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Physiological and yield responses of chickpea (*Cicer aerietinum* L.) to foliar fertilizer application

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Abstract
A field investigation entitled "Effect of Foliar Application of Fertilizers on Growth and Yield of Chickpea (*Cicer arietinum* L.)" was conducted during rabi season of 2020-21 at the Experimental Farm of Cotton Research Scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani. The objective was to evaluate the effect of foliar application of different fertilizers on the growth and yield of chickpea and to analyse the economics of each treatment. The experiment was laid out in a Randomized Block Design (RBD) with eight treatments replicated thrice. The treatments included were T_1: RDF (Recommended Dose of Fertilizers: 25:50:25 NPK kg/ha) without spray, T_2 - RDF + 1% Urea, T_3 - RDF + 1% DAP, T_4 - RDF + 1% 19:19:19 NPK, T_5 - RDF + 1% 00:52:34 NPK, T_6 - RDF + 1% 13:00:45 NPK, T_7 - RDF + 1% 13:40:13 NPK, T_8 - Control (no RDF, no spray). Foliar sprays were applied at two critical stages: flowering and pod development. Results indicated that T_4 (RDF + 1% 19:19:19 NPK) recorded the highest seed yield, gross monetary returns (GMR), net monetary returns (NMR), and benefit-cost ratio (B:C), followed closely by T_7 (RDF + 1% 13:40:13 NPK) and T_5 (RDF + 1% 00:52:34 NPK), with statistically non-significant differences among these top treatments. The soil of the experimental site was black cotton soil, clayey in texture, low in organic carbon and nitrogen, medium in phosphorus, and high in potassium, with an alkaline pH. Environmental conditions during the study were favourable for chickpea growth and development. Foliar sprays were applied at two critical stages: flowering and pod development. Results indicated that T_4 (RDF + 1% 19:19:19 NPK) recorded the highest seed yield, gross monetary returns (GMR), net monetary returns (NMR), and benefit-cost ratio (B:C), followed closely by T_7 (RDF + 1% 13:40:13 NPK) and T_5 (RDF + 1% 00:52:34 NPK), with statistically non-significant differences among these top treatments. It can be concluded that foliar application of NPK fertilizers, particularly 1% 19:19:19, 13:40:13, or 00:52:34 in combination with RDF at flowering and pod development stages, significantly enhanced the growth, seed yield, and profitability of chickpea cultivation.

Keywords: Chickpea, foliar fertilization, 19:19:19 NPK, 00:52:34 NPK, 13:40:13 NPK, yield, economics

Introduction
Background
Chickpea (*Cicer arietinum* L.) is a major rabi pulse crop in India and a key source of dietary protein, particularly for smallholder farmers in semi-arid regions. India remains the world's largest producer and consumer of chickpea, and pulses have been central to national food-security and pulse self-sufficiency programmes over recent years.

In Maharashtra, chickpea is widely cultivated across the plateau and black-soil tracts of the state (including the Marathwada region), where it forms an important component of the dryland cropping system. Several studies document that area expansion and improved agronomy have contributed to increased chickpea production in the state, though yields remain well below the crop's potential due to multiple biotic and abiotic constraints. Major chickpea-growing districts in Maharashtra include those on the Deccan plateau and Vertisolic (black cotton) soils, such as parts of Parbhani, where the present study was conducted.

Vertisols (black cotton soils) that predominate in Marathwada are deep and clayey but often show low to medium organic carbon, limited available nitrogen and sometimes low availability of certain nutrients (e.g., P, Zn). These soil characteristics, together with erratic winter rainfall and moisture stress in the rabi season, constrain nutrient availability and crop uptake, contributing

to yield gaps for chickpea in the region. Therefore, site-specific nutrient management is critical to improve productivity and resource use efficiency on these soils. (Chandana *et al*. 2025) [19]
Foliar fertilization the application of water-soluble nutrients directly to foliage at critical growth stages has been shown to be an effective complementary strategy to soil fertilization. Foliar sprays can supply readily available nutrients during periods of peak demand (e.g., flowering, pod development), overcome temporary soil-root uptake limitations, and correct foliar deficiencies rapidly. Field experiments and reviews on chickpea and other pulse crops report that foliar application of NPK and micronutrients at critical stages can improve physiological traits, seed yield and economic returns, particularly under rain-fed conditions. However, responses vary with fertilizer formulation, concentration, timing and baseline soil fertility, necessitating localized trials. (Sri Abisankar M *et al*. 2024) [5].

