

Original Research Article

The Effect of foliar applied Micronutrients (Zinc, Boron and Iron) on Growth and Yield of Chickpea (*Cicer arietinum* L.) Varieties

ABSTRACT

Comprehensively, nutrient deficiencies in humans and animals are a quiet epidemic in many underdeveloped nations. Hence, a field experiment was conducted to study the effect of foliar applied Zinc, Boron and Iron on Growth, Yield attributes and Yield of chickpea (*Cicer arietinum* L.) varieties during the *Rabi* season of 2018-19 and 2019-20. The field experiment was laid out in Split Plot Design assigning three varieties in main plots comprising of V₁-KGD-1168, V₂-Radhey and V₃-KWR-108 and seven micronutrients combined in subplots treatments *i.e.*, (M₁-Control), (M₂-Zinc @ 0.5%), (M₃-Boron @ 0.2%), (M₄-Iron @ 0.1%), (M₅-Zinc @ 0.5% + Boron @ 0.2%), (M₆-Zinc @ 0.5% + Iron @ 0.1%) and (M₇: Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1%). Thus, total 21 treatment combinations were replicated thrice. The results revealed that the variety Radhey had a significant effect on plant height, number of branches plant⁻¹, fresh weight of 100-seed weight (17.21, 17.25g), seed yield (2118, 2228 kg ha⁻¹), gross return (112396, 113628 ₹ ha⁻¹), Net return (83154, 83616 ₹ ha⁻¹) and B:C ratio (2.84, 2.79 ₹ ha⁻¹) of chickpea during both the years 2018-19 and 2019-20, respectively. In case of micronutrients treatment, foliar application of Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1% exerted significantly higher plant height, number of branches plant⁻¹, fresh weight of plant, 100-seed weight (16.94, 16.97g), seed yield (2162, 2276 kg ha⁻¹) gross return (114634, 116076 ₹ ha⁻¹), Net return (85041, 85712 ₹ ha⁻¹) and B:C ratio (2.87, 2.82 ₹ ha⁻¹) of chickpea both the years 2018-19 and 2019-20, respectively. On the basis of observed results, farmers were instructed to grow the chickpea variety Radhey with foliar applications of Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1% for greater growth and yield.

Keyword: Chickpea; Micronutrients; Zinc; Boron; Iron; Growth; Yield,

INTRODUCTION

Pulses are an important dietary ingredient in Oriental cuisine due to their high protein content, and their significance is even greater in countries like India where the majority of the population is vegetarian. Pulses are a cost-effective source of not only protein but also carbohydrates, minerals, and β-complex vitamins, making them a crucial component of a vegetarian diet. Pulses typically contain 20-25% protein in their dry seeds, which is 2.5-3.0 times higher than that found in cereals. This makes grain legumes an essential element in ensuring the nutritional security of the country's poor masses, as they are the primary source of protein for the predominantly vegetarian Indian population. Pulses are often referred to as the "poor man's meat" and the "rich man's vegetables" due to their versatility and nutrient content. Additionally, their contribution to

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maintaining soil fertility through biological nitrogen fixation is significant, making them a crucial part of sustainable agriculture (Gaur *et al.*, 2010). However, pulse production in the country has not kept pace with the increasing population, leading to a sharp decline in per capita availability of pulses from 71g in 1995 to 34.4g per day in 2009. This low consumption of pulses is partly attributed to low productivity, and increasing pulse production remains a crucial area of focus. Pulses occupy an area of about 95.16 million hectares, contributing 95.97 metric tons of production to the world food basket (FAO, 2020).**References must be listed at the end of the manuscript and numbered in the order that they appear in the text. In the text, citations should be indicated by the reference number in brackets.** <https://journalijecc.com/index.php/IJECC/about/submissions>

Chickpea, also known as *Cicer arietinum* L., is a highly valued pulse crop in the Indian subcontinent. It is commonly consumed as a pulse, and its dried form is used in the preparation of a variety of snacks, sweets, and condiments. Additionally, its fresh green form is consumed as a vegetable. This crop is primarily grown in semi-arid and tropical climates and is of great economic importance. India is the world's largest producer and consumer of chickpeas, accounting for 36.76% of the area and 26% of global pulse production. Furthermore, India is the largest producer of pulses worldwide, occupying an area of 34.99 million hectares and producing a total of 24.21 million tons with productivity of 806 kg ha⁻¹ (Agricultural Statistics at a Glance 2019). It is noteworthy that during the 20th century, the world's population increased fourfold, along with a 4.5-fold increase in economic activity per person. The world's population is expected to increase by 50% in the next four to five decades, necessitating a doubling of food output to accommodate this human expansion and those moving up the food chain (Thavarajah and Thavarajah, 2015).**References must be listed at the end of the manuscript and numbered in the order that they appear in the text. In the text, citations should be indicated by the reference number in brackets.**

