Original Research Article

Response of popular varieties on foliar application of micronutrients on growth, seed yield and quality in greengram

ABSTRACT

Effect of foliar application of micronutrients on seed yield and quality were studied in three green gram varieties i.e., KKM-3, WGG-42 and TRCRM-147. Among three varieties, seed quality parameters were significantly differed in yield and seed quality parameters. KKM-3 recorded the highest in growth and yield parameters *viz*., plant height at 30 DAS and 60 DAS (14.55 and 30.83 cm, respectively), number of nodules and number of branches per plant (28.43 and 6.65, respectively), number of pods per plant and pod yield per plant (g) (12.96 and 11.98, respectively), seed yield per plot (g) and seed yield (q/ha) (204.42 and 3.24, respectively) also, in seed quality parameters *viz*., number of seeds per pod and 100 seed weight (g) (11.67 and 3.93, respectively), total dehydrogenase activity (1.836) (A_{480nm}) respectively) and protein (24.01 %). But, highest germination (%), mean seedling dry weight (mg) and seedling vigor index-II were recorded in WGG-42 (96.07, 220 and 2111 respectively) and highest mean seedling length (cm) and seedling vigor index-I recorded (33.70 and 3046 respectively) in TRCRM-147. Among foliar treatments studied seed quality parameter were significantly differed. $FeSO_4$ recorded the highest in growth and yield parameters *viz*., plant height at 30 DAS and 60 DAS (15.31 and 31.49 cm, respectively), number of nodules and number of branches per plant (32.10 and 12.83, respectively), number of pods per plant and pod yield per plant (g) (14.11 and 7.60, respectively), seed yield per plot (g) and seed yield (q/ha) (234.18 and 3.72, respectively) also, in seed quality parameters *viz*., 100 seed weight (4.16 g), mean seedling dry weight (220 mg), seedling vigor index-II (2049), total dehydrogenase activity (1.939) (A_{480nm}) and protein (24.24 %) But, $ZnSO_4$ recorded highest in number of seeds per pod (12.09), germination (94.89 %), mean seedling length (33.89 cm) and seedling vigor index-I (3217).

Keywords: Greengram, Micronutrients, Foliar application, KKM-3, WGG-42 and TRCRM-147

1. **Introduction:**

Pulses are wonderful gift of nature with unique ability of biological nitrogen fixation, deep root system, mobilization of insoluble soil nutrients and bringing qualitative changes in soil properties - which make them known as soil fertility restores. It is also called as vegetable meat due to high amount of protein in grain and better biological value on dry weight basis. Greengram (*Vigna radiata* L.) is an important pulse crop of India. It is warm weather crop and cultivated in all the three growing season in various parts of the country. Greengram belong to family *Leguminoseae* and sub family *Papilionaceae*. Besides being a rich source of protein, they maintain soil fertility through biological nitrogen fixation in soil and thus play a vital role in furthering sustainable. The productivity of green gram in our country is very low. Hence, there is need for enhancement of the productivity of green gram by proper agronomic practices. One among them is foliar application of organic and inorganic sources of nutrients for exploiting genetic potential of the crop. This is considered to be an efficient and economic method of supplementing part of nutrients requirements at critical stages.

Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching, fixation and regulating the uptake of nutrients by plant. Since foliar nutrients usually penetrate the leaf cuticle or stomata and enters the cells facilitating easy and rapid utilization of nutrients. Foliar spray of $FeSO_4$ is commonly used as a mean to control lime induced chlorosis in field crops grown on calcareous soils, but spraying with iron salts alone has usually been found to be relatively less effective because of precipitation of iron from the spray solution and poor translocation of applied iron within the plant. The reasons for decreasing productivity are due to decreasing soil fertility especially macro and micronutrients, imbalanced use of fertilizer and occurrences of physiological disorders factors such as inefficient partitioning of assimilates, poor pod setting, excessive flower abscission and lack of nutrients during the critical stages of crop growth leads to nutrient stress, poor growth and productivity were found to be some of the yield barriers of pulse crop. These nutrients are more important because in pulse crop to synchronized flowering altered the source-sink relationship due to rapid translocation of nutrients from leaves to the developing pods. To overcome these constraints, additional nutrition through foliar feeding is play a vital role in pulse production by stimulating root development, nodulation, energy transformation, various metabolic processes and increasing pod setting and thereby increasing the yield.