Justification

Despite national and state-level improvements, chickpea productivity in Maharashtra (and locally in Marathwada) still shows a substantial yield gap relative to experimental/varietal potential. The primary causes include low inherent soil fertility in Vertisols (especially low organic carbon and available N), limited synchrony between soil nutrient availability and critical crop demand, and periodic moisture stress during the rabi season. These constraints reduce nutrient uptake efficiency and ultimately seed yield and farmer profitability. Targeted agronomic interventions that improve nutrient availability at critical phenological stages are therefore needed to narrow the yield gap.
Foliar nutrient application offers a practical, low-cost option to supply nutrients directly to the crop during flowering and pod formation — stages when nutrient demand is highest and conventional soil application may be sub-optimal in uptake. Several recent field studies indicate yield and profitability gains from foliar NPK or combined macro- and micro-nutrient sprays in chickpea, but there is variation across agro-ecologies and fertilizer formulations (e.g., different NPK blends). Hence, region-specific evaluation is required to identify the best foliar formulations, concentrations and timings for rain-fed vertisols of Parbhani. (Sri Abisankar M *et al*. 2024) [5].
The present experiment at the Cotton Research Scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani, therefore addresses an important knowledge gap: it evaluates several commercially available NPK foliar formulations (19:19:19, 13:40:13, 00:52:34, 13:00:45, 1% urea and 1% DAP) applied at two critical stages (flowering and pod development) in combination with the recommended soil RDF. By assessing growth, yield and economics under local black soil and rain-fed conditions, the study generates location-relevant recommendations that can improve nutrient use efficiency, seed yield and profitability for chickpea farmers in the Marathwada region. The results showing that 1% 19:19:19 (and similar blends) delivered the highest seed yield and benefit-cost ratio in this trial therefore provide actionable information for extension and fertilizer management guidelines tailored to Parbhani's vertisols.

Materials and Methods

Experimental site location: A field experiment entitled "Effect of Foliar Application of Fertilizers on Growth and Yield of Chickpea (*Cicer arietinum* L.)" was carried out during the *rabi* season of 2020-21 at the Experimental Farm, Cotton Research Scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani (19°09′ N, 76°46′ E, 410 m a.m.s.l.), Maharashtra, India. The site is geographically situated at 19°09′ N latitude, 76°46′ E longitude, and at an altitude of410meters above mean sea level (MSL). Parbhani is located in the Central Maharashtra Plateau Zone (Agro-Climatic Zone V) characterized by semi-arid tropical climate, with mean annual rainfall of about 900 mm, predominantly received from the southwest monsoon (June-September). The mean maximum and minimum temperatures during the cropping season ranged from 28-32 °C and 11-14 °C, respectively.

Initial Soil Analysis: The soil of the experimental site was *deep black cotton soil (Vertisol)*, clayey in texture, low in available nitrogen (187.5 kg ha^{-1}), medium in phosphorus (15.8 kg ha^{-1}), high in potassium (395 kg ha^{-1}), and low in organic carbon (0.46%), with an alkaline pH of 8.1. Before sowing, composite soil samples were collected from the experimental site at a depth of 0-15 cm from several spots and analyzed for their physico-chemical properties using standard analytical methods (Jackson, 1973) [18].

