Original Research Article

The Effectof foliar applied Micronutrients(Zinc, Boron, and Iron) on Growth and Yield of Chickpea (*Cicerarietinum* 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 (*Cicerarietinum* L.) varieties during the *Rabi* season of 2018-19 and 2019-20. The field experiment ~~way~~ waslaid out in Split Plot Design assigning three varieties in main plots comprising of V_1-KGD-1168, V_2-Radhey, and V_3-KWR-108 and seven micronutrients combined in subplots treatments *i.e*., (M_1-Control), (M_2-Zinc @ 0.5%), (M_3-Boron @ 0.2%), M_4-Iron @ 0.1%), (M_5-Zinc @ 0.5% + Boron @ 0.2 %), (M_6-Zinc @ 0.5% + Iron @ 0.1 %) and (M_7: Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 %). Thus, a total of 21 treatment combinations were replicated thrice. The results revealed that the variety Radhey had a significant effect on plant height, the 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~~Based on 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; IronGrowth; 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 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).

Chickpea, also known as *Cicerarietinum* 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).

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~~ productionquality. 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 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 chickpeas, to find out of micronutrients on yield of chickpea 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 25º 26' to 26º 58' North latitude and 79º 31' to 80º 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.

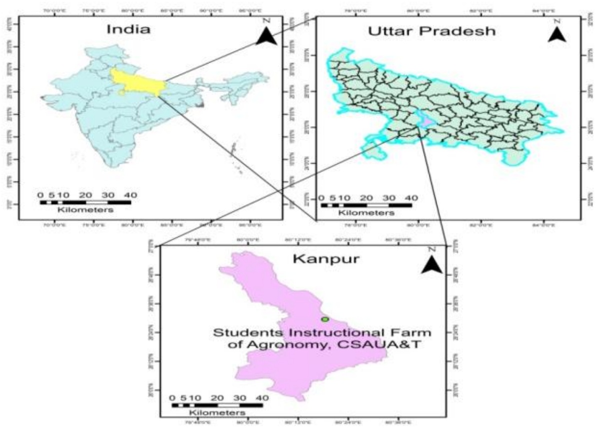

Fig. 1 LOCATION MAP OF THE STUDY AREA

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^{o}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 25ºC, 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 P_2O_5 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~~- a ~~split~~ split-plot design with three replications. The experiment ~~consisting~~ consistsof Twenty-One treatment combinations, where 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 m^2), 4.0 m long and 3.0 m width.

2.5 Crop Varieties:

a) KGD-1168: ~~it~~ It is also known as the 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~~,~~and 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 a variety of chickpea released in the year ~~of~~ 1968 by crossing of T-197 x 76. It is good for the 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 a variety of chickpea developed by Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh in the year ~~of~~ 1996 for cultivation in northeastern plain zones (Eastern Uttar Pradesh, Bihar, and West Bengal) of India. It is medium in plant height~~,~~and 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 P_2O_5 and K_2O, 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 $ZnSO_4$, boric acid (H_3BO_3), and $FeSO_4$, 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 theInfrastructure build-up over ~~a period of~~some time. The Growth characteristics of chickpeas (Table) were significantly influencedby 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 significantlysuperior for plant height over the rest of the treatmentsduring both ~~the~~ years.~~Plant~~ The plant height of Chickpea increased progressively with the advance in age of thecrop up to maturity. Plant height varied due to varieties. The plant height is the varietal character and may be influenced bythe 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 boronenhancing the rate of absorption of N, P and K, and other nutrients. Moreover, boron tookpart in sugar translocation which might have helped to the increase height of plants. Thisis ~~in accordance with~~per the findings of (Kayan*et al*.,2015) in chickpeas. The Increase in plantheight may be due to the involvement of (zinc, boron, and ferrous) in cell division andmeristematic growth of the tissue. Similar findings were reported by (Hossain *et al*.**,** 2016). The micronutrients (Zn, Fe, and Boron)were reported to improve the plant height of chickpeas. ~~Similar~~ A similar resultwas observed by (Kuldeep*et al*., 2018).