The foliar spray of micro-nutrients was found to have beneficial effect on enhancing growth and increasing seed yield. Zinc sulphate needed by plants in small amounts, but yet crucial to plant development. In plants, zinc is key constituent of many enzymes and proteins. It is essential in the formation of auxins, which help with growth regulation and stem elongation. Iron is very important to the growth of plants. It is a constituent of several enzymes and some pigments, and assists in nitrate and sulphate reduction and energy production within plant. Although iron is not used in the synthesis of chlorophyll but it is essential for its formation. Iron plays a significant role in various physiological and biochemical pathway in plants. In plants, iron is involved in the synthesis of chlorophyll and it is essential for the maintenance of chloroplast structure and function. Molybdenum is a key element required by the microorganisms for nitrogen fixation. It is a structural component of nitrogenase enzyme which is actively involved in nitrogen fixation by Rhizobium bacteria in the root nodules of leguminous crops and simultaneously essential for absorption and translocation of iron in plants as well as seed. Boron is one of the mineral nutrients required for normal plant growth. The most important functions of boron in plants are thought to be its structural role in cell wall development, cell division, seed development and stimulation or inhibition of specific metabolic pathways for sugar transport and hormone development. Boron is mainly required for reproduction of plant and germination of pollen grain. It is also primarily needed to maintain the growth of apical growing point. Foliar feeding practice would be more useful in early maturing crops, which could be combined with regular plant protection programmes. If foliar nutrition is applied it reduces the cost of cultivation which in turn reduces the amount of fertilizer thereby reducing the loss and also economizing crop production.

Foliar application is credited with the advantage of quick and efficient utilization of nutrients, elimination of losses through leaching and fixation and regulating the uptake of nutrient by plants. Foliar application of nutrients using water soluble fertilizer is one of the possible ways to enhance the productivity of greengram. To increase seed yield and quality of green gram the present experiment was carried with four micronutrients using the foliar method of application.

2. Material and Methods:

The present research on foliar application of micronutrients was carried out at University of agricultural sciences, GKVK, Bangalore during Rabi 2020-21 to study the role of four micronutrients (B, Mo, Zn, Fe) on plant growth, yield and seed quality parameters in three different green gram varieties which was collected from GKVK, Raichur, Telangana. The varieties and micronutrients used in this study were represented here below. All the micro nutrient sprays was done during vegetative and flowering period of the crop i.e. 20 DAS and 45 DAS respectively. The micronutrients were prepared by dissolving the nutrient powder in water through weight by volume ratio. The field layout was carried out in 3.0 ×2.1 m^2 for each plot. The experiment was designed with Factorial RCBD and statistically analysed.

Varieties:

V_1: KKM-3

V_2: WGG-42

V_3: TRCRM-147

Micronutrients:

M_1: Foliar application of 0.1 % Boran @ vegetative & flowering stage

M_2: Foliar application of 0.05 % Molybdenum @vegetative & flowering stage

M_3: Foliar application of 0.5 % $ZnSO_4$ @ vegetative & flowering stage

M_4: Foliar application of 0.5 % $FeSO_4$ @ vegetative & flowering stage

M_5: Control

In the present experiment the role of these micronutrients were studied on plant and seed parameters like Plant height (cm) at 30 and 60 DAS, Number of branches^{-1}, Pods plant^{-1}, Pod yield plant^{-1}, 100 seed weight (g), Seed yield (g), Number of seeds pod^{-1}, Seed yield plot^{-1}, Seed yield hac^{-1}, Number of nodules plant^{-1}, Seed germination (%), Seedling length (cm), Seeding dry weight (mg), Seedling Vigour Index I & II, Electrical conductivity of seed leachates (dSm^{-1}/g), Total dehydrogenase activity of seeds (A_{480nm}), Protein content (%), Malate dehydrogenase activity (μ mol min^{-1} mg^{-1} protein) of seeds by application of micronutrients.