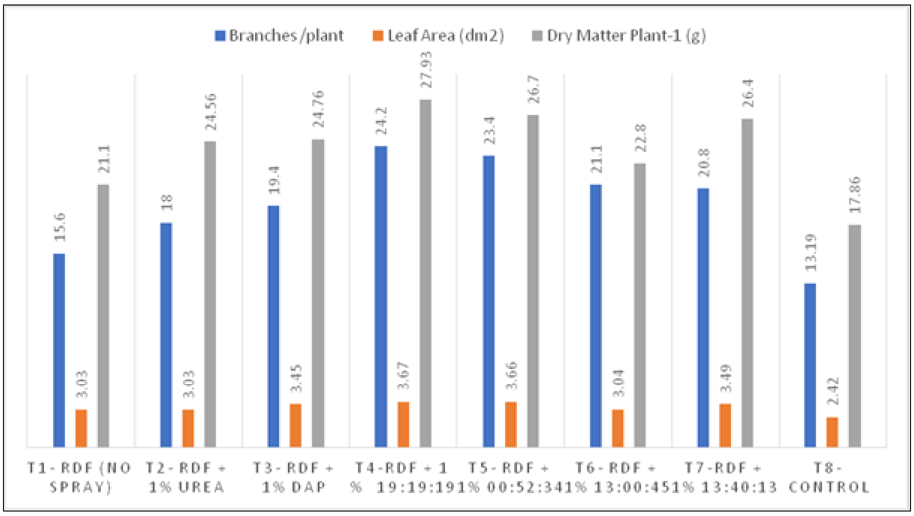
Results and Discussion

Growth Attributes

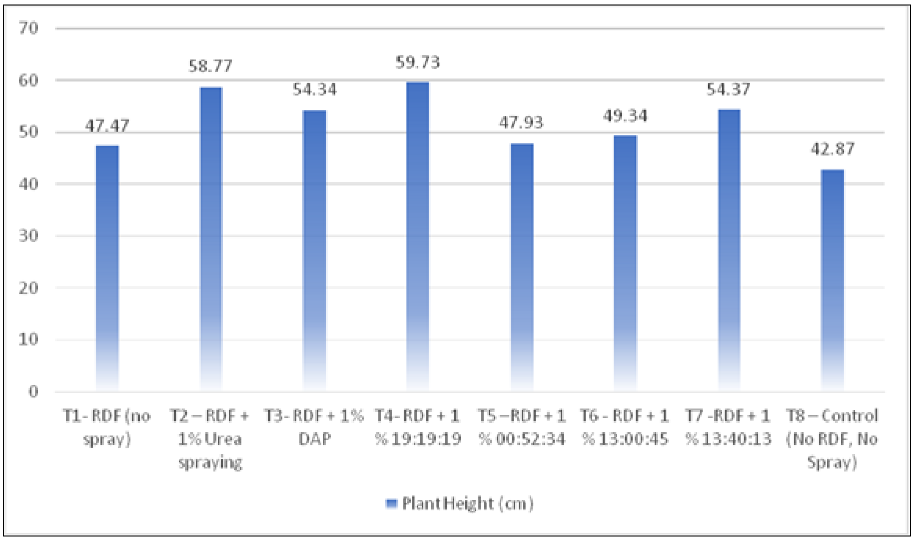
The data revealed that foliar application of fertilizers had a significant influence on the growth attributes of chickpea (*Cicer arietinum* L.). Among all treatments, T_4 - RDF + 1% 19:19:19 NPK recorded the highest plant height (59.73 cm), number of branches per plant (23.40), number of leaves $plant^{-1}$ (291), leaf area (3.67 dm^2), and dry matter accumulation (26.70 g) at harvest, followed by T_7 - RDF + 1% 13:40:13 NPK and T_5 - RDF + 1% 00:52:34 NPK, while the lowest values were recorded in the control (T_8 - No RDF, no spray).
Improvement in growth parameters with foliar nutrition may be attributed to the rapid absorption of nutrients through leaf tissues, providing immediate availability during critical growth stages (flowering and pod development), which enhances photosynthetic rate and metabolic activity (Raut *et al*., 2024) [9]. Similar results were reported by Takankhar *et al*. (2015) [2], who observed significant increases in plant height and dry matter accumulation of chickpea due to foliar application of 1% 19:19:19 NPK. Jat *et al*. (2023) [17] also reported that foliar feeding of NPK at flowering and pod formation stages promoted vegetative growth by ensuring balanced nutrient availability under rainfed conditions.

Table 1: Growth attributing characters of chickpea as influenced by different treatments at harvest.

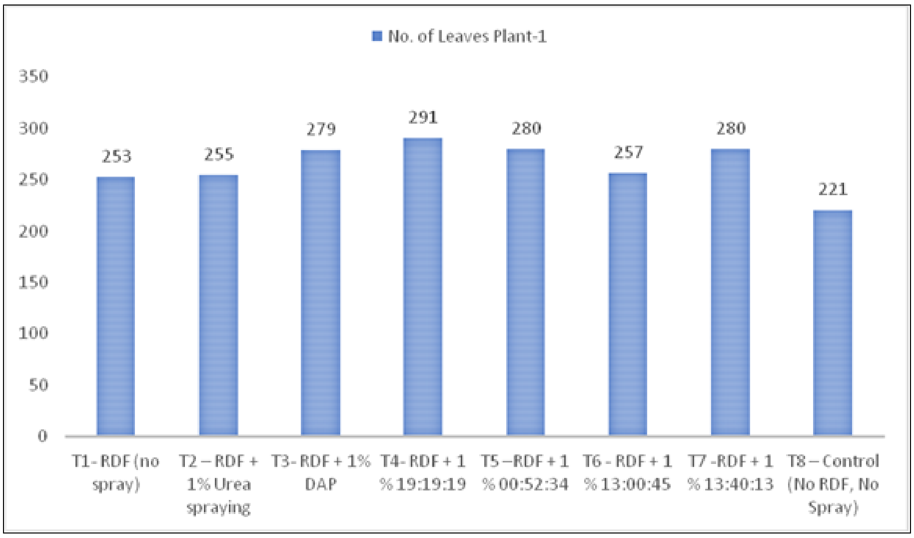
Treatments	Plant Height (cm)	No. of Branches $Plant^{-1}$	No. of Leaves $Plant^{-1}$	Leaf Area (dm^2)	Dry Matter $Plant^{-1}$ (g)
T_1- RDF (no spray)	47.47	15.60	253	3.03	21.10
T_2 - RDF + 1% Urea spraying	58.77	18.00	255	3.03	24.56
T_3- RDF + 1% DAP	54.34	19.40	279	3.45	24.76
T_4- RDF + 1% 19:19:19	59.73	24.20	291	3.67	27.93
T_5 -RDF + 1% 00:52:34	47.93	23.40	280	3.66	26.70
T_6 - RDF + 1% 13:00:45	49.34	21.10	257	3.04	22.80
T_7 -RDF + 1% 13:40:13	54.37	20.80	280	3.49	26.40
T_8 - Control (No RDF, No Spray)	42.87	13.19	221	2.42	17.86
S.E. (m) +	1.15	0.76	10.33	0.13	0.53
CD at 5%	3.47	2.31	31.21	0.39	1.61
General mean	51.85	19.46	264	3.22	24.04



