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Impact of biofortification of zinc and iron on growth parameters and yields of chickpea *(Cicer arietinum* L.) through agronomic intervention in Chhattisgarh plains

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Abstract
A field experiment was carried out during *Rabi* season in 2018-19 at Instructional Cum Research Farm of IGKV, Raipur (Chattisgarh). To study the "Impact of biofortification of zinc and iron on growth parameters and yields of chickpea (*Cicer arietinum* L.) through agronomic intervention in Chhattisgarh plains" The experiment was laid out in Split Plot Design with four replications. The experiment consists of two varieties viz., Vaibhav and Indira chana-1 and nutrient levels of different zinc and iron treatment combination. The significant variation was found in chickpea varieties and nutrient levels of different zinc and iron treatment combinations. The maximum plant growth parameters viz., plant height, dry matter accumulation, number of branches recorded under variety Indira chana-1. In case of different Zn and Fe treatment combination, the treatment RDF+ Soil application of $ZnSO_4$ @ 25 kg ha^{-1} at basal recorded maximum plant growth parameter viz., plant height, dry matter accumulation, number of branches at 30 DAS and later stage of crop growth treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage" at 60 DAS, 90 DAS and at harvest where as plant population showing non significant variation in varieties and different Zn and Fe treatment combination at 20 DAS. The maximum plant population recorded at harvest under variety Indira chana-1 and treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage followed by treatment RDF+ Soil application of $ZnSO_4$ @ 25 kg ha^{-1} at basal. The maximum seed yield, stover yield and harvest index observed under variety Indira chana-1 as compared to variety vaibhav. In case nutrient levels of different Zn and Fe treatment combination, the treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage recorded maximum seed yield, stover yield and harvest index.

Keywords: Zinc, Iron, biofortification, vegetarians and malnutrition

Introduction
In leguminous crops, Chickpea occupies an important position due to its nutritious value (17-23% protein) in large vegetarian population of the country (Ali and Kumar, 2006) [1]. Pulses are good source of proteins, minerals, vitamins and carbohydrates which plays an important role in human nutrition. Its leaves contain malic acid which is very useful as stomach ailments and blood purification (Shakya, *et al.,* 2008) [13].

Pulses maintains soil fertility through biological atmospheric nitrogen fixation with the help of symbiotic nitrogen fixing bacteria Rhizobium. Micronutrient deficiency Zn and Fe is major problem of now days. Nutrient deficiency is a major factor of lower yield of pulses (Quddus et al., 2011) [11]. Mostly macronutrients are applied and micronutrients are ignored.

Sufficient supply of micronutrients is necessary for normal growth and yield of crops. A balanced nutrition supply, having micro and macronutrients is necessary to attain high yield and quality of field crops (Sawan *et al*., 2001) [12]. Zinc (Zn) is an important element needed by the humans, animals and plants in minor quantity (Kabata-pendias, 2011) [5]. Shenkin (2006) [14] reported that micronutrients like Zn and iron (Fe) are necessary for betterment in the human immune system, normal growth and development. Application of Zn enhance quality and yields of chickpea reported by Khan *et al*., 2003 [7]. As pulses are considered a good source of protein for poor people, improving Zn contents in pulse seed might be useful to reduce malnutrition in human beings.

Material and Methods
A field experiment was conducted at Instructional Cum Research Farm of IGKV, Raipur (Chattisgarh), during *Rabi* season in 2018-19. To study the impact of biofortification of zinc and iron on growth parameter and yield of chickpea (*Cicer arietinum* L.) through agronomic

