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Effect of varieties and micronutrient applications on yield attributes and yield of chickpea (*Cicer arietinum* L.)

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Abstract
A field experiment was conducted to study the effect of varieties and micronutrient applications on yield attributes and yield of chickpea during two consecutive *rabi* seasons of years 2018-19 and 2019-20, respectively. The experiment was laid out in split plot design with three varieties in main plot *viz.* (V_1) KGD-1168, (V_2) Radhey and (V_3) KWR-108 and seven micronutrient treatments in sub plots *viz.* (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%. The results reported that the higher values of number of pods plant^{-1}, seeds pod^{-1}, seeds plant^{-1}, pod weight plant^{-1}, seed weight plant^{-1}, 100-seed weight (g), seed yield, straw yield and biological yield were recorded with variety Radhey. However it was statistically at par with variety KWR-108 during both the experimental years. Among the micronutrients, application of M_7 (Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1%) recorded higher values of above parameters which were at par with Zinc @ 0.5% + Boron @ 0.2% and Zinc @ 0.5% + Iron @ 0.1%.

Keywords: Harvest index, micronutrients, number of pods, seed yield and zinc

Introduction
Chickpea (*Cicer arietinum* L.) the premier pulse crop of Indian subcontinent, is predominantly consumed as a pulse; dry chickpea is also used in preparation of a variety of snacks, sweets and condiments and green fresh chickpea are commonly consumed as a vegetable. India is the largest chickpea producer as well as consumer in the world. According to the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) chickpea seeds contain on average 21.1% protein, 64% total carbohydrates (47% starch, 6% soluble sugar), 5% fat, 6% crude fibre and 3% ash. High mineral content has been reported for phosphorus (340 mg per 100 g), calcium (190 mg per 100 g) and magnesium (140 mg per 100 g), iron (7 mg per 100 g) and zinc (3 mg per 100 g). The germinated seeds are recommended to cure scurvy. Malic and oxalic acids secreted from leaves locally known as 'Amb', helps to lower the blood cholesterol level. Recent studies have also shown that they can assist in lowering of cholesterol in the bloodstream (Pittway *et al.*, 2008) [20].

The shortage of pulses has aggravated the problem of malnutrition in humans and thus, there is an urgent need for meeting their increasing demand by manipulating the production technologies appropriately. This could be achieved by increasing the area under these crops or by increasing their per unit productivity. The area under pulses does not seem likely to expand, as the land has become limiting factor due to rapid industrialization and urbanization. The low production of this crop is due to improper use of fertilizers, weed competition, improper time of sowing and seed rate, pest and disease management and selection of genotypes (Gaur *et al.*, 2010) [9]. Chickpea varieties play an important role in the production of pulses. Selection of proper variety for a set of agro-climatic conditions is very important to achieve maximum potential, because of differential growth and development behaviour due to different genetic characters of varieties. There are several evidences indicating that the high yielding chickpea varieties are showing response to application of micronutrients. Critical evaluation and selection of the superior varieties with high yield potential and good quality for particular region is, therefore always has a good promise.