3.2 Number of Branches Plant^{-1}: The Branching (Table 2) in Chickpea as indicated by the number of branches plant^{-1} has beenconsidered as a growth parameter by some researchers, while a group of researchersclaimed it as a yield attribute. In the present investigation, branching has beenconsidered as a growth parameter. The Production of branches tended to increase with advancein the age of the crop up to maturity, irrespective of plant varieties.~~Maximum~~ The maximum number of branches plant^{-1} was noticed in the Radhey variety, while the lowestnumber of branches was noticed in the KGD-1168 variety and similar results have beenreported by several workers (Bahadur*et al*., 2002 and Durga*et al*., 2005). This may alsobe due to variation in the production of branches plant^{-1} in individual variet~~y wa~~ies due tovariation in their growth behavior reflected due to differences in genetic makeup. Asimilar result was also reported by (Chauhan and Singh 2000); (Neenu*et al*. (201). The Application of micronutrients (Zn, B, and Fe) resulted in an increased number of branches plant^{-1}of chickpea.The probable reason for its enhancement might be due to the promotive effects ofmicronutrients on vegetative growth which ultimately lead to more photosyntheticactivities. Another reason could be the result of the availability of the required quantity ofessential plant nutrients at various growth stages leading to hastening the metabolicprocesses of plants that might have resulted in the 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.

3.3 Fresh Weight of Plant: TheFresh weight (Table 3) of chickpeas increased progressively with an increase inthe age of the crop up to maturity.The interaction effect of varieties and micronutrients was found to be non-significant.The higher freshweight production was observed with the Radhey variety which was statistically atpar with the KWR-108 variety while lower fresh weight production was noticed inthe KGD-1168 variety during both years. The accumulation of higher fresh weight production in**the** Radhey variety was due to enhanced growth characteristics like CGR (crop growth rate),RGR (relative growth rate), photosynthetic rate, and chlorophyll content coupled withbetter utilization of moisture and nutrients from the soil with high yield potential andimproved 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 the product of luxurious plant growth andassimilation 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 micronutrients made it efficient utilization micronutrients. Iron enhanced enhanceschlorophyll metabolism, zinc is helpful in carbohydrate andprotein synthesis, and protected protectsthe chickpea crop against photo photo-oxidative damage. Boronalso regulated the transport of sugar through the membrane and played quite an essential role forincell division and cell development. The results are in close association with (Velencianoetal., 2010) and (Balaiet al., 2017).

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 4indicates the effect of different treatments on 100-seed weight of chickpea. The Different varieties exhibited significant differences in the 100-seed weight of chickpeas. ButHowever,micronutrients (Zn, B, and Fe) responded with a non-significant effect on 100-seed weight. Among the varieties, Radheyexerted 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, at 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 appPresentfindings are in concurrence with those of (Siag and Yadav, 2004); (Chaitanya and Chandrika, 2006). tion of (Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 %) than the rest of the treatments but the difference was found to be non-significant during both the years. However, a 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.

3.5 Seed Yield: Yield The 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 the yield of chickpea crops. The interaction effect of varieties and micronutrients was found to be non-significant. The highest seed yield was produced by the Radhey variety while the lowest seed yield was noticed in variety KGD-1168 of chickpea. The variety Radhey with more number of branches, number of pods plant^{-1}, and number of seed pod^{-1} with higher seed weight has resulted in the 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 the 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 is increases the rate and efficiency of metabolic activities resulting in high assimilation of proteins

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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).

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~~ arejudged 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~~of considering 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~~ The application of micronutrients influenced the gross returns, net returns, and ~~benefit~~ benefit-cost ratio of chickpeas. 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 ad straw yield. This confirms the findings of (Patel *et al*., 2009).

Table 1:Effect of Varieties and Micronutrients (Zinc, Boron, and Iron) onPlant height (cm) of chickpea