intervention in Chhattisgarh plain. The experiment comprised of main plots treatment two varieties viz., Vaibhav, Indira chana-1 and nutrient levels of Zn and Fe treatment combination viz., T1: Recommended dose of NPK (Standard control), T2: RDF+ 0.5% $ZnSO_4$ foliar application at flowering and pod formation stage, T3: RDF+ 0.5% FeSO4 foliar application at pre flowering and pod formation stage, T4: RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage, T5: RDF+ Seed treatment 2g $ZnSO_4$ kg^{-1} of seed, T6: RDF+ Soil application of $ZnSO_4$ @ 25 kg/ha at basal in sub plots. The data on plant growth parameter and yields were recorded at different stage of crops. The data of plant population was counted at random five spot as per meter square area. The plant growth parameters viz., plant height, dry matter accumulation and number of branches was recorded at different intervals of time and seed yield, stover yield and harvest index recorded after harvest of crops. The data were tabulated and statistically analysed.

Results and Discussion

Plant population (no. of plant m^{-2})

Plant population was recorded at 20 DAS and at harvest are depicted in Table 1. The plant population at 20 DAS shows non-significant variation. The maximum plant population (28.87) at harvest was observed in variety Indira chana-1 as compared to variety Vaibhav (28.06) at harvest. In case nutrient levels of different Zn and Fe treatment combination, the "highest plant population (30.50) was recorded under treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage compared to other treatment combination and minimum plant population (27.20) was observed in standard control

Plant height (cm)

Plant height was measured at 30, 60, 90 DAS and at harvest are presented in Table 1. The plant height was increased rapidly between 30 to 60 DAS and 60 to 90 DAS. The maximum plant height was observed in chickpea variety Indira chana-1 (19.08, 33.99, 42.80 and 42.79 cm) as compared variety Vaibhav at different intervals of 30, 60, 90 DAS and at harvest, respectively."

In case nutrient levels of different Zn and Fe treatment combination, the highest plant height (19.85 cm) observed at 30 DAS in treatment RDF + soil application of $ZnSO_4$ @ 25 kg ha^{-1} at basal and later stage of crop growth, the treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage had maximum plant height (35.22 cm) at 60 DAS, (45.71cm) at 90 DAS and (45.71 cm) at harvest. The similar results were also recorded by Kayan *et al*., (2015).

Dry matter accumulation (g $plant^{-1}$)

The data on dry matter accumulation was recorded at 30, 60, 90 DAS and at harvest and presented in Table 2. The maximum dry matter accumulation (6.07 g) at 60 DAS, (14.08 g) at 90 DAS, (14.84 g) at harvest were recorded in variety Indira chana-1 and minimum dry matter accumulation were observed in variety Vaibhav whereas 30 DAS shows non-significant variation.

In case nutrient levels of different Zn and Fe treatment combination't the maximum dry matter accumulation at 30 DAS is 0.66 g was observed in soil application of $ZnSO_4$ @ 25 kg ha^{-1} at basal and at later stage of crop growth the treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage recorded maximum dry matter accumulation (6.81 g) at 60 DAS, (15.40 g) at 90 DAS and (16.59 g) at harvest. Similar results were also reported by Amanullah (2010) [2].

Number of branches $plant^{-1}$

The data on number of branches plants-1 was recorded at 30, 60, 90 DAS and at harvest and presented in Table 2.

The maximum number of branches (23.39, 28.07, 28.06) at 60, 90 DAS and at harves respectively was observed in variety Indira chana-1 as compared to variety vaibhav, whereas number of branches observed 30 DAS showed non-significant variation.

In case nutrient levels of different Zn and Fe treatment combination, the significant variation was found in all treatment at different intervals of time except at 30 DAS showed non-significant variation. The more number of branches plant-1 was observed under treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage are (25.00, 30.97 and 30.96) at 60, 90 DAS and at harvest, respectively followed by treatment basal soil application of $ZnSO_4$ @ 25 kg ha^{-1} at harvest compared to other treatment combination. Similar results were found by Verma *et al*. (2017) [15].

Interaction effect of chickpea varieties and nutrient levels of different Zn and Fe treatment combination was showed non significant variation.