In modern agriculture micronutrients are becoming deficient day by day due to intensive cultivation with high yielding varieties of crops using high analysis fertilizers, which not only reduce the crop productivity but also deteriorates the quality of produce. Farmers are not well aware about nutrients management of chickpea. They apply only inadequate major nutrients to chickpea. Four micronutrients *i.e*. Manganese (Mn), Iron (Fe), Copper (Cu) and Boron (B) are required for higher plants (Welch *et al.*, 2005) [29]. This has been well documented to involve in photosynthesis, nitrogen fixation, respiration and other biochemical pathway (Foth and Ellis, 2006) [8]. Micronutrients are essential for the normal growth of plants (Kennedy *et al*., 2003) [13]. Micronutrient malnutrition affects more than half of the world population particularly in the developing countries (Alloway, 2008) [2] and in particular Fe and Zn deficiency in human nutrition are wide-spread in developing Asian countries including India (Shively *et al.,* 2014) [24]. Iron plays an important role in chlorophyll synthesis, being a structural component of hems, hematic and leg-haemoglobin and it is also an important part of the enzyme nitrogen's, which is essential for the N_2 fixation in legumes. The agronomic importance of chickpea is linked to its high protein content and other essential minerals, especially micronutrients. Zinc plays an important role in formation of chlorophyll and growth hormones (Hotz and Brown, 2004; Welch and Graham, 2004) [12, 30]. Zn is recognized as essential component of several enzyme systems having vital roles in the plant metabolism, e.g. carbonic anhydrase for reversible hydration of CO_2 to form HCO_3^- for transport and utilization of CO_2 in photosynthesis. It is also responsible for resisting pH changes in cytoplasm. Zn is involved in auxin metabolism like, tryptophan synthesis, tryptamine metabolism (Shively *et al.*, 2014) [24]. Secondly, Iron is a nutrient that all plants need to function properly. Many of the vital functions of the plant, like enzyme, chlorophyll production, nitrogen fixation, and development and metabolism are all dependent on iron. Without iron, the plant simply cannot function properly (Shively *et al.*, 2014) [24].

Boron regulates transport of sugars through membranes, cell division, cell development and auxin metabolism. Without adequate levels of boron, plants may continue to grow and add new leaves but fail to produce fruits or seeds. The application of B is important when the concentration of B in the soil is less than 0.3 mg kg^{-1} (Ahlawat *et al*., 2007) [1]. A continuous supply of boron is important for adequate plant growth and optimum yields. Boron (B) may cause yield losses of up to 100% (Ahlawat *et al*., 2007) [1]. In general, each tonne of chickpea grain removes 38 g of Zn and it has been estimated that 35 g of B and 1.5 g of Mo are also removed from the soil (Ahlawat *et al*., 2007) [1]. Furthermore, nutrients particularly, micronutrients when applied to the foliage are generally absorbed more rapidly through trichomes present in leaves as well as providing a means of quickly correcting the plant nutrient deficiencies (Welch and Graham, 2004) [30].

However, information regarding varieties and application of micronutrients in chickpea production in Uttar Pradesh is lacking. Keeping in view the above discussed facts of sufficient information and sparce related research, the present investigation was undertaken to find out the effect of varieties and micronutrients application on yield attributes and yield of chickpea in Kanpur conditions.

Materials and Methods

The experiment was conducted during two consecutive *rabi* seasons of years 2018-19 and 2019-20, respectively at Students' Instructional Farm, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur, situated at latitude of 25º 26' to 26º 58 North latitude and East latitude of 79º 31' to 80º 34', with altitude of 125.9 meters above the mean sea level. The total rainfall of 37.5 and 164.0 mm were received during crop growing season of year, 2018-19 and 2019-20, respectively. Soil of the experiment field had sandy loam in texture, slightly alkaline in reaction, low in electrical conductivity, low in organic carbon, available nitrogen and medium in available phosphorus and potassium. However, soil was deficient in micronutrients.

The experiment was laid out in split plot design with three varieties in main plot *viz*. (V_1) KGD-1168, (V_2) Radhey and (V_3) KWR-108 and seven micronutrient treatments in sub plots *viz*. (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%. Each main plot was surrounded by a buffer of 1.5 m width whereas subplot was surrounded by 0.5 m width to protect the plots from accidental irrigation and gain of water through seepage. The treatments were replicated three times. The recommended dose of fertilizers (20:50:50 kg N:P:K ha^{-1}) were applied through prilled urea for nitrogen, single super phosphate for phosphorus, muriate of potash for potash. However, application of Zinc, boron and iron was applied as per treatment by using zinc sulphate monohydrate for zinc, boric acid for boron and ferrous sulphate for iron. Full single super phosphate, muriate of potash and 1/2 part of urea were applied at the time of sowing and remaining 1/2 part of prilled urea was broadcasted at 30 days after sowing. Application of micronutrients was done by using knapsack sprayer at 25 and 50 days after sowing. Observations related to yield attributes and yield were through standard procedures. The data relating to each character were analyzed as per the procedure of analysis of variance and significance was tested by "F" test (Gomez and Gomez 1984) [10].

