Effect of Zn & Fe on growth, yield and quality of Chick pea [*Cicer arietinum* (L.)]

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ABSTRACT

Zinc (Zn) and iron (Fe) deficiency-related health problems in humans may be elucidated by improving their concentration in edible grains. The study was carried out during Rabi season in the semi-arid eastern plain zone (Zone-III) of Rajasthan state. The experiment was conducted in Split Plot Design (SPD), with two varietal treatments assigned to main plot and five nutrient management practices allocated to sub-plot *viz*. V_1 (RSG-888), V_2 (RSG-902), and F_1 {Water Spray}, F_2 {Foliar Application of Zinc sulphate @ 0.5%}, F_3 {Foliar Application of Ferrous sulphate @ 0.5%}, F_4 { Foliar Application of Zinc sulphate & Ferrous sulphate @ 0.5%} , F_5 { Soil Application of Zinc sulphate @ 25Kg/ha}. The seeds were transplanted at a spacing of 30 x 10 cm. It is conclude from result that the treatment F_5 {Soil application of zinc sulphate 25 kg ha^{-1} (F_5)} was found superior over other treatments in terms of growth, yield and quality of Chickpea with highest B:C ratio (1.37). Seed yield and protein content were significantly increased over control with these treatments.

Key words: Biofortification, Chickpea, Iron, Zinc and Protein content

INTRODUCTION

Seeds of chickpea serve as a staple source of protein in human diets, especially for those with vegetarian food habit. Enhancement of the nutritional composition of chickpea and other food legumes has the potential to combat micronutrient malnutrition besides having beneficial effects on human health. Chickpea (*Cicer arietinum* L.) is an important pulse crop in the world ranking second after dry bean and constitutes 20% of the world's production [**1**]. It is belongs to genus *Cicer*, tribe Cicereae, family Fabaceae, and subfamily Papilionaceae. It is a self-pollinated annual crop that can complete its life cycle in 90 to 180 days depending on the prevailing meteorological conditions. The crop plays an important role in human diet and agricultural systems [2]. Chickpea is rich source of highly digestible dietary protein (21.7%), low in fat (4.2%) and sodium (24 mg), cholesterol free and is an excellent source of both soluble and insoluble fibre (3.9%), ash (2.7%), complex carbohydrates (54.2%), vitamin-A (67 IU), vitamin-C (4 mg), niacin (1.541 mg), riboflavin (0.212

mg), folate (557 µg), thiamin (0.477 mg) and minerals, especially calcium (280 mg), phosphorus (301 mg), iron (6.2 mg), zinc (2.76 mg) and magnesium (79 mg) [**3**,**4**,**5**].

Chickpea is grown mostly in South Asia and Sub-Saharan Africa, which accounts for more than 75% of the world chickpea's area. Globally, chickpea grown over an area of 139.81 lakh ha with a production of 137.3 lakh tones and productivity 982 kg/ha yield [**6**] [**7**]. India ranked first in area and production in the world, followed by Pakistan, Iran and Australia. Chickpea's cultivation area in India is 99.27 lakh ha, production is 98.80 lakh tones and productivity 995 kg/ha yield [**8**]. In India Rajasthan has third place in cultivated area and second place in production. In Rajasthan cultivated area is 13.72 lakh ha, production 12.10 lakh tones and productivity is 882 kg/ha yield.

Wuehler *et al.* reported that approximately 20.5% of the world's population is estimated to be at risk of inadequate Zn intake, with the percentage of individuals at risk highest in the South East Asia (33%) followed by Sub Saharan Africa (28%), South Asia (27%), Latin America and the Caribbean (25%) [**9**]. Micronutrient deficiency remains a significant public health concern, especially deficiencies in iron, vitamin A, folic acid, iodine, and zinc (Zn), affecting the physical and mental functioning and growth, brain development during pregnancy, visual impairment, increased susceptibility to diseases, and increased mortality risk [**10**]. A number of studies have reported the growth and yield responses of chickpea cultivars grown under micronutrient deficient soils [**11**, **1**2, **13**, **14, 15**]. The magnitude of yield losses in chickpea due to nutrient deficiency varies among the nutrients [**16**]. The use of fertilizer can be considered an important complementary approach to the breeding efforts to develop cultivars adapted to soils with low micronutrient availability. A recent report by Shivay et al. [**17**] indicated that the application of Zn had a positive effect on grain yield and seed Zn concentration, especially under Zn deficient soils. Iron acts as a co-factor for several enzymes performing basic functions in human body. Inadequate supply of iron contributes to disability, anemia and stunted mental growth.