Seed yield (kg ha^{-1})

The data on seed yield was recorded and presented in Table 3. The significant variation was found in chickpea varieties and nutrient levels of different Zn and Fe treatments combination. The maximum seed yield (1768.16 kg ha^{-1}) was observed in Indira chana-1 as compared to variety Vaibhav (1640.04 kg ha^{-1}).

In case nutrient levels of different Zn and Fe treatments combination, the maximum seed yields (1858.84 kg ha^{-1}) was recorded under treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage compared to other treatments and minimum seed yield (1458.69 kg ha^{-1}) under treatment RDF (Standard control). The similar results was observed by Anitha *et al*. (2005) [3], (Mali *et al*., 2003) [9] and (Jin *et al*., 2008) [4].

Interaction effect of chickpea varieties and nutrient levels of different Zn and Fe treatment combination was showed non-significant variation.

Table 1: Plant population and Plant height of chickpea as influenced by varieties and biofortification Zn and Fe through agronomic intervention

Treatment	Plant population (no. m^{-2})		Plant height (cm)			
	20 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Varieties						
V_1 – Vaibhav	30.06	28.06	17.37	32.45	41.37	41.36
V_2 - Indira chana-1	31.03	28.87	19.08	33.99	42.80	42.79
SEm±	0.24	0.10	0.19	0.15	0.13	0.14
CD (p= 0.05)	NS	0.46	0.89	0.70	0.63	0.67
Nutrient levels						
T_1 - Recommended dose of NPK (standard control)	29.65	27.20	17.17	31.50	38.22	38.20
T_2 - RDF + 0.5% $ZnSO_4$ foliar application at pre flowering and pod formation stage	30.72	28.80	17.98	33.30	42.48	42.47
T_3 - RDF + 0.5% $FeSO_4$ foliar application at pre flowering and pod formation stage	30.02	27.57	17.75	32.93	41.05	41.03
T_4 - RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage	32.05	30.50	17.72	35.22	45.71	45.70
T_5 - RDF+ Seed treatment 2 g $ZnSO_4$ kg^{-1} of seed	30.07	28.02	18.87	31.96	40.20	40.17
T_6 - RDF+ Soil application of $ZnSO_4$ @ 25 kg ha^{-1} at basal	30.77	28.72	19.85	34.42	44.85	44.83
SEm±	0.54	0.71	0.34	0.28	0.31	0.29
CD (p= 0.05)	NS	2.08	1.00	0.83	0.90	0.87

Table 2: Dry matter accumulation and number of branches $plant^{-1}$ of chickpea as influenced by varieties and biofortification of Zn and Fe through agronomic intervention

Treatment	Dry matter accumulation (g $plant^{-1}$)				Number of branches $plant^{-1}$			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
Varieties								
V_1 – Vaibhav	0.60	5.78	13.14	13.97	3.44	22.00	27.17	27.16
V_2 - Indira chana-1	0.62	6.07	14.08	14.84	3.53	23.39	28.07	28.06
SEm±	0.013	0.04	0.17	0.17	0.04	0.23	0.18	0.11
CD (p= 0.05)	NS	0.19	0.80	0.81	NS	1.07	0.85	0.54
Nutrient levels								
T_1 - Recommended dose of NPK (standard control)	0.57	4.84	12.02	12.69	3.32	19.25	24.87	24.84
T_2 - RDF + 0.5% $ZnSO_4$ foliar application at pre flowering and pod formation stage	0.60	6.06	13.85	14.53	3.52	23.17	27.77	27.76
T_3 - RDF + 0.5% $FeSO_4$ foliar application at pre flowering and pod formation stage	0.59	5.71	13.22	13.96	3.45	22.30	26.87	26.85
T_4 - RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage	0.61	6.81	15.40	16.59	3.65	25.00	30.97	30.96
T_5 - RDF+ Seed treatment 2 g $ZnSO_4$ kg^{-1} of seed	0.63	5.56	12.56	13.23	3.40	22.07	26.15	26.12
T_6 - RDF+ Soil application of $ZnSO_4$ @ 25 kg ha^{-1} at basal	0.66	6.57	14.60	15.40	3.57	23.70	29.10	29.08
SEm±	0.017	0.11	0.30	0.26	0.07	0.38	0.49	0.45
CD (p= 0.05)	0.05	0.33	0.88	0.75	NS	1.12	1.42	1.31