Treatments	Plant height (cm) at 25 DAS		Plant height (cm) at 50 DAS		Plant height (cm) at 75 DAS		Plant height (cm) at 100 DAS		Plant height (cm) at maturity	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Varieties										
V_1: KGD-1168	7.67	7.71	26.78	27.63	50.05	52.59	58.09	58.77	62.19	62.96
V_2: Radhey	7.96	7.99	28.62	29.70	53.57	56.11	61.42	62.23	66.35	67.63
V_3: KWR-108	7.23	7.28	25.60	26.49	47.26	48.29	54.04	54.62	57.17	57.84
SEm±	0.24	0.25	0.83	0.86	1.68	1.70	2.06	2.09	2.14	2.17
LSD (*p*=0.05)	0.75	0.77	2.55	2.61	5.12	5.19	6.23	6.28	6.44	6.53
Micronutrients										
M_1: Control	7.52	7.54	25.41	26.54	46.12	48.34	52.78	53.19	56.98	58.02
M_2: Zinc @ 0.5%	7.62	7.65	26.73	27.81	49.41	51.28	57.67	58.27	61.27	62.12
M_3: Boron @ 0.2%	7.58	7.61	26.56	27.62	48.99	51.12	56.09	56.97	60.29	61.24
M_4: Iron @ 0.1%	7.55	7.59	26.31	27.39	48.37	50.23	55.27	56.11	59.78	60.57
M_5: Zinc @ 0.5% + Boron @ 0.2 %	7.68	7.72	27.84	28.90	53.51	55.27	60.67	61.37	64.29	65.47
M_6: Zinc @ 0.5% + Iron @ 0.1 %	7.71	7.74	27.21	28.29	51.09	53.47	58.67	59.48	62.87	63.49
M_7: Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 %	7.73	7.77	28.96	29.06	54.57	56.61	63.78	64.39	67.84	68.78
SEm±	0.20	0.21	0.72	0.75	1.36	1.39	1.72	1.75	1.91	1.93
LSD (*p*=0.05)	NS	NS	2.21	2.28	4.14	4.22	5.21	5.26	5.78	5.81
Interaction (V x M)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2:Effect of Varieties and Micronutrients (Zinc, Boron and Iron) on Number of Branches Plant^{-1}of Chickpea

Treatments	Number of Branches Plant^{-1} at 25 DAS		Number of Branches Plant^{-1} at 50 DAS		Number of Branches Plant^{-1} at 75 DAS		Number of Branches Plant^{-1}at 100 DAS		Number of Branches Plant^{-1}at maturity	
	2018-19	**2019-20**	**2018-19**	**2019-20**	**2018-19**	**2019-20**	**2018-19**	**2019-20**	**2018-19**	**2019-20**
Varieties										
V_1: KGD-1168	5.65	5.76	9.40	9.74	12.97	14.12	14.30	15.22	15.69	14.12
V_2: Radhey	6.30	6.51	11.23	11.56	15.34	16.50	16.85	17.87	18.02	16.50
V_3: KWR-108	5.88	5.99	10.02	10.42	14.09	15.21	15.54	16.64	17.12	15.21
SEm±	0.19	0.20	0.34	0.38	0.43	0.50	0.52	0.54	0.56	0.50
LSD (*p*=0.05)	0.58	0.61	1.03	1.16	1.34	1.52	1.56	1.63	1.68	1.52
Micronutrients										
M_1: Control	5.72	5.89	8.89	9.20	12.11	13.25	13.57	14.64	14.92	13.25
M_2: Zinc @ 0.5%	5.97	6.12	10.24	10.57	14.26	15.39	15.72	16.69	16.97	15.39
M_3: Boron @ 0.2%	5.87	5.97	9.87	10.16	13.88	14.99	15.39	16.24	16.56	14.99
M_4: Iron @ 0.1%	5.78	5.86	9.58	9.91	13.46	14.58	14.87	15.87	15.99	14.58
M_5: Zinc @ 0.5% + Boron @ 0.2 %	6.09	6.24	10.99	11.34	14.97	16.11	16.39	17.38	17.97	16.11
M_6: Zinc @ 0.5% + Iron @ 0.1 %	6.02	6.18	10.58	10.99	14.58	15.72	15.89	16.97	17.65	15.72
M_7: Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 %	6.15	6.34	11.36	11.84	15.67	16.89	17.11	18.24	18.54	16.89
SEm±	0.15	0.17	0.28	0.30	0.36	0.41	0.42	0.43	0.45	0.41
LSD (*p*=0.05)	NS	NS	0.87	0.92	1.11	1.24	1.27	1.31	1.36	1.24
Interaction (V x M)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 3:Effect of Varieties and Micronutrients (Zinc, Boron, and Iron) on Fresh weight (g) of chickpea

