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EFFECT OF FOLIAR APPLICATION OF MICRONUTRIENTS ON CHEMICAL, BIOCHEMICAL PARAMETERS AND YIELD ATTRIBUTES IN CHICKPEA (*Cicer arietinum* L.)

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ABSTRACT

An investigation was undertaken at farm of Botany, College of Agriculture, Nagpur during the *rabi* season of 2020-21. The experiment was set in randomized block design with three replications and ten treatments of ferrous sulphate and zinc sulphate (0.25%, 0.5%, 1%) sprayed individually and in combination. Spraying was done at 25 and 45 DAS. Spraying the plants with 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ significantly enhanced the total chlorophyll content, nitrogen content, phosphorus content, potassium content, number of pods plant^{-1}, weight of pods plant^{-1}, number of seeds plant^{-1}, 100-seed weight, seed yield plant^{-1}, seed yield ha^{-1}. Next to this treatment combine application of 0.25% $FeSO_4$ + 0.25% $ZnSO_4$ also showed their superiority over other treatments in enhancing all above parameters.

(Key words ; Ferrous sulphate, zinc sulphate, yield, chickpea)

INTRODUCTION

Chickpea is the second most important *rabi* pulse crop after pigeon pea in the world for human diet and other use which has high digestible protein, iron, vitamin B and C. Its leaves contain malic acid which is very useful as stomach ailments and blood purification (Shakya *et al.*, 2008). This crop showing 17-24% protein, 41-51% carbohydrates, and a high percentage of other mineral nutrients and unsaturated linoleic and oleic acids and is *Cicer arietinum* (L). (2n=16) belongs to genus Cicer, tribe cicereae, family Leguminosae and subfamily Papilionaceae. Chickpea is high in protein, low in fat and sodium, cholesterol-free, and is an excellent source of both soluble and insoluble fibre, complex carbohydrates, vitamins, folate, and minerals especially calcium, phosphorus, iron, zinc, and magnesium (Nwokolo and Smart, 1996). It may also lower blood cholesterol levels due to its high content of soluble fibre and vegetable protein. These facts have made chickpea a potential staple food to help reduce micronutrient deficiencies in humans globally. Chickpea is a valued crop and provides nutritious food for an expanding world population and will become increasingly important with climate change. The nutritional value of chickpea in terms of nutrition and body health has been recently emphasized frequently by a nutritionist in the health and food area in many countries around the world.

Iron is an indispensable microelement and required by the plant in a tracer amount for their optimal growth and productivity (Curie and Briat, 2003). Iron is an essential micronutrient for plant growth and also establishes its relative significance in eliminating the adverse effect of chlorosis in plants. Iron is found to be localized inside the different cellular compartments such as chloroplasts, mitochondria and vacuoles (Jeong and Guerinot, 2009). It also acts as a redox cofactor in a variety of plant cellular metabolism (Puig *et al.,* 2005).

Zinc performs several important functions in plants such as regulation of carbonic anhydrase for fixation to carbohydrates in plants (Carbon dioxide to reactive bicarbonate species), promotion of the metabolism of carbohydrate, protein, auxin, pollen formation (Marschner 1995), etc., governs biological membranes and performs defense mechanism against harmful pathogens, presence of Zn as a cofactor, protects the plant from oxidative stress and the fundamental attribute of Zn is being the component of all the six enzyme classes are as follows oxidoreductases, transferases, hydrolases, lyases, isomerases, ligases. Additionally, Zn being participatory in the structure of Rubisco activates several biochemical reactions in the photosynthetic metabolism (Brown *et al.*, 1993).Consider the above facts previous investigation was under taken for study the effect of foliar.

