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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(2): 486-490

www.thepharmajournal.com
Received: 16-12-2022
Accepted: 19-01-2023

# Physiological responses of ferrous sulphate and zinc sulphate on biochemical parameters, yield and yield contributing parameters of mung bean

**SK Sasane, PV Shende, PR Manapure, Sapana Baviskar, SS Pokale, SR Barde and Sakshi V Ingle**

**SK Sasane**
P. G. Student, Department of Agricultural Botany (Plant Physiology), Dr. PDKV University, College of Agriculture Nagpur, Maharashtra, India

**PV Shende**
Associate Professor, Department of Agricultural Botany Dr. PDKV University, College of Agriculture Nagpur, Maharashtra, India

**PR Manapure**
Associate Professor, Department of Agricultural Botany Dr. PDKV University, College of Agriculture Nagpur, Maharashtra, India

**Sapana Baviskar**
Assistant Professor, Department of Agricultural Botany Dr. PDKV University, College of Agriculture Nagpur, Maharashtra, India

**SS Pokale**
P.G. Student, Department of Agricultural Botany (Plant Physiology), Dr. PDKV University, College of Agriculture Nagpur, Maharashtra, India

**SR Barde**
P.G. Student, Department of Agricultural Botany (Plant Physiology), Dr. PDKV University, College of Agriculture Nagpur, Maharashtra, India

**Sakshi V Ingle**
P.G. Student, Department of Agricultural Botany (Plant Physiology), Dr. PDKV University, College of Agriculture Nagpur, Maharashtra, India

**Corresponding Author:**
**SK Sasane**
P. G. Student, Department of Agricultural Botany (Plant Physiology), Dr. PDKV University, College of Agriculture Nagpur, Maharashtra, India

## Abstract
A field experiment was conducted during *kharif* 2021, to study the physiological responses of ferrous sulphate and zinc sulphate on mung bean. The experiment was laid down in randomized block design with sixteen treatments and three replications at research farm of Botany Section College of Agriculture, Nagpur. The aim of this work was to study the effect of foliar application of ferrous sulphate and zinc sulphate at $T_1$ (CONTROL), $T_2$ ($FeSO_4$ @ 0.50%), $T_3$ ($FeSO_4$ @ 0.75%), $T_4$ ($FeSO_4$ @ 1.00%), $T_5$ ($ZnSO_4$ @ 0.50%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{13}$ ($FeSO_4$@ 0.75% + $ZnSO_4$ @ 1.00%), $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%), $T_{15}$ ($FeSO_4$@ 1.00% + $ZnSO_4$ @ 0.75%) and $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%). on biochemical parameters and yield in mung bean. Spraying of ferrous sulphate and zinc sulphate was done two times i.e., on 20 and 35 DAS. Observations about biochemical parameters like leaf chlorophyll, nitrogen content in leaves and protein content in seed were also estimated. Observation on yield contributing parameters like 100 seed weight (g), number of pods plant$^{-1}$, grain yield plant$^{-1}$, plot$^{-1}$, ha$^{-1}$, harvest index recorded. Foliar sprays of $FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00% followed by $FeSO_4$@ 0.75% + $ZnSO_4$ @ 1.00% significantly enhanced biochemical parameters and yield contributing parameters when compared with control and rest of the treatments under study.

**Keywords:** Mung bean, $FeSO_4$, $ZnSO_4$, foliar spray, biochemical parameters

## Introduction
Mung bean (*Vigna radiata* L.) is belonging to family leguminoceae. Mung bean alternatively known as green mash. Green-gram mainly cultivated in East Asia, South-east Asia and the Indian Subcontinent mung bean is an important pulse crop ranked as the Second most drought resistance after soybean. It has more protein contents better digestibility than any other crop (Tabasum *et al.* 2010) [16]. It can be grown under drought stress condition where the short time is available for growth it grows well under both irrigated as well as rainfed conditions. Mung bean grain contain carbohydrate 61%, protein 26% and 10% moisture and also 3% vitamin.