The choice of chickpea variety is crucial for achieving maximum productivity, as different varieties have varying growth and development patterns due to their unique genetic makeup. In modern agriculture, the use of high-yield crop varieties and intensive fertilization has led to a depletion of micronutrients, such as Manganese (Mn), Iron (Fe), Copper (Cu), and Boron (B), which are crucial for plant growth and development. Micronutrient deficiencies have been shown to adversely affect plant growth, metabolism, and reproduction, as well as human and animal health. Fe and Zn deficiencies are particularly common in developing Asian countries, including India. Foliar application of micronutrients, such as Zn, Fe, Mg, B, and Mn, has been found to improve plant growth and yield, with the best results obtained when they are applied in combination with nitrogen. Studies have shown that foliar application of micronutrient mixtures can increase the number of pods and seeds per plant, seed weight per plant, seed yield per hectare, harvest index, and 100-seed weight. Spray application of boron has been found to increase pod number per plant and 100-seed weight. It is noteworthy that Indian soils are often deficient in micronutrients, with Zn, Fe, Mn, and B deficiencies reported in 49%, 12%, 5%, and 3% of soils, respectively. The selection of appropriate chickpea varieties is crucial for optimal

pulse production, as each variety has unique genetic traits that affect growth and development under specific agro-climatic conditions. However, modern agricultural practices that rely on high-yielding crops and synthetic fertilizers have led to micronutrient deficiencies, which can reduce crop productivity and degrade produce quality. Four essential micronutrients - Manganese, Iron, Copper, and Boron - are required for optimal plant growth, development, and biochemical pathways. Micronutrient deficiencies can severely affect plant growth, metabolism, and reproductive phases, which can ultimately impact animal and human nutrition. In developing countries, more than half of the population suffers from micronutrient malnutrition, particularly in Fe and Zn, which are widespread in developing Asian countries, including India. Foliar application of micronutrient mixtures, such as Zn, Fe, Mg, B, and Mn, in combination with nitrogen, has been shown to improve plant growth, yield, and yield attributes, including number of pods plant⁻¹, number of seed plant⁻¹, and seed weight plant⁻¹. The application of micronutrients has also been shown to increase seed yield ha⁻¹, harvest index, and 100-seed weight. Additionally, foliar application of multi micronutrients has been found to increase seed protein content, pod number plant⁻¹, and 100-seed weight. In India, the soil is potentially deficient in essential micronutrients, such as Zn, Fe, Mn, and B, which can be addressed through foliar application of micronutrients. With the following objectives viz., to study the impact of micronutrients on growth and yield attributes of chickpea, to find out of micronutrients on yield of chick pea varieties.

2. MATERIALS AND METHODS

2.1 Experimental site: The Student's Instructional Farm (SIF) at Chandra Shekhar Azad University of Agriculture and Technology in Kanpur, Uttar Pradesh, India, was the site of the field experiment. The farm is located in the alluvial tract of the Indo-Gangetic plains in the central part of Uttar Pradesh, between 25° 26' to 26° 58' North latitude and 79° 31' to 80° 34' East longitude, at an elevation of 125.9 m above mean sea level. The region is classified as agro-climatic zone V (Central Plain Zone) of Uttar Pradesh. The experimental field was located in the same area for both years of the study, as shown in Figure 1.