Results and Discussions

Effect of varieties

Varieties of chickpea influenced significantly almost all the yield attributes and yield (Table 1-4). Variety, Radhey recorded highest values during both the experimental years for number of pods plant^{-1} (43.49 and 43.89), number of seeds pod^{-1} (1.71 and 1.97), seeds plant^{-1} (74.37 and 86.46), pod weight plant^{-1} (17.26 and 17.58 g), seed weight plant^{-1} (13.04 and 13.51), 100-seed weight (17.21 and 17.25 g), seed yield (2118 and 2228 kg ha^{-1}), straw yield (4378 and 4427 kg ha^{-1}) and biological yield (6496 and 6655 kg ha^{-1}). However, variety KWR-108 recorded higher values which were significantly at par with Radhey variety for all the above parameters. While, harvest index could not reach the level of significance with different varieties.

Maximum number of pods plant^{-1} and seeds pod^{-1} was recorded by V_2 (Radhey). This was due to the branching pattern was better with more number of branches, resulting in production of more number of pods plant^{-1}. Similar results were reported by Shivakumar (2001) [22]; Shivay *et al*. (2014) [23]; Sekhar *et al*. (2015) [21].

More of no. of seeds pod^{-1} was noticed in V_2 (Radhey), due to higher canopy contributed to better seed filling than in the other varieties, resulting in production of more number of seeds pod^{-1}. The number of seeds pod^{-1} of chickpea is mostly a genetic parameter and is likely to be altered hardly by agronomic manipulation. In the present investigation, marked variation in the number of seeds pod^{-1} was not noticed. Although a few workers reported slight variation in number of seeds pod^{-1} of chickpea, many researchers did not notice any distinct disparity (Chauhan and Singh, 2000 and Pankaj Kumar and Deshmukh, 2006) [6, 18]. The results are enclosing conformity with the finding of Khatum *et al.* (2010) [15].

The 100-seed weight was also more with V_2 (Radhey) variety due to more branching associated with more leaf area might have produced more photosynthates and supported grain filling better and was resulted in more weight of the seed. Formation and development of seed inside the pod depends up on level of effective translocation of assimilates during the pod formation stage. At different intervals, the larger quantity of dry matter was diverted to pods V_2 (Radhey) variety due to better translocation of assimilates, resulting in high seed weight. Present findings are in concurrence with those of Siag and Yadav (2004) [26]; Chaitanya and Chandrika (2006) [5].

The variety V_2 (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, seed weight etc. Similar results were reported by Panchariya and Lidder (2000) [17]; Shrivastav *et al.* (2000) [25] and Khatun *et al.* (2010) [15].

Effect of micronutrients

Among the micronutrient (Table 1-4), application of Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1% recorded significantly higher number of pods plant^{-1} (43.89 and 44.21), number of seeds pod^{-1} (1.95 and 2.09), seeds plant^{-1} (85.59 and 92.40), pod weight plant^{-1} (17.42 and 17.83 g), seed weight plant^{-1} (13.20 and 13.76), seed yield (2162 and 2276 kg ha^{-1}), straw yield (4372 and 4426 kg ha^{-1}) and biological yield (6534 and 6702 kg ha^{-1}) during *rabi*, 2018-19 and 2019-20, respectively. However, application of Zinc @ 0.5% + Boron @ 0.2% and Zinc @ 0.5% + Iron @ 0.1% were statistically at par with Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1%. While, 100-seed weight and harvest index were could not reach the level of significance with various micronutrients.