It's also used in various fried and spiced dishes such as noodles and balls. Dried seeds are sometime used for animal feeding, particularly in poultry Toasting and boiling is recommended to improve its nutritional value. The mung bean immature Seed pod is occasionally eaten as vegetable. The leaves and stalks can be utilized for animal feeding. Mung bean is alternatively known as golden gram, mung bean, haricot mungo, mash etc. It is an annual, semi erect to erect or sometimes twining, 25-100 cm tall, deep rooted herbaceous plant, It can grow under drought stress conditions, where, the short time is available for growth. It grows well under both irrigated as well as rainfed conditions. Salt affected soils are fit for its production, while, it cannot grow well in waterlogged condition (Yadav *et al.* 1998) [17].

Ferrous sulphate is a compound of iron and sulphate in the ratio of iron ($Fe^{2+}$) to sulphate ions is 1:1. It has a role as a reducing agent. Ferrous sulphate appears as greenish or yellow-brown crystalline solid used for a fertilizer ingredient. Iron is an essential micronutrient for almost all living organism because it plays critical role in metabolic processes such as DNA synthesis, respiration and photosynthesis, further, many metabolic pathways are activated by iron and it is a prosthetic group constituent of many enzymes. Iron plays a significant role in various physiological and biochemical pathways in plants. Fe plays a paramount role in physiological forms and functions ultimately induced the plant growth, flowering, source to sink relationship, biological nitrogen fixation, seed yield and quality. It also plays prominent role in increasing protein content of seed due to activation of associated enzymes. $FeSO_4$, a soil amendment for lowering the pH of a high alkaline soil so that plants can access the soil's nutrients in horticulture. It is used for treating iron chlorosis. Its effects are longer-lasting. It can be mixed with compost.

Zinc sulphate is the inorganic compound with equation $ZnSO_4$. It was generally known as "white vitriol". It is a powder that is colourless and totally water solvent. It is a fundamental part of catalysts engaged with metabolic reaction. Zinc sulphate is most ordinarily utilized source of zinc in granular fertilizer due to its high solvency in water and it is relatively low cost of production. They are responsible for use in a wide range of soils. It influences a few biochemical cycles in the plant, like cytochrome and nucleotide synthesis, chlorophyll production, enzyme activation, membrane integrity and hormone regulation (e.g., Tryptophan synthesis, a precursor of IAA).Sulphur assumes urgent part in controlling metabolic and enzymatic cycles including photosynthesis, respiration and legume rhizobium symbiotic nitrogen fixation, energy transformation, activation of enzymes and also in carbohydrate metabolism which reflected in expanded yield. (*Nalini et al.,* 2013) [7]

## Material and Methods

The project entitled "physiological responses of ferrous sulphate and zinc sulphate on mung bean" was conducted during *kharif* season 2021 at research farm of Botany Section College of Agriculture, Nagpur in a Randomized Block Design with sixteen treatments and three replications. Treatment consists $T_1$ (CONTROL), $T_2$ ($FeSO_4$ @ 0.50%), $T_3$ ($FeSO_4$ @ 0.75%), $T_4$ ($FeSO_4$ @ 1.00%), $T_5$ ($ZnSO_4$ @ 0.50%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{13}$ ($FeSO_4$@ 0.75% + $ZnSO_4$ @ 1.00%), $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%), $T_{15}$ ($FeSO_4$@ 1.00% + $ZnSO_4$ @ 0.75%) and $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) were tested. The gross plot size was 3.00 m x 2.20 m and net plot size was 2.40 m x 2.00 m with spacing of 30 cm x 10 cm. Five plants from each plot were selected randomly and data were collected at 25, 40 and 55 DAS on total chlorophyll content, nitrogen content in leaves and protein content in seeds were calculated 55 DAS. Total chlorophyll content of oven dried leaves was estimated by colorimetric method as suggested by Bruinsma (1982) [4]. Nitrogen content in leaves was estimated by micro kjeldahl's method as given by Somichi *et al.*, 1972 [14]. Protein content in seed plant$^{-1}$, test weight, number pods, grain yield plant$^{-1}$, plot$^{-1}$, ha$^{-1}$, harvest index and B:C ratio were calculated after harvest. Data was estimated by to statastical analysis as per method suggested by Panse and Sukhatme (1958) [10].