MATERIALS AND METHODS

The present study was conducted at farm of Agril. Botany section, College of Agriculture, Nagpur in a Randomized Block Design with ten treatments and three replications. Treatments comprising T_1- Control, T_2- 0.25%

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$FeSO_4$, T_3- 0.5% $FeSO_4$, T_4- 1.0% $FeSO_4$, T_5- 0.25% $ZnSO_4$, T_6- 0.5% $ZnSO_4$, T_7- 1.0% $ZnSO_4$, T_8- 0.25% $FeSO_4$ + 0.25% $ZnSO_4$, T_9- 0.5% $FeSO_4$ + 0.5% $ZnSO_4$ and T_{10}- 1.0% $FeSO_4$ + 1.0% $ZnSO_4$ were evaluated in a randomised block design with three replications. Each plot measured 2.10 m × 2.20 m gross and 1.50 m × 2.00 m net with spacing of 30 cm x 10 cm. At 25 and 45 DAS two foliar sprays of ferrous sulphate and zinc sulphate were given as per treatment. In the present study analysis of total chlorophyll and NPK content in chickpea were taken at 25, 45, 60 and 75 DAS. Total chlorophyll content of oven dried leave was estimated by colorimetric method as suggested by Bruinsma (1982). Nitrogen content in leaves was estimated by micro kjeldahl's method as given by Somichi *et al*, 1972. Phosphorus content in leaves was determined by vando-molybdate yellow colour method suggested by Jackson (1967). Potassium content in leaves was estimated by di-acid extract as given by Jackson (1967). Protein content in seed, number of pods, weight of pod, number of seeds plant^{-1}, 100 seed weight were calculated after harvest. Data was estimated by to statistical analysis as per method suggested by Panse and Sukhatme (1958).

RESULTS AND DISCUSSION

Total chlorophyll content in leaves

Chlorophyll is an antioxidant compound which is present and store in the chloroplast of green leaves and plants and mainly it is present in the green areas of leaves, flower, stem and root. These are essential photosynthetic pigments capable of absorbing light energy for the synthesis of carbohydrates. Chlorophyll content of the plant tissue represents the photosynthetic capacity of plant.

The greenness of the leaf is generally considered to be a parameter contributing to yielding ability of cultivar. Leaves constitute most important aerial organ of the plants, playing a major role in the anabolic activities by means of the so called 'green pigments or chlorophyll' is the sole medium of the photosynthetic progress which in turn is the major synthesis pathway operatives in plants.

Data on leaf chlorophyll content in leaves gave significant variation at 45, 60 and 75 DAS except 25 DAS.

At 45 DAS total chlorophyll content in leaves ranged between 1.52-1.91 mg g^{-1}. Significantly highest chlorophyll content was observed in treatment T_9 (0.5% $FeSO_4$+ 0.5% $ZnSO_4$) followed by treatment T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$), T_3 (0.5% $FeSO_4$) over control and rest of the treatment. Treatments T_{10} (1.0% $FeSO_4$+ 1.0% $ZnSO_4$), T_5 (0.25% $ZnSO_4$) and T_2 (0.25% $FeSO_4$) also observed significantly higher chlorophyll content when interrelated with treatment T_1 (control). But, treatments T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) were found at par with control.

At this stage (60 DAS) total chlorophyll content in leaves varied from 2.03-3.14 mg g^{-1}. The significantly maximum chlorophyll noticed in treatment T_9 (0.5% $FeSO_4$+ 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$), T_3 (0.5% $FeSO_4$), T_{10} (1.0% $FeSO_4$+ 1.0% $ZnSO_4$) and T_5 (0.25% $ZnSO_4$) over control and rest of the treatments. Next to these treatments significantly more chlorophyll content was also recorded in treatmentsT_2 (0.25% $FeSO_4$), T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) over control and rest of the treatments.

At 75 DAS significantly highest total chlorophyll content in leaves was registered in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$) and T_6 (0.5% $ZnSO_4$). Next to these treatments significantly higher chlorophyll content was also recorded in treatments T_3 (0.5% $FeSO_4$), T_{10} (1.0% $FeSO_4$+ 1.0% $ZnSO_4$) and T_5 (0.25% $ZnSO_4$) over control and rest of the treatments. Next to these treatments again significantly more chlorophyll content was also recorded in treatment T_2 (0.25% $FeSO_4$) over control. But, treatments T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) were found at par with control.

The encouraging effect of the iron application on CO_2 assimilation and photosynthetic pigments is due to the association of iron with chlorophyll formation (Rout and Sahoo, 2015). Iron functions as a component of proteins in significant cellular events such as respiration and cell division; moreover, it has a role in the reduction steps of important biological events, such as nitrogen fixation, transpiration and photosynthesis, and also in chlorophyll biosynthesis.