Treatments	Fresh weight of plant (g) at 25 DAS		Fresh weight of plant (g) at 50 DAS		Fresh weight of plant (g) at 75 DAS		Fresh weight of plant (g) at 100 DAS		Fresh weight of plant (g) at maturity	
	2018-19	**2019-20**	**2018-19**	**2019-20**	**2018-19**	**2019-20**	**2018-19**	**2019-20**	**2018-19**	**2019-20**
Varieties										
V_1: KGD-1168	7.75	7.96	49.67	51.10	92.41	94.96	133.82	135.76	174.22	177.07
V_2: Radhey	8.47	8.87	55.69	57.94	105.06	107.81	163.81	167.99	213.81	217.91
V_3: KWR-108	8.16	8.47	53.35	54.77	101.80	103.22	157.90	159.63	196.64	200.70
SEm±	0.24	0.26	1.69	1.74	3.04	3.12	4.13	4.22	6.17	6.23
LSD (p=0.05)	NS	NS	5.11	5.23	9.16	9.37	12.48	12.67	18.52	18.73
Micronutrients										
M_1: Control	8.06	8.36	47.23	48.65	80.68	83.74	135.46	136.58	169.12	173.60
M_2: Zinc @ 0.5%	8.26	8.57	53.14	54.67	101.69	104.04	152.59	154.12	193.39	196.25
M_3: Boron @ 0.2%	8.16	8.47	51.61	53.35	97.51	99.45	148.82	151.47	189.82	193.19
M_4: Iron @ 0.1%	7.96	8.36	50.69	52.22	91.19	93.23	143.92	145.15	182.99	185.84
M_5: Zinc @ 0.5% + Boron @ 0.2 %	8.16	8.47	55.90	57.73	109.85	112.00	160.96	163.02	210.85	214.10
M_6: Zinc @ 0.5% + Iron @ 0.1 %	8.06	8.36	54.47	56.00	105.98	107.92	155.96	160.22	202.23	207.22
M_7: Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 %	8.26	8.57	57.32	59.57	111.38	113.73	165.34	170.75	215.85	219.75
SEm±	0.16	0.18	1.09	1.11	2.36	2.41	3.39	3.50	4.76	4.86
LSD (p=0.05)	NS	NS	3.27	3.34	7.13	7.28	10.21	10.54	14.29	14.58
Interaction (V x M)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4:Effect of Varieties and Micronutrients (Zinc, Boron, and Iron) on Yield and Economics of chickpea

Treatments	100- seed weight (g)		Seed yield (kg ha^{-1})		Cost of cultivation (₹ ha^{-1})		Gross returns (₹ ha^{-1})		Net returns (₹ ha^{-1})		B:C ratio	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Varieties												
V_1: KGD-1168	16.18	16.21	1921	2020	29242	30012	101785	103020	72543	73008	2.48	2.43
V_2: Radhey	17.21	17.25	2118	2228	29242	30012	112396	113628	83154	83616	2.84	2.79
V_3: KWR-108	17.04	17.07	2063	2156	29242	30012	109350	109956	80108	79944	2.74	2.66
SEm±	0.33	0.34	62	65	-	-	-	-	-	-	-	-
LSD (p=0.05)	1.01	1.03	187	196	-	-	-	-	-	-	-	-
Micronutrients												
M_1: Control	16.57	16.61	1869	1939	28908	29679	99048	98889	70140	69210	2.43	2.33
M_2: Zinc @ 0.5%	16.84	16.87	2038	2134	29188	29959	108063	108834	78875	78875	2.70	2.63
M_3: Boron @ 0.2%	16.79	16.82	2010	2113	29128	29899	106571	107763	77443	77864	2.66	2.60
M_4: Iron @ 0.1%	16.72	16.75	1967	2102	29093	29864	104314	107202	75221	77338	2.59	2.59
M_5: Zinc @ 0.5% + Boron @ 0.2 %	16.91	16.94	2113	2227	29408	30179	111183	113577	81775	83398	2.78	2.76
M_6: Zinc @ 0.5% + Iron @ 0.1 %	16.89	16.92	2096	2152	29373	30144	111961	109752	82588	79608	2.81	2.64
M_7: Zinc @ 0.5% + Boron @ 0.2 % + Iron @ 0.1 %	16.94	16.97	2162	2276	29593	30364	114634	116076	85041	85712	2.87	2.82
SEm±	0.24	0.25	37	39	-		-	-	-	-	-	-
LSD (p=0.05)	NS	NS	112	119	-	-	-	-	-	-	-	-
Interaction (V x M)	NS	NS	NS	NS	-	-	-	-	-	-	-	-

4. CONCLUSION

The two-year study's findings allowed the following conclusions.Among the varieties, the 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 provedsuperior over the rest of the treatments in withrespect of togrowth, chlorophyll content, relative water content yield attributes, and yield of chickpea.On the basis ofBased on 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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Comment [D4]: Obsolete references!

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