Graph 1: Growth attributing characters of chickpea as influenced by different treatments at harvest.



Graph 2: Plant height (cm) of chickpea as influenced by different treatments at harvest.



Graph 3: No. of leaves of chickpea as influenced by different treatments at harvest

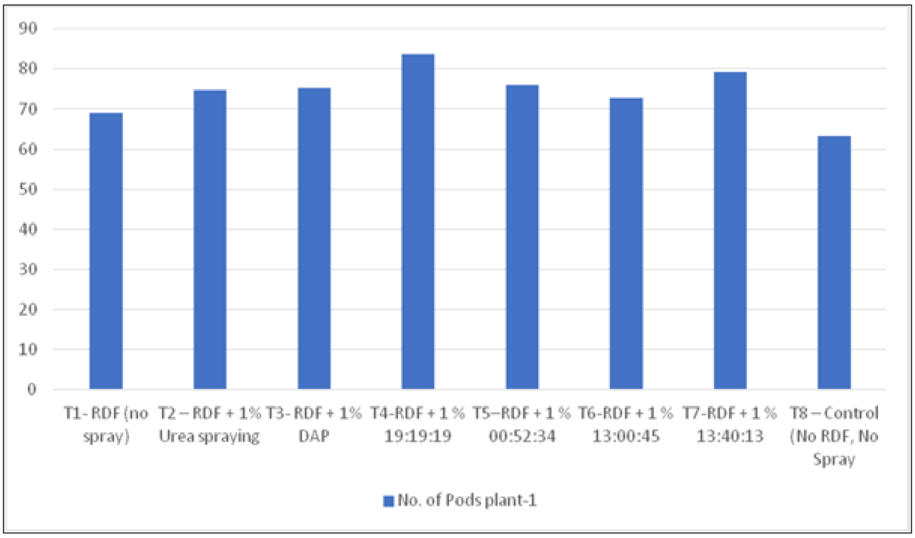
Yield Attributes

Yield contributing parameters such as number of pods plant^{-1} (83.78), number of seeds pod^{-1}, seed weight plant^{-1}, and 100-seed weight were significantly affected by different foliar fertilizer treatments. The treatment T_4 -(RDF + 1% 19:19:19 NPK) recorded the maximum number of pods plant^{-1} and seed weight plant^{-1}, which was statistically at par with T_7 (RDF + 1% 13:40:13 NPK) and T_5 (RDF + 1% 00:52:34 NPK).