The results indicate that the higher value of chlorophyll content was noted by the foliar application of iron and zinc. It might be due to zinc and iron take part in chlorophyll synthesis and imparts dark green colour to the plants. These might be the reasons for an increase in chlorophyll content in the present investigation.

Purushottam *et al*. (2017) studied the growth and yield of chickpea (*Cicer arietinum* L.) as influenced by irrigation scheduling and zinc application. The results of the experiment revealed that treatment irrigation at branching + pre-flowering + pod development and Zn (0.5% zinc sulphate) recorded the highest chlorophyll content (3.14 mg g^{-1}). Pal *et al.* (2019) observed that foliar application of both $ZnSO_4$ (0.5%) and urea (2%) spread to foliage at flowering and flowering + pod formation stage significantly enhanced chlorophyll content in leaves of chickpea.

Nitrogen content in leaves

Nitrogen is as vital as it is a major component of chlorophyll, the compound by which photosynthesis occurs. It is a major component of amino acids, the building block of proteins. It has more influence on plant growth, appearance and quality than any other essential element. The nitrogen present mostly as protein is constantly moving and under the concentration of nitrogen is found in young leaves, tender plant tissues like tips of shoots, buds and new leaves. An abundance of essential nitrogenous compounds is required in each plant cell for normal cell division, growth and respiration.

At 45 DAS N content was differed among the treatments and ranged from 1.88–2.79%. The best and significant results were obtained in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$) and T_3 (0.5% $FeSO_4$) also showed significantly more nitrogen content over control and rest of the treatments. Treatments T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$), T_5 (0.25% $ZnSO_4$) and T_2 (0.25% $FeSO_4$) also observed significantly higher nitrogen content when interrelated with treatment $T_{1.}$

At 60 DAS N content in leaves ranged from 2.87–3.71%. Significantly maximum increment in N content over control was observed in case of treatment T_9 (0.5% $FeSO_4$+ 0.5% $ZnSO_4$) followed by treatment T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$) and T_3 (0.5% $FeSO_4$). Treatments T_{10} (1.0% $FeSO_4$+ 1.0% $ZnSO_4$), T_5 (0.25% $ZnSO_4$) and T_2 (0.25% $FeSO_4$) also showed significantly more nitrogen content over control. Whereas, treatments T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) exhibited least nitrogen content and found at par with control.

Among all the treatments significantly maximum N content at 75 DAS was recorded in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$) and T_6 (0.5% $ZnSO_4$) over control and rest of the treatments. However, treatments T_3 (0.5% $FeSO_4$), T_{10} (1.0% $FeSO_4$+ 1.0% $ZnSO_4$), T_5(0.25% $ZnSO_4$), T_2(0.25% $FeSO_4$), T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) were found also significantly superior in a descending manner when compared with treatment T_1 (control) in leaf nitrogen content.

Younger leaves and developing organs such as seeds act as strong sink demand and may heavily draw nitrogen for their growth from older leaves. So, a decrease in the nitrogen content may occur in later stages of plant growth. The effect of zinc application on chlorophyll mainly attribute to more availability of zinc both during seedling and subsequent stages of plant growth which has been known to increase photosynthates and 'N' fixation. Zn and Fe enhance enzymatic activity and translocation processes from leaves to grain linking or converting to other plant metabolites (Amin *et al.*,2013). This might be the reason for the increase in nitrogen content in the present study.

Similar results were obtained by the following scientist. Blesseena *et al.* (2020) found that the foliar application of 100 ppm tocopherol + 0.5 % $ZnSO_4$ recorded the highest nitrogen content in the leaves of chickpea. Pise *et al.* (2020) reported that foliar application of $ZnSO_4$ 0.5 % + $FeSO_4$ 0.5% at 25 and 40 DAS showed a significant increase in nitrogen content in leaves of lathyrus.

Phosphorus content in leaves

Phosphorus is a part of the nucleic acid structure of plants which is responsible for the regulation of protein synthesis. Without phosphorus, photosynthesis does not occur. Phosphorus plays a key role in complex energy transformations that are necessary to all life, as the main ingredient in the form of ATP (adenosine triphosphate).