## Results and Discussion

### Total chlorophyll content (mg g$^{-1}$)

At 40 DAS significantly highest total chlorophyll content in leaves was registered in treatments $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), $T_{13}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 1.00%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%) followed by treatments $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_5$ ($ZnSO_4$ @ 0.50%) $T_2$ ($FeSO_4$ @ 0.50%, $T_3$ ($FeSO_4$ @ 0.75%) Next to these treatments significantly higher chlorophyll content was also recorded in treatments $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%) and $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%) over control and rest of the treatments. Next to these treatments $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) and $T_4$ ($FeSO_4$ @ 1.00%) again significantly more chlorophyll content was also recorded in treatment over control.

At this stage 55 DAS total chlorophyll content in leaves varied from 1.28-1.66 mg g$^{-1}$. The significantly maximum chlorophyll content noticed in treatment $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), $T_{13}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 1.00%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%) followed treatments $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_5$ ($ZnSO_4$ @ 0.50%) $T_2$ ($FeSO_4$ @ 0.50% and $T_3$ ($FeSO_4$ @ 0.75%) over control and rest of the treatments. Next to these treatments $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%) and $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%), $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) and significantly more chlorophyll content was also recorded in treatment $T_4$ ($FeSO_4$ @ 1.00%) and over control and rest of the treatments.

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 leaves.

Purushottam *et al.* (2018) [12] 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) [9] observed that foliar application 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

### Protein content in seeds

Data revealed that significantly higher protein content was observed Treatments considering for evaluation of this study were found significantly superior over control. However, treatment $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), recorded the highest protein content 23.99%, while control ($T_1$) treatment recorded minimum 21.30%.

Data regarding protein content was significantly in treatments $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), $T_{13}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 1.00%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%) followed by treatments $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_5$ ($ZnSO_4$ @ 0.50%) $T_2$ ($FeSO_4$ @ 0.50%, $T_3$ ($FeSO_4$ @ 0.75%), $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%) and $T_2$ (0.25% $FeSO_4$) when compared with treatment $T_1$ (control) and remaining treatments. Treatments $T_3$ ($FeSO_4$ @ 0.75%) $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%) and $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%) were also significantly increase protein content in seed when compared with treatment. Treatments $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) and $T_4$ ($FeSO_4$ @ 1.00%) 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.

Similar results were reported by Pise *et al*. (2019) [11] reported that foliar application of $ZnSO_4$ 0.5% 25 and 40 DAS showed a significant increase in protein content in seeds of lathyrus.

**Leaf nitrogen content**

Scrutiny of the data revealed marked effect of foliar spray of $FeSO_4$ and $ZnSO_4$ on the nitrogen content of mung bean at 25, 40 and 55 DAS.

At 25 DAS N content is differed among the treatments and ranged from 1.34-2.28%. The best and significant results were obtained in treatment $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), $T_{13}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 1.00%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%) followed by treatments $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_5$ ($ZnSO_4$ @ 0.50%) $T_2$ ($FeSO_4$ @ 0.50%, $T_3$ ($FeSO_4$ @ 0.75%) $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%) and $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%), showed significantly more nitrogen content over control and rest of the treatments. Treatments and $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) also observed significantly higher nitrogen content when interrelated with treatment $T_4$ ($FeSO_4$ @ 1.00%) But treatments were found at par with control.

At 40 and 55 DAS N content in ranged from 2.49-3.13 and 2.37-2.76 respectively. The highest nitrogen content in mung bean was recorded in treatment $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%) (2.76%), $T_{13}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 1.00%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%) followed by treatment, $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_5$ ($ZnSO_4$ @ 0.50%) and $T_2$ ($FeSO_4$ @ 0.50%) also, significantly more nitrogen content over control. Whereas, $T_3$ ($FeSO_4$ @ 0.75%) $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%) and $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%), $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) and $T_4$ ($FeSO_4$ @ 1.00%) showed least nitrogen content and found at par with control.