Agronomic biofortification is one of effective approach to curbing micronutrient deficiencies in the edible part of crop to address the global challenge of micronutrient malnutrition over short-term. In order to increase the concentration of Zn & Fe in edible tissue like seed, the application of micronutrient fertilization as foliar spray improves the uptake of these minerals by plants as the foliar-applied Zn & Fe are phloem-mobile and can be readily trans located into developing grains (Anderson, 2015). Taking perception of all the above-mentioned facts, the present investigation was conducted to determine the effect of zinc sulphate & ferrous sulphate on growth, yield and quality of chickpea [*Cicer arietinum* (L.)].

MATERIALS AND METHOD

Experimental site: - The experiment was conducted in the semi-arid eastern plain zone (Zone-III) of Jaipur District, Rajasthan state in *Rabi* season of 2018-19. Geographically, the study area is located at 075°88'99" E longitude and 26°81'17" N latitude at an altitude of 389 meters above mean sea level. The region's climate is classified as semi-arid with characterized by aridity of the atmosphere and extremity of temperature both in summer (45.5ºC) and winter (4ºC) with annual rainfall of 500-700 mm. The soil of experimental field was loamy sand in texture, slightly alkaline in reaction.

Experimentation and crop husbandry: - The field experiment was laid out with two varietal treatments consigned to main plot and five nutrient management practices assigned to sub-plot of split plot design. The experiment consisting of five treatment combinations *viz.*, F_1 {Water Spray}, F_2 {Foliar Application of Zinc sulphate @ 0.5%}, F_3 {Foliar Application of Ferrous sulphate @ 0.5%}, F_4 {Foliar Application of Zinc sulphate & Ferrous sulphate @ 0.5%}, F_5 {Soil Application of Zinc sulphate @ 25Kg/ha} were applied on two varieties of chickpea assigned to main plot i.e. V_1 (RSG-888), V_2 (RSG-902). Standard crop production practice and methods were followed for weeding, fertilizer application and crop protection management to grow the crop.

Data collection: - Five plants were selected from net plot and tagged for measurement of number of pod plant^{-1}, number of seeds pod^{-1}, test weight, seed yield, straw yield, biological yield and harvest index of chickpea. Total numbers of pods of the five plants selected from the net plot were counted and mean value for number of pods plant^{-1} was calculated. Ten pods were randomly selected from each plants and numbers of seeds pod^{-1} were counted and mean value of seeds pod^{-1} was calculated. 1000 seeds were counted from seed sample taken from seed yield of each plot separately and weighed on electric balance. The weight was recorded as test weight of respective treatment. The weight of crop biomass (biological yield) including above-ground shoot with pod, stem and foliage was recorded. The harvested plants in the net plot (excluding the border rows) were threshed, dried and cleaned to record the seed yield. The net plot yield was converted to kg per hectare. Straw yield was obtained by subtracting the seed yield (q ha^{-1}) from biological yield. The harvest index is the ratio of seed yield to biological yield and expressed in percentage. Economics of different treatments were worked out by considering the cost of inputs and income obtained from output based on the prevailing market price.

Statistical analysis: - Comprehensive statistical analysis (treatment mean, standard error mean, critical difference and range of variation) and test of significance test (F-test) were carried out for each quantitative and qualitative trait. For this, entire biometric data recorded during the course of investigation were compiled in proper tables and statistically analysed by using the standard procedures of statistical analysis for split plot design (Gomez and Gomez, 1984). The critical differences were calculated to assess the significance of treatment mean wherever the 'F' test was found significant at 5 per cent level of significance.