Data pertaining to phosphorus content in leaves were estimated at four stages of observations *i.e.* 25, 45, 60 and 75 DAS. Phosphorus has been recognized as an important environmental factor limiting crop growth and production. Significant results were recorded at all the stages of observations *viz.,* 25, 45, 60 and 75 DAS except 25 DAS.

At 45 DAS treatment T_9 (0.5% $FeSO_4$+ 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$), T_3 (0.5% $FeSO_4$), T_{10} (1.0% $FeSO_4$+ 1.0% $ZnSO_4$) and T_5 (0.25% $ZnSO_4$) were increased leaf phosphorus content over control and rest of the treatments. Treatments T_2 (0.25 % $FeSO_4$) and T_7 (1.0% $ZnSO_4$) also significantly enhanced leaf phosphorus content over control.Treatment T_4 (1.0% $FeSO_4$) was found at par with control in leaf phosphorus content.

At 60 DAS treatment T_9 (0.5% $FeSO_4$+ 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$) and T_3 (0.5% $FeSO_4$) registered significantly highest leaf phosphorus content when compared with control and remaining treatments. Treatment T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$) also showed their significance in phosphorus content over control and rest of the treatments. Treatments, T_{10}(1.0% $FeSO_4$+ 1.0% $ZnSO_4$), T_5 (0.25% $ZnSO_4$), T_2 (0.25% $FeSO_4$), T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) depicted least phosphorus content and were found at par with control.

At 75 DAS significantly maximum phosphorus content was examined in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$), T_3 (0.5% $FeSO_4$), T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$), T_5 (0.25% $ZnSO_4$) and T_2 (0.25% $FeSO_4$) over control and rest of the treatments under study. Next to these treatment, T_7 (1.0% $ZnSO_4$) showed significantly more phosphorus content. Whereas, treatment T_4 (1.0% $FeSO_4$) showed least phosphorus content and remained at par with control.

The reason behind the increase in the phosphorus content gradually up to 60 DAS might be due to translocation of leaf phosphorus and it's utilization for the development of food storage organs. Zn and Fe enhance enzymatic activity and translocation processes from leaves to grain filing or converting to other plant metabolites (Amin *et al.*,2013).

Raut *et al.* (2020) reported that spraying with 200 ppm of ascorbic acid and 0.5% zinc sulphate significantly enhanced phosphorus content in leaves of chickpea.

Potassium content in leaves

Potassium is an essential macronutrient for plants involved in many physiological processes. It triggers the activation of enzymes and essential for the production of Adenosine Triphosphate (ATP) which is an important energy source for many chemical processes taking place in plants. It is an important macronutrient for plants involved in many physiological processes. It regulates the opening and closing of stomata therefore regulates, carbon-dioxide uptake. Plant responses to low potassium involve changes in the concentrations of many metabolites as well as an alteration in the transcriptional levels of many genes and the activity of many enzymes.

It is evident from the data that potassium content at 45 DAS was significantly maximum in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$) and T_6 (0.5% $ZnSO_4$)over control and rest of the treatments under study. Next to these treatments significantly higher potassium content was also recorded in treatments T_3 (0.5% $FeSO_4$), T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$) and T_5 (0.25% $ZnSO_4$) when compared with control. Treatments, T_2 (0.25% $FeSO_4$), T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) exhibited least potassium content and remained at par with control.

At 60 DAS significantly maximum increment in leaf potassium content was recorded in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$) and T_6 (0.5% $ZnSO_4$). Similarly, treatments T_3 (0.5% $FeSO_4$), T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$), T_5 (0.25% $ZnSO_4$) and T_2 (0.25% $FeSO_4$) were also found significantly highest leaf potassium content. But treatments T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) were found at par with control.

In the view of result at 75 DAS significantly maximum potassium was exhibited in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$) and T_6 (0.5% $ZnSO_4$) as compared to control and rest of the treatments under study. Next to these treatments significantly more potassium content was also recorded in treatments T_3 (0.5% $FeSO_4$), T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$), T_5 (0.25% $ZnSO_4$) and T_2 (0.25% $FeSO_4$). Treatments T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) were found at par with treatment T_1 (control).