This treatment $T_{10}$ may be best application of RDF and combination $FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%. The inferences drawn from the data that leaf N content was increased from 25 DAS to 40 DAS and it decreased thereafter at 55 DAS.

The decrease in N content might be due to fact that younger leaves and developing organs, such as grains act as strong sink. demand and may draw heavily nitrogen from older leaves and leaves in general respectively (Gardner *et al.*, 1988) [6].

**Test Weight**

Test weight is varied ranged in the range of 3.10 to 3.63 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 $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), over control and rest of the Next to these treatments $T_{13}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 1.00%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%), $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_5$ ($ZnSO_4$ @ 0.50%) $T_2$ ($FeSO_4$ @ 0.50%, $T_3$ ($FeSO_4$ @ 0.75%), significantly more test weight was also recorded in treatments $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%), $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%), $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) and $T_4$ (1.0% $FeSO_4$) could not achieved their target and 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 it might have activated the enzymes and seed formation.

Saini and Singh (2017) [13] recorded maximum test weight in mung bean (39.67 g) by the application of 40 kg S ha as gypsum + 0.5% $FeSO_4$ foliar spray 25 DAS.

Banjara and Majgahe (2019) [16] 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 is in accordance with findings of Pal *et al.* (2019) [9] who found highest 100-seed weight in the treatment $ZnSO_4$ of soil application of foliar application of $ZnSO_4$ at flowering and pod formation stages in chickpea crop

**Number of Pod Plant$^{-1}$**

Number of pods plant is an important yield 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 14.07- 18.13 to maximum of 18.13 pods plant Among all the treatments significantly highest number of pods plant was registered in treatment $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), followed by treatments $T_{13}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 1.00%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%), $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_5$ ($ZnSO_4$ @ 0.50%) $T_2$ ($FeSO_4$ @ 0.50%, $T_3$ ($FeSO_4$ @ 0.75%), $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%), $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%), over control and rest of the treatments. But treatments and $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%), $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) and $T_4$ ($FeSO_4$ @ 1.00%) in manner were found at par with treatment $T_1$ (control).

These findings are in agreement with Nandan *et al.* (2018) [8], who recorded foliar spray of 0.5% Zn and 0.5% Fe along with RDF produced maximum number of pods plant in chickpea.

Pal *et al.* (2019) [9] found that highest number of pods plant was by the application of 0.5% $ZnSO_4$ at sowing and foliar spray at flowering + pod formation stages of chickpea. Blesseena *et al.* (2020) [3] revealed that foliar application of 100 ppm tocopherol + 0.5% $ZnSO_4$, to chickpea showed highest number of pods plant.

**Seed Yield Plant$^{-1}$(g), Plot$^{-1}$ (kg) and HA$^{-1}$(q)**

Foliar application of ferrous sulphate and zinc sulphate significantly increased seed yield $plant^{-1}$, $plot^{-1}$ and $ha^{-1}$ over control. The highest seed yield (19.23 g $plant^{-1}$, 0.64 kg $plot^{-1}$ and 13.46 q $ha^{-1}$) was recorded in treatment $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), as compared to treatment $T_1$ control (14.99 g $plant^{-1}$, 0.50 kg $plot^{-1}$ and 10.49 q $ha^{-1}$).

Among the entire treatments superior seed yield $plant^{-1}$, $plot^{-1}$ and $ha^{-1}$ manifested in treatment $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), followed by treatments $T_{13}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 1.00%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%), $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_5$ ($ZnSO_4$ @ 0.50%) $T_2$ ($FeSO_4$ @ 0.50%, $T_3$ ($FeSO_4$ @ 0.75%), $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%), over control and rest of the treatments. But, treatments $T_2$ (0.25% $FeSO_4$), $T_3$ ($FeSO_4$ @ 0.75%) $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%) and $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%), $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) 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 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) to 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 has significant Influence on the yield of cowpea. Combined spraying of 0.5% $FeSO_4$ and 0.5% $ZnSO_4$ 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%).