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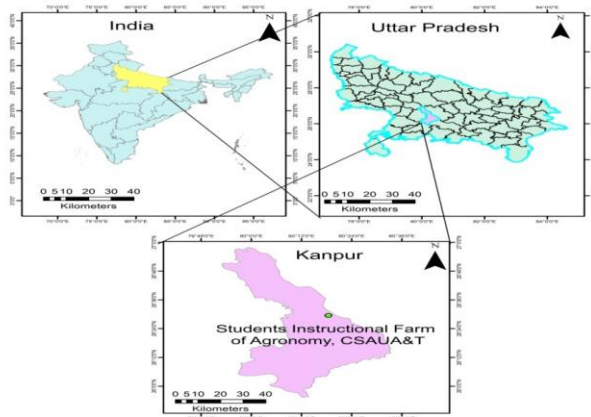


Fig. 1 LOCATION MAP OF THE STUDY AREA

2.2 Climate and weather conditions: The study site falls within a semi-arid climate zone with fertile alluvial soil. Annual rainfall averages around 890 mm, with the majority falling between mid-July and the end of September. Winters are characterized by cooler temperatures, occasional rain, and frost from the last week of December to mid-January. In contrast, temperatures in May and June can reach as high as 44-47°C or more, while winters experience a certain degree of temperature drop. Mean relative humidity at 7:00 A.M. is relatively stable between 80-90% from July to the end of March, and then gradually drops to 40-50% by the end of April, before stabilizing again at 80% throughout May.

2.3 Soil Characteristics: The properties of the soil, as a medium for plant growth, are bound to profoundly affect the rate of plant growth and ultimately the final yield. The soil in the experimental field was characterized as sandy loam with a pH of 7.83-7.87, electrical conductivity of 0.26-0.27 dSm⁻¹ at 25°C, bulk density of 1.39-1.40 g cm⁻³, particle density of 2.64-2.63 g cm⁻³, organic carbon content of 0.33-0.35%, available nitrogen content of 156.22-161.32 kg ha⁻¹, available P₂O₅ content of 17.24-18.15 kg ha⁻¹, available K₂O content of 175.35-181.49 kg ha⁻¹, available Zn content of 0.56-0.58 mg kg⁻¹, available Fe content of 8.02-8.07 mg kg⁻¹, and available B content of 0.28-0.38 mg kg⁻¹, in both the years 2018-19 and 2019-20.

2.4 Experimental Details: The experimental design was split-split plot design with three replications. The experiment consisting of Twenty-One treatment combinations, were three chickpea varieties (V1-KGD-1168, V2-Radhey, V3-KWR-108) are allocated in the main plots and micronutrients (M1-Control), (M2- Zinc @ 0.5%), (M3- Boron @ 0.2%), (M4- Iron @ 0.1%), (M5- Zinc @ 0.5% + Boron @ 0.2 %), (M6- Zinc @ 0.5% + Iron @ 0.1 %) and (M7- Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 %) were allocated in the sub-plots. The size of each plot was (12 m²), 4.0 m long and 3.0 m width.

2.5 Crop Varieties:

a) KGD-1168: it is also known as Alok variety of chickpea developed by Chandra Shekhar Azad University of Agriculture and Technology, Kanpur in the year of 1996 for cultivation in north western plain zones (Punjab, Haryana, Delhi, North Rajasthan and Western Uttar Pradesh) of India. It is medium in plant height, resistant to wilt disease and root node nematode. Important features are Duration: (140-145 days), Plant height: (55-60 cm), Yield: (19-21 q ha⁻¹), Seeds: Medium and bold, Husk (14.14%), Dhal recovery (72%), Protein (23%), Seed index: (15.48g).

b) Radhey: It is variety of chickpea released in the year of 1968 by crossing of T-197 x 76. It is good for Uttar Pradesh area. It has light green foliage and semi-spreading in nature. The pods are generally two-seeded, grains are bold, light brown in colour and smooth and flowers are pink in colour. Important features viz., Plant height: (60-70 cm), Yield: (26-30 q ha⁻¹), Seeds: Medium and bold, Husk: (13.18%), Dhal recovery (78.8%), Protein: (21.50%).

c) KWR-108: It is variety of chickpea developed by Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh in the year of 1996 for cultivation in north eastern plain zones (Eastern Uttar Pradesh, Bihar and West Bengal) of India. It is medium in plant height, resistant to wilt disease. Some important features of this variety are Duration: 130-135 days, Plant height: 45-55 cm, Yield: 22-23 q ha⁻¹, Seeds: Small Seed, color: Dark brown Husk (16%). Dhal recovery (74%), Protein (24.10%), Seed index: 17 g.