Zn and Fe enhance enzymatic activity and translocation processes from leaves to grain filling or converting to other plant metabolites (Amin *et al.,* 2013). This might be the reason for an increase in potassium content.

Protein content in seeds

Although quality of crop products such as oil, protein and sucrose content and appearance are genetically controlled. The nutrition of plants can have considerable impact on the expression of quality. It is therefore, essential to judiciously take care on the nutrient supply at grain formation stage. Protein content of the seed is one of the considerable factors for seed quality determination also.

Treatments considering for evaluation of this study were found significantly superior over control. However, treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) recorded the highest protein content *i.e.* 24.16 %, while control (T_1) treatment recorded minimum *i.e.* 16.07 %.

Data regarding protein content was significantly increased in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$), T_3 (0.5% $FeSO_4$), T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$) and T_5 (0.25% $ZnSO_4$) when compared with treatment T_1 (control) and remaining treatments. Treatments T_2 (0.25% $FeSO_4$) and T_7 (1.0% $ZnSO_4$) were also significantly increased protein content in seed when compared with treatment T_4 (1.0% $FeSO_4$) and control (T_1). Treatment T_4 (1.0% $FeSO_4$) was found at par with control in present investigation.

The micronutrients especially zinc have an important role in chlorophyll formation, carbohydrate metabolism, synthesis of proteins and activation of oxidation process and enzymes. Zinc is essential for the biosynthesis of plant growth regulator (IAA) and carbohydrate and nitrogen metabolism leads to improvement in seed quality components. This might be the reason for the increase in protein content.

A field experiment was carried out by Malakootie *et al.* (2017) to study the effects of foliar and soil application of iron and zinc on quantitative and qualitative yield of two soybean cultivars, Results showed that Fe+Zn foliar application (0.2% + 0.3% respectively) could increase the grain protein content about 16%.

Yield and yield contributing parameters

Yield being a complex character is governed by a genetic makeup and environmental conditions. The present investigation was carried out to study the influence of ferrous sulphate and zinc sulphate on yield and yield attributing parameters *viz.,* number of pods plant^{-1}, pod weight plant^{-1}, number of seeds pod^{-1}, test weight.

Number of pods plant^{-1}

Number of pods plant^{-1} is an important yield features for pulses. Pod is the output of total metabolic activities taking place in plant body. It is differed significantly among the treatments. It varied from a minimum 46.42 to maximum of 69.57 pods plant^{-1}.

Among all the treatments significantly highest number of pods plant^{-1} was registered in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$), T_3 (0.5% $FeSO_4$) and T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$) over control and rest of the treatments. But treatments T_5 (0.25% $ZnSO_4$), T_2 (0.25 % $FeSO_4$), T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) in descending manner were found at par with treatment T_1 (control).

The enhancement effect on pods plant^{-1} attributed to the favourable influence of the Zn application to crops on nutrient metabolism, biological activity and growth parameters. Fe involves in the chlorophyll synthesis process. Hence, zinc and ferrous resulted in taller and higher enzyme activity which in turn encourages pods plant^{-1} (Michail *et al*., 2004).

Ali *et al*. (2014) studied data regarding number of pods plant^{-1} in mungbean and obtained results showed maximum number of pod plant^{-1} under highest level of Fe (1.5% $FeSO_4$) at both branching and flowering stages.

Susan *et al.* (2017) observed application of 125 per cent recommended dose of fertilizers plus 0.5% $ZnSO_4$ and 1% PPFM (Pink Pigmented Facultative Methylotrophs) recorded significantly higher pods plant^{-1} in green gram.

These findings are in agreement with Nandan *et al*. (2018), who recorded foliar spray of 0.5% Zn and 0.5% Fe along with RDF produced maximum number of pods plant^{-1} in chickpea.

Pal *et al*. (2019) found that highest number of pods plant^{-1} was recorded by the application of 0.5% $ZnSO_4$ at sowing and foliar spray at flowering + pod formation stages of chickpea.

Blesseena *et al*. (2020) revealed that foliar application of 100 ppm tocopherol + 0.5 % $ZnSO_4$ to chickpea showed highest number of pods plant^{-1}.

