and kernel yields indicates that soil application of recommended dose of potassium at the time of sowing results in considerable loss of potassium because of its fixation in soil dominated by smectite group of clays in Vertisol. This is obvious because of the lower availability of potassium at the later stages of crop might reduce the uptake of nutrients by the groundnut crop (Madkour *et al.*, 1992) [8].

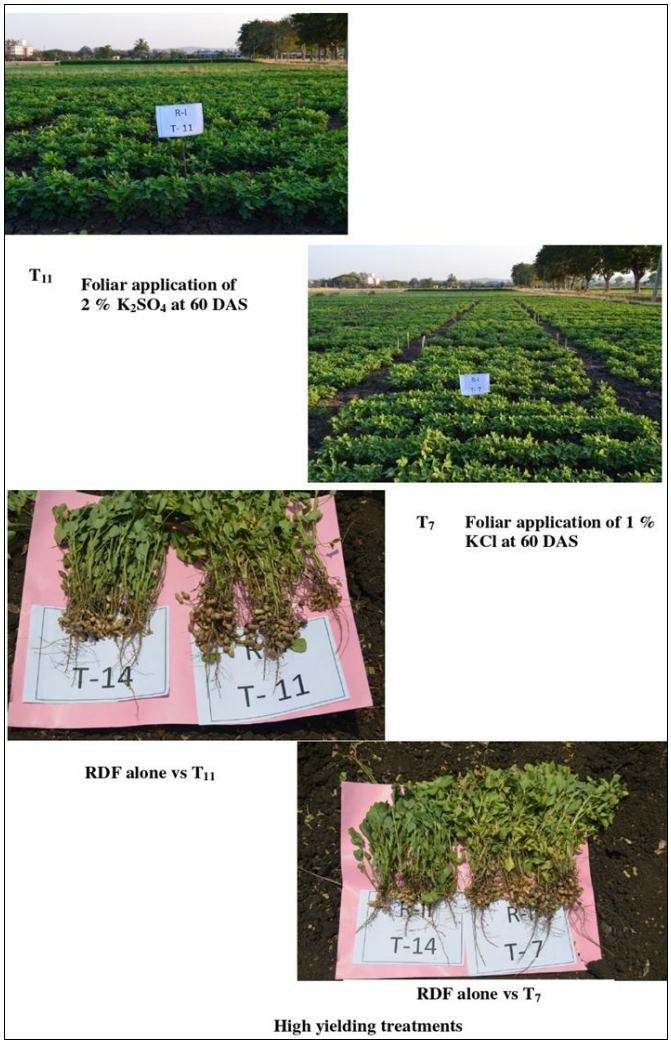

Fig 1: High Yielding Treatments

Conclusion

The study concludes that foliar application of 2% K_2SO_4 at 60 DAS along with basal application of recommended dose of fertilizer (25:50:25 kg ha^{-1} $N:P_2O_5:K_2O$) is the most effective nutrient management strategy for groundnut cultivation in Vertisol. This treatment not only enhances yield and quality parameters but also provides maximum economic returns. The practice can be recommended for adoption by farmers in similar agro-climatic conditions to achieve higher groundnut productivity and profitability.

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