2.6 Agronomical Practices Adopted: During the experimental period, the land underwent several steps of preparation. First, a tractor-drawn cultivator was used to plow the field, which was then harrowed. Weeds and stubble were removed, and the field was leveled with a leveler before being divided into plots according to the experimental design. Large clumps of soil were broken down into finer particles, and the surface was smoothed until the desired tilth was achieved. The recommended doses of nitrogen, phosphorus, and potassium (20:60:60 kg ha⁻¹, respectively) were applied using urea, single super phosphate, and muriate of potash, respectively. The entire amount of P₂O₅ and K₂O, as well as half of the nitrogen, were applied as a basal dose. The remaining half of the nitrogen was applied as a top dressing 30 days after sowing. Micronutrients (zinc, boron, and iron) were applied as foliar spray treatments using ZnSO₄, boric acid (H₃BO₃), and FeSO₄, respectively. The micronutrients were applied twice, at 25 and 50 days after sowing (DAS), using fresh solution at each spray. The spray solution was prepared by dissolving the required amount of micronutrients in distilled water and adding a sticker for better absorption of the solution by cabbage leaves. The spraying was done with a knapsack sprayer, and all necessary precautions were taken during the process.

2.7 Observations Recorded: During the study, the biometrical observations were collected at various stages of growth, including 25, 50, 75, and 100 DAS as well as at maturity. To minimize any potential sampling error, all necessary precautions were taken. The growth attributes and yield parameters such as plant height, number of branches per plant, Fresh weight of plant, 100-

seed weight and seed yield were recorded. The obtained data were subjected to appropriate statistical analysis using the method outlined by Gomez and Gomez (1984) to determine any differences among the treatment means. The LSD test was used to compare treatment means at a 5% level of probability. The analysis was performed using SPSS Version 10.0, a statistical software package developed by SPSS, Chicago, and IL.

3. RESULTS AND DISCUSSION

3.1 Plant Height: The Plant height (Table 1) is a reliable index of growth and development representing the infrastructure build-up over a period of time. The Growth characteristics of chickpea (Table) were significantly influenced by different varieties and Micronutrients (Zn, B and Fe). The interaction effect of varieties and micronutrients was found to be non-significant. Among the varieties, Radhey was found to be significantly superior for plant height over rest of the treatments during both the years. Plant height of Chickpea increased progressively with the advance in age of the crop up to maturity. Plant height varied due to varieties. The plant height is the varietal character and may be influenced by the environment. The Varietal variation in plant height was reported by (Durga *et al.*, 2005); (Chaitanya and Chandrika, 2006); (Badini *et al.*, 2015). The Increase in plant height might be due to the stimulating influence of boron enhancing the rate of absorption of N, P and K and other nutrients. Moreover, boron took part in sugar translocation which might have helped to the increase height of plants. This is in accordance with the findings of (Kayan *et al.*, 2015) in chickpea. The Increase in plant height may be due to involvement of (zinc, boron and ferrous) in cell division and meristematic growth of the tissue. Similar findings were reported by (Hossain *et al.*, 2016). The micronutrient (Zn, Fe and Boron) reported to improve the plant height of chickpea. Similar result was observed by (Kuldeep *et al.*, 2018). **References must be listed at the end of the manuscript and numbered in the order that they appear in the text. In the text, citations should be indicated by the reference number in brackets.**

3.2 Number of Branches Plant⁻¹: The Branching (Table 2) in Chickpea as indicated by the number of branches plant⁻¹ has been considered as growth parameter by some researchers, while a group of researchers claimed it as yield attribute. In the present investigation, branching has been considered as growth parameter. The Production of branches tended to increase with advance in the age of the crop up to maturity, irrespective of plant varieties. Maximum number of branches plant⁻¹ was noticed in Radhey variety, while the lowest number of branches was noticed in KGD-1168 variety and similar results have been reported by several workers (Bahadur *et al.*, 2002 and Durga *et al.*, 2005). This may also be due to variation in production of branches plant⁻¹ in individual variety was due to variation in their growth behavior reflected due to differences in genetic makeup. A similar result was also reported by (Chauhan and Singh 2000); (Neenu *et al.* (2011)). The Application of micronutrients (Zn, B and Fe) resulted in increased number of branches plant⁻¹ of chickpea. The probable reason for its enhancement might be due to the promotive effects of micronutrients on vegetative growth which ultimately lead to more photosynthetic activities.