Pod weight plant^{-1}

Significant increase in pod weight plant^{-1} was registered in treatment T_9(0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$), T_3 (0.5% $FeSO_4$) and T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$) over control and rest of the treatments under observations. Similarly, treatment T_5 (0.25% $ZnSO_4$) was also found significantly superior over treatment T_1 (control). Treatments T_2 (0.25% $FeSO_4$), T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) were found at par with treatment T_1 (control).

Thalooth *et al*. (2006) observed that foliar application of zinc (300 ppm Zn-EDTA) with regular irrigation showed enhancement in pod dry weight plant^{-1} of chickpea.

Habbasha *et al*. (2013) indicated that application of 60 kg N faddan^{-1} in combination of foliar application with Zn (0.2% $ZnSO_4.7H_2O$) at seed filling stage showed increment in pod weight plant^{-1} of chickpea.

Number of seeds plant^{-1}

Number of pods plant^{-1} differed significantly among the treatments. It varied from a minimum 50.32 to maximum of 74.58 seeds plant^{-1}.

A close perusal of data on number of seeds plant^{-1} indicated that there was significant difference due to the different treatments.

Data regarding number of seeds plant^{-1} was subjected to statistical analysis and it was found to be significant. Foliar application of 0.5% $FeSO_4$+ 0.5% $ZnSO_4$ (T_9) gave significantly maximum number of seeds plant^{-1} followed by treatments T_8 (0.25% $FeSO_4$ + 0.25% $ZnSO_4$), T_6 (0.5% $ZnSO_4$), T_3 (0.5% $FeSO_4$) and T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$)as compared to untreated treatment T_1 (control) and rest of the treatments. But the treatments T_5 (0.25% $ZnSO_4$), T_2(0.25% $FeSO_4$),T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) in descending manner were found at par with treatment T_1 (control).

A field experiment was conducted by Heidarian *et al.* (2011) to investigate the effect of foliar application of Zn (116 ppm), Fe (116 ppm) on yield and yield contributing parameters of soybean. Results showed significant effect of Zn+Fe treatment on number of pods plant^{-1}.

Lakshmi *et al.* (2017) recorded maximum number of seeds plant^{-1} in black gram with combine application of recommended dose of fertilizer with foliar application of 1% each of $CaNO_3$, $MgNO_3$ and sulphur along with foliar application of $ZnSO_4$ @ 0.2%.

Blesseena *et al*. (2020) investigated that foliar application of 100 ppm tocopherol + 0.5 % $ZnSO_4$ to chickpea showed highest number of pods plant^{-1}. In 2020, Raut *et al*. observed maximum number of pods plant^{-1} by the application of 200 ppm ascorbic acid + 0.5 % $ZnSO_4$ on chickpea.

Test weight

Test weight is varied in the range of 18.40 to 22.77 g among the treatments. The present study demonstrated that foliar application of ferrous sulphate and zinc sulphate alone or in combination significantly increased the 100-seed weight over control. Among all the treatments tested the highest 100 seed weight was obtained in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) when compared with control and rest of the treatments. Next to this treatment significantly more test weight was also recorded in treatmentsT_8 (0.25% $ZnSO_4$ + 0.25% $FeSO_4$), T_6 (0.5% $ZnSO_4$),T_3 (0.5% $FeSO_4$) and T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$) over control and rest of the treatments. But, treatments T_5 (0.25% $ZnSO_4$), T_2 (0.25% $FeSO_4$), T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) were found at par with treatment T_1 (control). Maximum seed weight might be due to more number of new loading sinks and role of Zn in metabolic activity. Higher photosynthesis rate, translocation and assimilation metabolites in the sink ultimately results in increasing the size of seed. Foliar application of sulphur had profound influence on seed weight being a part of amino acid might have activated the enzymes and seed formation. Saini and Singh (2017) recorded maximum test weight in green gram (39.67g) by the application of 40 kg S ha^{-1} as gypsum + 0.5% $FeSO_4$ foliar spray at 25 DAS.

Banjara and Majgahe *et al*. (2019) revealed that foliar application of RDF + 0.5% $ZnSO_4$ and 0.1% $FeSO_4$ was found significantly superior in 100-seed weight in chickpea compared to control and rest of all other treatments. This result was in accordance with the findings of Pal *et al*. (2019), who found highest 100-seed weight in the treatment of soil application of $ZnSO_4$ + foliar application of $ZnSO_4$ at flowering and pod formation stages in chickpea crop.