It might be due to the reason that zinc, boron and ferrous act as an important catalyst in the enzymatic reactions of plant metabolism would have helped in the larger biosynthesis of photo assimilates thereby improving number of pods plant^{-1}. The foliar spray of other micronutrients also played an important role in improving the number of pods plant^{-1}. The results are in line with the findings of Valenciano *et al.* (2010) [28]; Gupta and Sahu (2012) [11]; Balai *et al*. (2017) [3]; Borah and Saikia (2021) [4]. Combined effect of micronutrients enhanced the number of seeds pod^{-1} and plant^{-1}. This might be due to additional supply of nutrients which increased the synthesis of chlorophyll, photosynthesis and amino acid which ultimately lead to increased the number of seeds. The results are in line with the findings of Khan *et al.* (2000) [14], Tahir *et al*. (2013) [27] and Morad *et al.* (2015) [16].

The increase in the weight of pod and seed might be due to physiological role of zinc, boron and ferrous. The favorable effects of zinc can be attributed to the fact that, the element is essential in nitrogen metabolism and it also increases the synthesis of auxin which promotes the cell size. Moreover, zinc acts as a catalyst in the oxidation and reduction process and is of great importance in sugar metabolism, which might have increased head weight. Moreover, as the soils of Uttar Pradesh are deficient in zinc and gives good response to the zinc application in several crops, because of this fact might have resulted in increasing the weight of heads in this treatment. The effect of boron for improving head weight could be due to its involvement in cell division and expansion. Iron played vital role in chlorophyll metabolism, which favoured more photosynthesis. The present findings are in conformity with the reports of Gupta and Sahu (2012) [11], Morad *et al.* (2015) [16] and Balai *et al.* (2017) [3] who reported that, foliar application of treatment combination of different micronutrients increases the pod and seed weight of chickpea.

Significantly higher seed yield due to contribution of application of different micronutrient combinations to increase in yields can be attributed to enhanced availability of essential plant nutrients at the required growth stages. Hence, increased 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 Valenciano *et al.* (2010) [28], Gupta and Sahu (2012) [11] and Elayaraja (2014) [7].

Table 1: Effect of varieties and micronutrients on no. of pods plant^{-1}, no. of seeds pod^{-1} and no. of seeds plant^{-1} of chickpea

Treatments	No. of pods plant^{-1}		No. of seeds pod^{-1}		No. of seeds plant^{-1}	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Varieties						
V_1: KGD-1168	39.31	39.63	1.45	1.70	57.00	67.37
V_2: Radhey	43.49	43.89	1.71	1.97	74.37	86.46
V_3: KWR-108	41.87	42.31	1.62	1.86	67.83	78.70
SEm±	1.22	1.25	0.04	0.05	2.27	2.58
LSD (p=0.05)	3.67	3.76	0.12	0.15	6.82	7.76
Micronutrients						
M_1: Control	39.00	40.12	1.46	1.59	56.94	63.79
M_2: Zinc @ 0.5%	41.56	41.94	1.73	1.87	71.90	78.43
M_3: Boron @ 0.2%	40.56	40.84	1.67	1.74	67.74	71.06
M_4: Iron @ 0.1%	40.00	40.27	1.59	1.71	63.60	68.86
M_5: Zinc @ 0.5% + Boron @ 0.2%	43.51	43.67	1.89	1.98	82.23	86.47
M_6: Zinc @ 0.5% + Iron @ 0.1%	42.37	42.56	1.86	1.93	78.81	82.14
M_7: Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1%	43.89	44.21	1.95	2.09	85.59	92.40
SEm±	0.69	0.74	0.03	0.04	1.72	1.97
LSD (p=0.05)	2.12	2.23	0.09	0.12	5.21	5.94

Table 2: Effect of varieties and micronutrients on pod weight plant^{-1}, seed weight plant^{-1} and 100- seed weight (g) of chickpea