Another reason could be the result of availability of required quantity of essential plant nutrients at various growth stages leading to hastening the metabolic processes of plant that might have resulted in production of more number of branches. The results of this study are also in line with (Pradhan *et al.*, 2018). The interaction effect of varieties and micronutrients was found to be non-significant. **References must be listed at the end of the manuscript and numbered in the order that they appear in the text. In the text, citations should be indicated by the reference number in brackets.**

3.3 Fresh Weight of Plant: The Fresh weight (Table 3) of chickpea increased progressively with increase in the age of the crop up to maturity. The interaction effect of varieties and micronutrients was found to be non-significant. The higher fresh weight production was observed with Radhey variety which was statistically at par with KWR-108 variety while lower fresh weight production was noticed in KGD-1168 variety during both years. The accumulation of higher fresh weight production in Radhey variety was due to enhanced growth characters like CGR (crop growth rate), RGR (relative growth rate), photosynthetic rate and chlorophyll content coupled with better utilization of moisture and nutrients from the soil with high yield potential and improved characters as compared to other varieties. The similar results were reported by (Kumar and Deshmukh, 2006); (Kumar *et al.*, 2006); (Meena and Baldev, 2013). The fresh weight of chickpea is product of luxuriant plant growth and assimilation of photosynthates. The chickpea fertilized with Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1% enjoyed healthy crop growth due to sufficient availability of micronutrients. Enrichment of soil with micro nutrients made it efficient utilization of micronutrients. Iron enhanced chlorophyll metabolism, zinc is helpful in carbohydrate and protein synthesis and protected the chickpea crop against photo oxidative damage. Boron also regulated transport of sugar through membrane and played quite essential role for cell division and cell development. The results are in close association with (Velenciano *et al.*, 2010) and (Balai *et al.*, 2017). **References must be listed at the end of the manuscript and numbered in the order that they appear in the text. In the text, citations should be indicated by the reference number in brackets.**

3.4 100-Seed weight: The 100-seed weight (seed index) indicates the nature and extent of seed development. It is a function of various production factors that influences seed development and filling pattern. The perusal of data in Table 4 indicates the effect of different treatments on 100-seed weight of chickpea. The different varieties exhibited significant difference in 100-seed weight of chickpea. But, micronutrients (Zn, B and Fe) responded non-significant effect on 100-seed weight. Among the varieties, Radhey exerted significantly higher 100-seed weight (17.21 and 17.25 g) which was statistically at par with variety KWR-108 during both the experimental years. However, least 100-seed weight was noted with variety KGD-1168. In the case of micronutrients, higher 100-seed weight (16.94 and 16.97 g) was observed with application of (Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1%) than rest of the treatments but the difference was found to be non-significant during both the years. However, minimum 100-seed weight (16.57 and 16.61 g) was observed with Control Treatment. The interaction effect of

varieties and micronutrients was found to be non-significant. **References must be listed at the end of the manuscript and numbered in the order that they appear in the text. In the text, citations should be indicated by the reference number in brackets.**

3.5 Seed Yield:Yield of the crop (Table 4) is the resultant of growth and yield contributing characters. The significant variation in growth characteristics and yield attributes as a result of differential varieties and micronutrients treatments further led to marked variation in yield of chickpea crop. The interaction effect of varieties and micronutrients was found to be non-significant. The highest seed yield was produced by Radhey variety while lowest seed yield was noticed in variety KGD-1168 of chickpea. The variety Radhey with more number of branches, number of pods plant⁻¹, number of seed pod⁻¹ with higher seed weight has resulted in highest seed yield. The final seed yield is always positively related to the yield attributes like pod number, pod weight, number of seed pod⁻¹, seed weight etc. Similar results were reported by (Panchariya and Lidder, 2000), (Shrivastava *et al.*, 2000) and (Khatun *et al.*, 2010). Among the micronutrients, the foliar application of Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 % recorded significantly higher seed yield during both the years. It might be due to application of different micronutrient combinations to increase in yields can be attributed to enhance availability of essential plant nutrients at the required growth stages. Hence, it increases the rate and efficiency of metabolic activities resulting in high assimilation of proteins and carbohydrates which in turn helps in better nutrient absorption by plants resulting in better yields. The results obtained corroborated with the reports of (Patel and Singh, 2010), (Valenciano *et al.*, 2010), (Gupta and Sahu, 2012) and (Elayaraja, 2014). **References must be listed at the end of the manuscript and numbered in the order that they appear in the text. In the text, citations should be indicated by the reference number in brackets.**