Seed yield plant^{-1} (g) and ha^{-1} (q)

Seed yield is a quantitative trait which is final result of physiological activities of plant. Seed yield is the combined effect of yield attributes and physiological efficiency of plant during the present investigation. It is the economic yield which is final result of physiological activities of plant. Economic yield is the part of biomass that is converted into economic product. Seed yield is the economic yield which is final result of physiological activities of plant.

Source–sink relation contributes to the seed yield. It includes phloem loading at source (leaf) and unloading at sink (seed and fruit) by which the economic part will be getting the assimilate synthesis by photosynthesis. Partitioning of assimilate in the plant during reproductive development is important for flower, fruit and seeds. Thus, crop yield can be increased either by increasing the total dry matter production or by increasing the proportion of economic yield (harvest index) or both (Gardner *et al*., 1988).

Foliar application of ferrous sulphate and zinc sulphate significantly increased seed yield plant^{-1}and ha^{-1} over control. The highest seed yield (7.42 g plant^{-1}and 24.74 q ha^{-1}) was recorded in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) as compared to treatment T_1 control (4.87 g plant^{-1}and 16.22 q ha^{-1}).

Among the entire treatments superior seed yield plant^{-1} and ha^{-1} manifested in treatment T_9 (0.5% $FeSO_4$ + 0.5% $ZnSO_4$) followed by treatments T_8 (0.25% $ZnSO_4$ + 0.25% $FeSO_4$), T_6 (0.5% $ZnSO_4$) and T_3 (0.5% $FeSO_4$) and T_{10} (1.0% $FeSO_4$ + 1.0% $ZnSO_4$) over control and rest of the treatments. But, treatments T_5 (0.25% $ZnSO_4$ 0.4%), T_2 (0.25% $FeSO_4$), T_7 (1.0% $ZnSO_4$) and T_4 (1.0% $FeSO_4$) could not achieved their target and were found at par with treatment T_1 (control).

Seed yield is a quantitative trait which is final result of physiological activities of plant. It is influenced by, number of pods plant^{-1} and 100 seed weight in the present investigation which are considered as yield contributing parameters. All these parameters significantly increased by the application of Zn and Fe alone or in combination. Similarly application of Zn and Fe also significantly enhanced chlorophyll, nitrogen, phosphorus and potassium content in leaves which might have helped in increase in yield in the present investigation.

Field experiments were conducted by Anitha *et al.* (2005) reported the response of cowpea to zinc and iron fertilization for augmenting the crop productivity. Results of the study indicated that foliar application of micronutrients like iron and zinc had significant influence on the yield of cowpea. Combined spraying of 0.5% $FeSO_4$ and 0.5% $ZnSO_4$ at 45 DAS proved most effective and increased the seed yield by 43.09 per cent when compared with control followed by combined spraying of 0.5% $FeSO_4$ and 0.5% $ZnSO_4$ at 25 DAS (40.14 %).

Sale and Nazirkar (2013) studied the effect of different micronutrients on yield of soybean and observed that the Zn (0.5 %) and Fe (0.5 %) combined application increased yield in comparison to their separate application of Zn, Fe and seed fortification of Mo (0.66 g kg^{-1} seed). Ali *et al.* (2014) conducted a field experiment on mung bean. The experiment was consisted of foliar application of 0.5%, 1% and 1.5% solutions of $FeSO_4$ both at branching and flowering stages. Application of 1.5% foliar $FeSO_4$ both at branching and flowering stages gave higher grain yield (38.66%) as compared to control.

Purushottam *et al.* (2018) studied the growth and yield of chickpea (*Cicer arietinum* L.) as influenced by irrigation scheduling and zinc application. The results of the experiment revealed that treatment of irrigation at branching + pre flowering + pod development and 0.5 % zinc sulphate recorded significantly higher seed yield and stock yield.