RESULTS AND DISCUSSION

Yield attributes and yield: - Data revealed that the yield attributing and yield character i.e. pods/plant, seeds/pod, seed yield, straw yield, biological yield of chickpea was also significantly influenced by different biofortification strategies. Among the different strategies, the soil application of zinc sulphate @ 25 kg/ha was recorded significantly a greater number of pods/plant (32.70), number of seeds/pod (1.32), seed yield (1519 kg/ha), straw yield (1920 kg/ha), biological yield (3439 kg/ha) compared to the remaining treatments. Although, the influence of biofortification strategies on seed index was found non-significant. Similarly, the lowest value of all the yield attributes was noticed from the plot sprayed with water. It was obvious found that the harvest index of chickpea varieties remained non-affected with different adapted strategies of biofortification. The effect of micronutrients on yield of Chickpea after application of Fe & Zn fertilization significantly increased the plant height and dry matter production of chickpea. The physiological basis for Zn efficiency and its importance for plant adaptation under low soil Zn availability have been reported by several authors [**30**,**31**,**32**]. The genotypic differences in Zn efficiency may be associated with different mechanisms in rhizosphere and within a plant system. These included higher uptake of zinc by roots and efficient use and re-translocation of Zn [**31**]. Cakmak et al. [**33**] reported that Zn efficiency in cereal is mainly related to the difference in the acquisition of Zn by the roots.

Economics: - Summary of the data on net returns and B: C ratio of chickpea revealed that all the treatments had significant impact on net returns and B: C ratio of mustard. The significantly maximum net return (₹ 19407 ha^{-1}) and B: C ratio (1.37) was obtained with the soil application of zinc sulphate @ 25 $kgha^{-1}$ which was closely followed by treatment foliar application of zinc sulphate @ 0.5% (₹14182 ha^{-1}) and foliar application of zinc sulphate & ferrous sulphate (₹13114 ha^{-1}) but superior to all other treatments.. Among the different biofortification approaches, soil application of zinc sulphate @ 25 kg/ha had statistically maximum gross return (72098 ₹/ha) over the remaining treatments. However, the effect of all the biofortification strategies on the net return and BC ratio was found non-significant. But, still the lowest value of all these parameters was retained by the water spray treatment.

CONCLUSION

It is revealed from the findings of present investigation that among the biofortification strategies, the soil application of zinc sulphate @ 25 kg/ha gave the best results with regards to the growth parameter, yield attributes and yield. The treatment of foliar application of 0.5% zinc sulphate and ferrous sulphate at pre-flowering and pod formation stage enhanced the Zn and Fe concentration in seed and straw. Soil application of 25 kg/ha $ZnSO_4$ had also statistically comparable Zn content in seed and straw with two foliar sprays of 0.5% zinc sulphate and ferrous sulphate.

Table 1. Effect of Zinc sulphate and ferrous sulphate on yield attributes and yield of chickpea

Treatments	Yield attributes			Yield (kg ha^{-1})			Harvest index (%)
	Number of pod $plant^{-1}$	Number of seeds pod^{-1}	Seed index	Seed yield	Straw yield	Biological yield	
F_1	28.11	1.14	17.44	1306	1649	2955	44.5
F_2	29.20	1.18	17.58	1357	1713	3070	44.2
F_3	28.91	1.17	17.40	1343	1699	3042	44.6
F_4	29.52	1.19	17.77	1372	1732	3104	43.8
F_5	32.70	1.32	18.40	1519	1920	3439	43.4
SEm$\pm$	0.92	0.04	0.55	42.32	53.11	95.36	0.28
CD	2.76	0.11	1.66	126.87	159.21	285.89	NS

Table 2. Effect of Nitrogen and Sulphur on economics of Mustard

Treatment	Cost of Cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	Benefit Cost ratio
F_1	49544	61987	12443	1.25
F_2	50202	64384	14182	1.28
F_3	51371	63745	12375	1.24
F_4	51982	65096	13114	1.25
F_5	52691	72098	19407	1.37
SEm±	-	2008	3586	0.04
CD	-	6020	NS	NS

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