**Table 1:** Total chlorophyll content in leaves (mg $g^{-1}$), Nitrogen content in leaves (%) and Protein content in seeds (%) at harvest

| Treatments | Biochemical analysis | | | | | | |
|---|---|---|---|---|---|---|---|
| | Total chlorophyll content (mg $g^{-1}$) | | | N content in leaves (%) | | | Protein Content in seeds (%) |
| | 25 DAS | 40 DAS | 55 DAS | 25 DAS | 40 DAS | 55 DAS | At harvest |
| $T_1$ (CONTROL) | 1.380 | 1.581 | 1.280 | 1.44 | 2.49 | 2.39 | 21.30 |
| $T_2$ ($FeSO_4$ @ 0.50%) | 1.487 | 1.688 | 1.387 | 1.82 | 2.95 | 2.45 | 22.13 |
| $T_3$ ($FeSO_4$ @ 0.75%) | 1.473 | 1.674 | 1.373 | 1.73 | 2.89 | 2.43 | 22.01 |
| $T_4$ ($FeSO_4$ @ 1.00%) | 1.393 | 1.594 | 1.293 | 1.73 | 2.56 | 2.34 | 21.45 |
| $T_5$ ($ZnSO_4$ @ 0.50%) | 1.507 | 1.708 | 1.407 | 1.88 | 2.98 | 2.51 | 22.51 |
| $T_6$ ($ZnSO_4$ @ 0.75%) | 1.520 | 1.721 | 1.420 | 1.93 | 2.98 | 2.60 | 23.03 |
| $T_7$ ($ZnSO_4$ @ 1.00%) | 1.543 | 1.744 | 1.443 | 2.11 | 3.06 | 2.70 | 23.65 |
| $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%) | 1.653 | 1.854 | 1.553 | 2.14 | 3.12 | 2.71 | 23.78 |
| $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%) | 1.680 | 1.881 | 1.580 | 2.23 | 3.23 | 2.74 | 23.96 |
| $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%) | 1.760 | 1.961 | 1.660 | 2.28 | 3.19 | 2.76 | 23.99 |
| $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%) | 1.577 | 1.778 | 1.477 | 2.13 | 3.16 | 2.74 | 23.53 |
| $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%) | 1.617 | 1.818 | 1.517 | 2.20 | 3.32 | 2.70 | 23.62 |
| $T_{13}$ ($FeSO_4$@ 0.75% + $ZnSO_4$ @ 1.00%) | 1.730 | 1.931 | 1.630 | 2.95 | 3.25 | 2.69 | 22.67 |
| $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%) | 1.433 | 1.634 | 1.333 | 1.68 | 2.77 | 2.41 | 21.84 |
| $T_{15}$ ($FeSO_4$@ 1.00% + $ZnSO_4$ @ 0.75%) | 1.420 | 1.621 | 1.320 | 1.62 | 2.72 | 2.38 | 21.66 |
| $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) | 1.407 | 1.608 | 1.307 | 1.53 | 2.68 | 2.35 | 21.49 |
| SE(m) | 0.018 | 0.016 | 0.019 | 0.08 | 0.04 | 0.02 | 0.41 |
| CD | 0.053 | 0.048 | 0.058 | 0.22 | 0.12 | 0.06 | 1.20 |

**Table 2:** Test weight, Number of pod $plant^{-1}$, Seed yield $plant^{-1}$ (g), Seed yield $plot^{-1}$ (kg), Seed yield $ha^{-1}$ (q) and Harvest index (%)