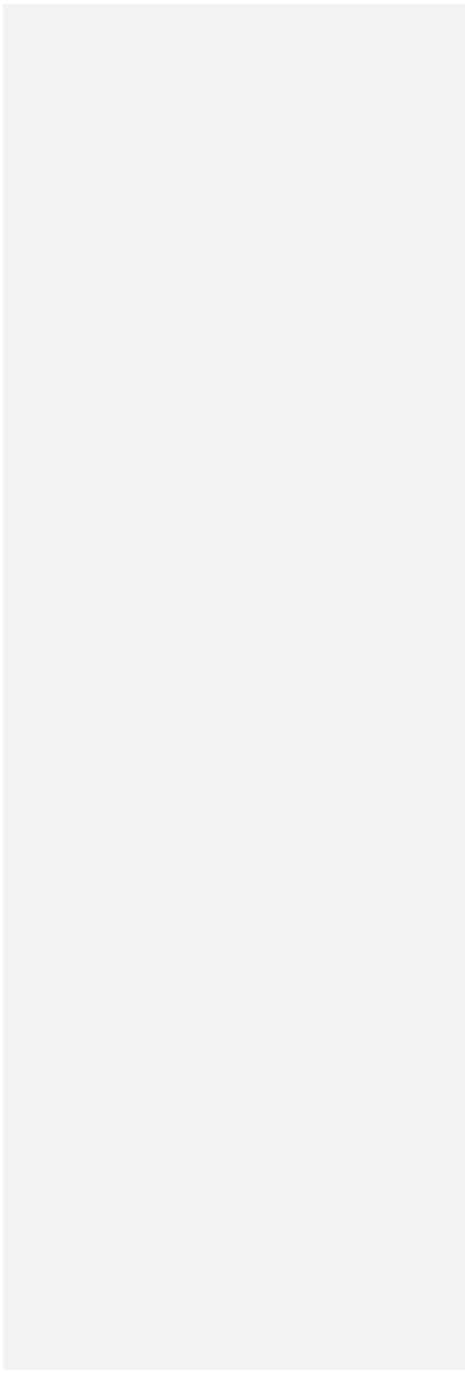
Economics:The data on economics viz., gross returns, net returns and benefit: cost ratio as influenced by different varieties and micronutrient treatments during course of investigations have been presented in Table 4. The practicability and usefulness of a treatment is judged ultimately in terms of net returns. The Radhey variety reported higher gross return (112396, 113628 ₹ ha⁻¹), Net return (83154, 83616 ₹ ha⁻¹) and B:C ratio (2.84, 2.79 ₹ ha⁻¹) of chickpea during both the years 2018-19 and 2019-20, respectively. This might be because of higher seed and straw yields as compared to other treatments which led to higher net returns. The above result is in agreement with the findings of (Patel and Singh, 2010) and (Balai *et al.*, 2017). The economic analysis of the treatments shows the relevance to consider the practical adaptability of a particular treatment from the farmers' point of view. The agriculture practices involving lower cost of production and giving higher net return and benefit: cost ratio are preferred for adoption. Application of micronutrients influenced the gross returns, net returns and benefit cost ratio of chickpea. Application of Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 % noted higher gross return (114634, 116076 ₹ ha⁻¹), Net return (85041, 85712 ₹ ha⁻¹) and B:C ratio (2.87, 2.82 ₹ ha⁻¹) of chickpea both the years 2018-19 and 2019-20, respectively because of higher seed and straw

yield. This confirms the findings of (Patel *et al.*, 2009).References must be listed at the end of the manuscript and numbered in the order that they appear in the text. In the text, citations should be indicated by the reference number in brackets.

UNDER PEER REVIEW

Interaction (V x M)	NS	NS	NS	NS	-	-	-	-	-	-	-	-
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UNDER PEER REVIEW



4. CONCLUSION

The two-year study's findings allowed the following conclusions. Among the varieties, Radhey variety resulted highest improvement in growth, chlorophyll content, relative water content yield attributes and yield. The foliar application Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 %) was proved superior over rest of the treatments in respect of growth, chlorophyll content, relative water content yield attributes and yield of chickpea. On the basis of observed results, farmers were instructed to grow the chickpea variety Radhey with foliar applications of Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1% for greater yield and profitability.

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