Stover yield (kg ha^{-1})

The data on stover yield was recorded and presented in Table 3. The maximum stover yield (2906.71 kg ha^{-1}) was observed in variety Indira chana-1 and minimum stover yields (2807. 87 kg ha-1) was observed in variety Vaibhav.

In case nutrient levels of different Zn and Fe treatments combination, the results showed significant variation among different treatments combination. The maximum stover yield (2936.24 kg ha-1) was recorded under treatment RDF +$ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage than other treatments and minimum stover yield (2784.04 kg ha-1) was observed in treatment RDF (Standard control). Similar results observed by Anitha *et al*. (2005) [3].

Interaction effect of chickpea varieties and nutrient levels of different Zn and Fe treatment combination was showed non-significant variation.

Harvest index (%)

The harvest index was calculated and presented in Table 3. The data showed non significant difference between both the varieties.

In case nutrient levels of different Zn and Fe treatments combination, the maximum harvest index (38.77%) was recorded in treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage compared to all other treatments and minimum harvest index (34.37%) was observed in treatment RDF (Standard control). Similar results was observed by Nandan *et al*. (2018).

Interaction effect of chickpea varieties and nutrient levels of different Zn and Fe treatment combination was showed non significant variation.

Conclusion

From the results it concluded that the maximum plant growth parameters viz., plant population, plant height, dry matter accumulation and number of branches $plant^{-1}$ was observed under variety Indira chana-1 as compared to variety Vaibhav. Similarly maximum seed and stover yield was recorded under variety Indira chana-1 whereas harvest index showed non-significant variation.

In case nutrient levels of different Zn and Fe treatments combination, the data showed significant variation among treatments combination. The application of RDF+ $ZnSO_4$ and $FeSO_4$ through foliar at pre flowering and pod formation stage

has beneficial influence on plant growth parameters viz., plant population, plant height, dry matter accumulation and number of branches plant^{-1}. Similarly maximum seed yield, stover yield and harvest index observed under treatment RDF+ $ZnSO_4$ and $FeSO_4$ through foliar at pre flowering and pod formation stage and interaction effect of chickpea varieties and nutrient levels of different Zn and Fe treatment combination was showed non significant variation.

Table 3: Yields of chickpea as influenced by varieties and biofortification Zn and Fe through agronomic intervention

Treatment	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)
Varieties			
V_1 - Vaibhav	1640.04	2807.87	36.80
V_2 - Indira chana-1	1768.16	2906.71	37.77
SEm±	19.52	10.62	0.34
CD (p= 0.05)	90.99	49.53	NS
Nutrient levels			
T_1 - Recommended dose of NPK (standard control)	1458.69	2784.04	34.37
T_2 - RDF + 0.5% $ZnSO_4$ foliar application at pre flowering and pod formation stage	1775.27	2877.60	38.11
T_3 - RDF + 0.5% $FeSO_4$ foliar application at pre flowering and pod formation stage	1690.59	2853.00	37.19
T_4 - RDF+ $ZnSO_4$ and $FeSO_4$ through foliar application at pre flowering and pod formation stage	1858.84	2936.24	38.77
T_5 - RDF+ Seed treatment 2 g $ZnSO_4$ kg^{-1} of seed	1648.64	2804.11	36.98
T_6 - RDF+ Soil application of $ZnSO_4$ @ 25 kg ha^{-1} at basal	1792.55	2888.74	38.28
SEm±	30.57	34.88	0.41
CD (p= 0.05)	88.72	101.23	1.19

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