| Treatments | Test weight (g) | Number of pod $plant^{-1}$ | Seed yield $plant^{-1}$ (g) | Seed yield $plot^{-1}$ (kg) | Seed yield $ha^{-1}$ (q) | Harvest index (%) |
|---|---|---|---|---|---|---|
| $T_1$ (CONTROL) | 3.10 | 14.07 | 14.99 | 0.504 | 10.49 | 35.12 |
| $T_2$ ($FeSO_4$ @ 0.50%) | 3.23 | 15.60 | 16.72 | 0.562 | 11.70 | 36.23 |
| $T_3$ ($FeSO_4$ @ 0.75%) | 3.21 | 15.33 | 16.56 | 0.556 | 11.59 | 38.31 |
| $T_4$ ($FeSO_4$ @ 1.00%) | 3.12 | 14.40 | 15.19 | 0.510 | 10.63 | 39.05 |
| $T_5$ ($ZnSO_4$ @ 0.50%) | 3.29 | 15.67 | 16.75 | 0.563 | 11.72 | 35.81 |
| $T_6$ ($ZnSO_4$ @ 0.75%) | 3.38 | 15.73 | 16.87 | 0.567 | 11.81 | 35.63 |
| $T_7$ ($ZnSO_4$ @ 1.00%) | 3.48 | 16.20 | 17.32 | 0.582 | 12.13 | 36.05 |
| $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%) | 3.56 | 16.73 | 17.67 | 0.594 | 12.37 | 34.92 |
| $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%) | 3.59 | 17.40 | 18.16 | 0.610 | 12.71 | 35.20 |
| $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%) | 3.63 | 18.13 | 19.23 | 0.646 | 13.26 | 39.22 |
| $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%) | 3.52 | 16.27 | 17.44 | 0.586 | 12.21 | 35.90 |
| $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%) | 3.63 | 16.40 | 17.48 | 0.587 | 12.23 | 35.49 |
| $T_{13}$ ($FeSO_4$@ 0.75% + $ZnSO_4$ @ 1.00%) | 3.57 | 17.47 | 18.23 | 0.613 | 12.76 | 34.93 |
| $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%) | 3.19 | 15.33 | 16.24 | 0.546 | 11.37 | 37.80 |
| $T_{15}$ ($FeSO_4$@ 1.00% + $ZnSO_4$ @ 0.75%) | 3.16 | 14.87 | 15.82 | 0.532 | 11.08 | 37.61 |
| $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) | 3.13 | 14.60 | 15.29 | 0.514 | 10.70 | 37.15 |
| SE(m) | 0.02 | 0.70 | 0.70 | 0.12 | 0.49 | 1.22 |
| CD | 0.06 | 2.03 | 2.01 | 0.36 | 1.41 | 3.52 |

**Harvest Index**

Data regarding harvest index was found statistically significant. The range of harvest index was significantly maximum in treatment $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%) and minimum in $T_1$ (control). The range of increased harvest index was 39.22% in treatment to 34.93% in $T_1$ (control).

Harvest index was significantly increased and was highest in $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), followed by treatments $T_{13}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 1.00%), $T_9$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.75%), $T_8$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 0.50%), $T_{12}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.75%), $T_{11}$ ($FeSO_4$ @ 0.75% + $ZnSO_4$ @ 0.50%), $T_7$ ($ZnSO_4$ @ 1.00%), $T_6$ ($ZnSO_4$ @ 0.75%), $T_5$ ($ZnSO_4$ @ 0.50%) $T_2$ ($FeSO_4$ @ 0.50%, $T_3$ ($FeSO_4$ @ 0.75%), over control and rest of the treatments significantly more test weight was also recorded in treatments $T_{14}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.50%), $T_{15}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 0.75%), $T_{16}$ ($FeSO_4$ @ 1.00% + $ZnSO_4$ @ 1.00%) and $T_4$ (1.0% $FeSO_4$) could not achieved their target and were found at par with treatment $T_1$ (control).

Purushottam *et al.* in 2018 [12], concluded that spraying of zinc sulphate at branching and pre flowering @ 0.5% probably helped the crop to produce good growth and development of chickpea and thereby, it recorded maximum seed yield (840 kg $ha^{-1}$) and stalk yield (1444 kg $ha^{-1}$).

The highest per cent increase in yield (39.22%) over control was observed by the application of $T_{10}$ ($FeSO_4$ @ 0.50% + $ZnSO_4$ @ 1.00%), as foliar spray at 20 and 35 DAS. Next to this treatment foliar spray of $T_{13}$ ($FeSO_4$ @ 0.75% +$ZnSO_4$ @ 1.00%), also enhanced yield by (38.31%) over control. From overall results it can be stated that foliar application of ferrous sulphate and zinc sulphate with different concentrations improved the morpho-physiological, biochemical and yield and yield contributing characters and ultimately yield.