Table1. Effect of ferrous sulphate and zinc sulphate on chemical and biochemical parameters in chickpea

Treatments	Total leaf chlorophyll content (mg g^{-1})			Leaf nitrogen content (%)			Leaf phosphorus content (%)			Leaf potassium content (%)		
	45 DAS	**60 DAS**	**75 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	**45 DAS**	**60 DAS**	**75 DAS**
T_1 (Control)	1.52	2.03	1.08	1.88	2.87	2.24	0.586	0.733	0.606	0.902	1.143	1.107
T_2 (0.25% $FeSO_4$)	1.71	2.76	1.25	2.27	3.28	2.57	0.660	0.757	0.720	0.970	1.399	1.273
T_3 (0.5% $ZnSO_4$)	1.77	3.08	1.35	2.62	3.49	2.89	0.693	0.797	0.750	1.193	1.537	1.417
T_4 (1.0% $FeSO_4$)	1.61	2.40	1.18	2.08	3.04	2.42	0.627	0.740	0.650	0.919	1.210	1.237
T_5(0.25% $ZnSO_4$)	1.73	2.80	1.27	2.34	3.32	2.73	0.663	0.763	0.727	1.104	1.437	1.314
T_6(0.5% $ZnSO_4$)	1.81	3.08	1.46	2.68	3.55	3.03	0.706	0.807	0.760	1.280	1.585	1.508
T_7(1.0% $ZnSO_4$)	1.66	2.56	1.21	2.16	3.18	2.48	0.653	0.744	0.703	0.950	1.293	1.253
T_8(0.25% $FeSO_4$ + 0.25% $ZnSO_4$)	1.87	3.13	1.48	2.73	3.68	3.42	0.712	0.810	0.767	1.310	1.624	1.523
T_9(0.5% $FeSO_4$ + 0.5% $ZnSO_4$)	1.91	3.14	1.52	2.79	3.71	3.50	0.721	0.820	0.773	1.331	1.710	1.579
T_{10}(1.0% $FeSO_4$ + 1.0% $ZnSO_4$)	1.75	2.96	1.33	2.51	3.45	2.85	0.667	0.779	0.740	1.157	1.512	1.329
SE(m)±	**0.05**	**0.12**	**0.04**	**0.09**	**0.07**	**0.18**	**0.020**	**0.010**	**0.020**	**0.030**	**0.050**	**0.050**
CD at 5%	**0.15**	**0.36**	**0.12**	**0.26**	**0.20**	**0.53**	**0.060**	**0.030**	**0.060**	**0.090**	**0.150**	**0.150**

Table 2. Effect of ferrous sulphate and zinc sulphate on yield and yield attributing parameters in chickpea

Treatments	No. of pods $plant^{-1}$	Weight of pods $plant^{-1}$(g)	No. of seeds $plant^{-1}$	Test weight (g)	Seed yield $plant^{-1}$ (g)	Seed yield ha^{-1} (q)
T_1 (Control)	46.42	8.17	50.32	18.40	4.87	16.22
T_2 (0.25% $ZnSO_4$)	56.04	10.32	58.54	20.22	5.62	18.74
T_3 (0.5% $ZnSO_4$)	63.12	9.46	65.90	21.42	6.25	20.56
T_4 (1.0 % $ZnSO_4$)	50.09	12.02	54.83	18.98	5.39	17.96
T_5(0.25% $ZnSO_4$)	57.76	11.04	61.34	20.40	5.86	19.53
T_6(0.5% $ZnSO_4$)	64.21	12.36	67.78	21.54	6.57	21.89
T_7(1.0% $ZnSO_4$)	53.17	9.78	57.10	19.67	5.41	18.04
T_8(0.25% $FeSO_4$ + 0.25% $ZnSO_4$)	67.30	12.91	69.10	22.44	6.80	22.68
T_9(0.5% $FeSO_4$ + 0.5% $ZnSO_4$)	69.57	13.24	74.58	22.77	7.42	24.74
T_{10}(1.0% $FeSO_4$ + 1.0% $ZnSO_4$)	59.88	11.86	63.94	20.86	5.98	19.94
SE (m)±	**3.87**	**0.72**	**4.10**	**0.67**	**0.40**	**1.32**
CD at 5%	**11.51**	**2.14**	**12.19**	**1.99**	**1.17**	**3.91**

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