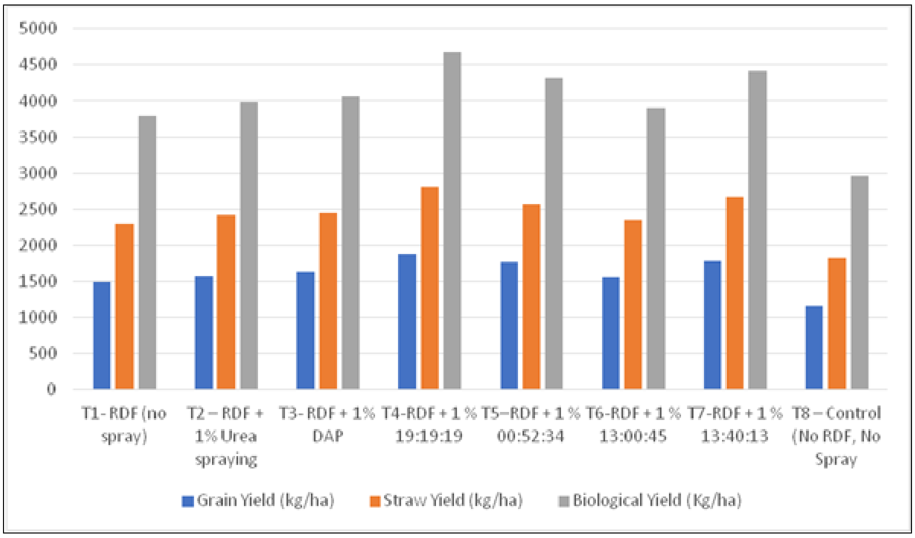
This improvement can be attributed to the supplemental supply of N, P, and K in readily available form, which enhanced flowering, pod formation, and seed filling. Balanced nutrition at the reproductive stage reduces flower drop and improves translocation of assimilates to developing pods (Kumar *et al*., 2023) [15]. Ratnam *et al*. (2023) [10] also emphasized that foliar feeding of water-soluble NPK (19:19:19 and 13:00:45) under rainfed conditions enhanced pod setting and grain filling, resulting in higher yield attributes.

Table 2: Yield attributing characters and yield of chickpea as influenced by different treatments at harvest.

Treatments	No. of Pods plant^{-1}	Seed Weight plant^{-1} (g)	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	Biological Yield (kg ha^{-1})
T_1- RDF (no spray)	69.06	6.80	1493	2299	3792
T_2 - RDF + 1% Urea spraying	74.71	7.20	1570	2418	3988
T_3- RDF + 1% DAP	75.36	7.50	1630	2445	4075
T_4-RDF + 1% 19:19:19	83.78	8.80	1870	2805	4675
T_5-RDF + 1% 00:52:34	75.89	8.10	1767	2575	4315
T_6-RDF + 1% 13:00:45	72.75	7.20	1557	2351	3908
T_7-RDF + 1% 13:40:13	79.24	8.20	1778	2665	4418
T_8 - Control (No RDF, No Spray	63.33	5.30	1150	1815	2965
S.E. (m) +	1.20	0.25	44.9	53.8	102.8
CD at 5%	3.62	0.76	135.6	162.5	310.5
General mean	74.26	7.38	1602	2422	4017



Graph 4: Number of pods^{-1} of chickpea as influenced by different treatments at harvest.



Graph 5: Grain yield, Straw yield, Biological yield (kg ha^{-1}) of chickpea as influenced by different treatments at harvest.

Seed Yield and Biological Yield

Significant differences in seed and biological yield were observed among treatments. The maximum seed yield (q ha^{-1}) and biological yield were recorded under T_4 - RDF + 1% 19:19:19 NPK, followed by T_7 - RDF + 1% 13:40:13 NPK, while the control treatment (T_8) recorded the lowest yield. The increase in yield over the control was attributable to improved growth and yield attributes, indicating the synergistic effect of basal fertilization (RDF) and foliar nutrient supplementation during critical phenological stages.

These findings corroborate with those of Raut *et al*. (2024) [9] and Jadon *et al*. (2023), who also reported yield enhancement in chickpea due to foliar sprays of multi-nutrient NPK formulations under limited soil fertility and moisture conditions. The increased yield might also be associated with improved nutrient uptake efficiency and photosynthate partitioning into reproductive organs (Meena *et al*., 2021) [13].

Economics

Economic analysis indicated that the highest gross monetary returns (GMR), net monetary returns (NMR), and benefit-cost ratio (B:C) were recorded with T_4 - RDF + 1% 19:19:19 NPK, followed closely by T_7 - RDF + 1% 13:40:13 NPK. The increase in net returns and profitability was mainly due to higher seed yield and marginal cost of foliar fertilizer application. These findings are consistent with Takankhar *et al.* (2015-16) [2] and Raut *et al*. (2024) [9], who reported that foliar nutrition with 19:19:19 and 13:40:13 NPK improved net returns and B:C ratio in chickpea.

Summary of Discussion

Overall, the results demonstrated that foliar application of NPK fertilizers significantly improved the growth, yield attributes, and economic returns of chickpea under rainfed *Vertisol* conditions. Among the treatments, 1% 19:19:19 NPK + RDF proved most effective, followed by 13:40:13 NPK + RDF and 00:52:34 NPK + RDF, without significant statistical differences among these top treatments. The beneficial effects of foliar feeding are more pronounced in rainfed areas, where nutrient uptake from the soil may be restricted due to moisture stress during reproductive stages (Sowmya *et al*., 2022) [6].

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