Treatments	Pod weight plant^{-1}		Seed weight plant^{-1}		100- seed weight (g)	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Varieties						
V_1: KGD-1168	15.03	15.40	10.81	11.33	16.18	16.21
V_2: Radhey	17.26	17.58	13.04	13.51	17.21	17.25
V_3: KWR-108	16.02	16.39	11.80	12.32	17.04	17.07
SEm±	0.52	0.54	0.42	0.44	0.33	0.34
LSD (*p*=0.05)	1.59	1.64	1.28	1.34	1.01	1.03
Micronutrients						
M_1: Control	14.21	14.55	9.99	10.48	16.57	16.61
M_2: Zinc @ 0.5%	16.08	16.45	11.86	12.38	16.84	16.87
M_3: Boron @ 0.2%	15.86	16.22	11.64	12.15	16.79	16.82
M_4: Iron @ 0.1%	15.45	15.76	11.23	11.69	16.72	16.75
M_5: Zinc @ 0.5% + Boron @ 0.2%	17.02	17.38	12.80	13.31	16.91	16.94
M_6: Zinc @ 0.5% + Iron @ 0.1%	16.69	17.02	12.47	12.95	16.89	16.92
M_7: Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1%	17.42	17.83	13.20	13.76	16.94	16.97
SEm±	0.43	0.45	0.25	0.28	0.24	0.25
LSD (*p*=0.05)	1.32	1.36	0.77	0.84	NS	NS

Table 3: Effect of varieties and micronutrients on seed and straw yield (kg ha^{-1}) of chickpea

Treatments	Seed yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
	2018-19	2019-20	2018-19	2019-20
Varieties				
V_1: KGD-1168	1921	2020	3814	3875
V_2: Radhey	2118	2228	4378	4427
V_3: KWR-108	2063	2156	4137	4173
SEm±	62	65	106	109
LSD (*p*=0.05)	187	196	319	327
Micronutrients				
M_1: Control	1869	1939	3729	3772
M_2: Zinc @ 0.5%	2038	2134	4125	4179
M_3: Boron @ 0.2%	2010	2113	4061	4112
M_4: Iron @ 0.1%	1967	2102	3997	4041
M_5: Zinc @ 0.5% + Boron @ 0.2%	2113	2227	4287	4331
M_6: Zinc @ 0.5% + Iron @ 0.1%	2096	2152	4198	4247
M_7: Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1%	2162	2276	4372	4426
SEm±	37	39	74	77
LSD (*p*=0.05)	112	119	224	231

Table 4: Effect of varieties and micronutrients on biological yield (kg ha^{-1}) and harvest index (%) of chickpea

Treatments	Biological yield (kg ha^{-1})		Harvest index (%)	
	2018-19	2019-20	2018-19	2019-20
Varieties				
V_1: KGD-1168	5735	5895	33.50	34.27
V_2: Radhey	6496	6655	32.60	33.48
V_3: KWR-108	6200	6329	33.27	34.07
SEm±	169	174	1.12	1.26
LSD (*p*=0.05)	512	527	NS	NS
Micronutrients				
M_1: Control	5598	5711	33.39	33.95
M_2: Zinc @ 0.5%	6163	6313	33.07	33.80
M_3: Boron @ 0.2%	6071	6225	33.11	33.94
M_4: Iron @ 0.1%	5964	6143	32.98	34.22
M_5: Zinc @ 0.5% + Boron @ 0.2%	6383	6558	32.84	33.96
M_6: Zinc @ 0.5% + Iron @ 0.1%	6311	6399	33.48	33.63
M_7: Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1%	6534	6702	33.09	33.96
SEm±	107	112	0.39	0.44
LSD (*p*=0.05)	324	339	NS	NS

Conclusions

From the above overall study, it is recommended that to obtain higher yield attributes and yield of chickpea should be grown by variety Radhey with application of M_7 (Zinc @ 0.5% + Boron @ 0.2% + Iron @ 0.1%) under ago-climatic conditions of Kanpur region of Uttar Pradesh.

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