**References**


1. Anith SE, Sreenivasan SM. Purushothaman, Response of cowpea (*Vigna unguiculata* L.) Walp.) to foliar nutrition of zinc and iron in the oxisols of Kerala. Legume Res. 2005;28(4):294-296.
2. Banjara GP, Majgahe SK. Effect of biofortification of zinc and iron attributes and yields of chickpea (*Cicer arietinum* L.) through agronomic intervention The Pharma Innov. J. 2019;8(10):45-47.
3. Blesseena A, Deotale RD, Raut DA, Pise S. Efficiency of foliar fertilization of tocopherol and micronutrient on chemical, biochemical parameters, yield and yield attributing factors in chickpea. J Soils and Crops. 2020;30(1):74-80.
4. Bruinsma J. A comment on spectrophotometric determination of chlorophyll. Bio-chem., Bio-phy., Acta. 1982;52:576-578.
5. Cakmack I. Plant nutrition research: Priorities to meet human needs for food in sustainable ways. J. Plant and Soil. 2002;247:3-24.
6. Gardner FP, Pearce RB, Mitchell RL. Transport and partitioning. In Physiology of Crop plants, 2nd Ed. Scent publishers, Jodhpur; c1988. p. 58-95.
7. Nalini P, Gupta B, Pathak GC. Foliar application at flowering stage improves plants performance, yield and yield attributes of blackgram. Indian J of exeperimental biology. 2013;51:548-555.
8. Nandan B, Sharma BC, Chand G, Bazgalia K, Kumar R, Banotra M. Agronomic fortification of Zn and Fe in chickpea an emerging tool for nutritional security: A global perspective. Acta. Sci. Nutr. Health. 2018;2(4):12-19.
9. Pal V, Guriqbal S, Salwinder SD. Yield enhancement and biofortification of chickpea (*Cicer arietinum* L.) grain with iron and zinc through foliar application of ferrous sulphate and urea. J of Plant Nutri. 2019;42(15):0190-4167.
10. Panse VG, Sukatme PV. In statistical method for agricultural worker ICAR publication, New Delhi 2nd; c1967. p. 63-66.
11. Pise SE, Shende PV, Deotale RD, Manapure PR, Madake VS, Raut DA, *et al*. Response of zinc and iron on chemical and biochemical, yield contributing parameters and yield of lathyrus (*Lathyrus sativus* L.). J Soils and Crops. 2020;30(1):165-171.
12. Purushottam SK, Gupta BK, Saren Sodi B, Rajwade OP. Growth and yield of chickpea (*Cicer arietinum* L.) as influenced by irrigation scheduling and zinc application. IJCS. 2018;6(1):1130-1133.
13. Saini AK, Singh R. Effect of sulphur and iron fertilization on growth of mung bean (*Vigna radiata* L.). Int. J Curr. Microbial. App. Sci. 2017;6(6):1922-1929.
14. Somichi Y, Doughlus SY, James AP. Laboratory manual. Physiological studies in rice analysis for total nitrogen (organic N) in plant tissue. The Inter Res. Instit. Los Banos, Languna, Phillipine 1972, II.
15. Susan PR, Bhaskar M, Angelin SR. Effect of foliar application of zinc and PPFM on growth, and yield parameters and quality of mung bean in alfisols. Int. J App. Res. and Technol. IJRI. 2017;2(2):131-135.
16. Tabasum A, Saleem M, Aziz I. Genetic variability, trait association and path analysis of yield and yield components in mung bean (*Vigna radiata* (L.) Wilczek). Pak. J Bot, 2010;42(6):3915-3924.
17. Yadav DS, Saxena A. Effect of summer greengram (*Phaseolus radiatus*) on rice (Oryza sativa)-wheat (*Triticum aestivum*) system (No. RESEARCH); c1998.