3. Results and Discussion:

A wide gap between the potential seed yield and average seed yield being harvested at farmer fields. There may be several possible reasons for poor seed yield. Among lack of optimum mineral nutrition particularly micronutrients management may be one of them, limiting higher productivity of mungbean.

3.1 Growth Parameters:

3.1.1 Plant height at 30 DAS (cm)

The varieties showed significant difference in plant height at 30 DAS. Among three varieties V_1 (KKM-3) recorded highest plant height (14.55 cm) and lowest was recorded in V_2 (WGG-42) (13.24 cm**)**. Plant height at 30 DAS differs significantly among different micro nutrient treatments. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest plant height (15.31 cm) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (14.67 cm), while lowest plant height was recorded in control (11.76 cm) (Table.1).

Effect of foliar nutrients in plants which will be helpful at tissue development, cell division and enhanced the plant growth through development of vigorous root system and it enable the plant to derive available soil nutrients also utilise the foliar applied nutrients lead to increasing the plant height. Increase in plant height due to basal nutrition along with foliar nutrition received by plant may ultimately result in better crop establishment, root and shoot growth. Similar results on increasing plant height with foliar applied nutrients were also recorded in Krishnaveni *et al.* (2013), Kumar *et al.* (2013), Pingoliya *et al.* (2014) in chickpea, Muthal *et al.* (2016) and Milan *et al.* (2021).

3.1.2 Plant height at 60 DAS (cm)

Among three varieties V_1 (KKM-3) recorded highest plant height (30.83 cm) and lowest was recorded in V_2 (WGG-42) (28.21 cm**)**. Micro nutrient spray on plant height differs significantly among three varieties. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest plant height (31.49 cm) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (30.89), while lowest plant height at 60 DAS was recorded in control (24.87 cm).

Increase in plant height due to involvement of nutrients in plant cell, cell wall elongation and translocation of nutrients to sink. The increased plant height might be due to activation of plant enzymes which are involved in carbohydrate metabolism and growth hormone synthesis, auxin production leads to cell enlargement, increase in cell division, internode elongation and the vigorous root growth (Table.1). Foliar application of nutrients at critical stage of crop growth such as vegetative and flowering stage helps to regulating the cell division and development of leaves. It also helps in synthesis of carbohydrates and ultimately improving photosynthetic ability of crop resulting better plant growth and plant height. Similarly increased metabolic and enzymatic activities with the supply of Fe and Zn were also reported by Krishnaveni *et al.* (2013) and Kumar *et al.* (2013), Muthal *et al.* (2016), Balai *et al.* (2017), Deepak kumar *et al.* (2018), Kuldeep *et al.* (2018) and Limba *et al.* (2020).

3.1.3 Number of nodules plant^{-1}

Among three varieties V_1 (KKM-3) recorded highest nodules (28.43) and lowest was recorded in V_2 (WGG-42) (24.32). Micro nutrient spray on number of nodules per plant per plant differs significantly among three varieties. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest number of nodules (32.10) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (28.19). While, lowest number of nodules was recorded in control (21.84) (Table.1).

Increase in nodules due to increased rhizobial colonisation in rhizosphere leads availability of iron is increased for formation of more nodules. Effect of micro nutrients required by rhizobia for nitrogen fixation in pulses and micronutrients will be main constituent of nitrate reductase, nitrogenise and also helpful for synthesis/activity of enzymes. If more number of nodules will leads to more nitrogen fixation in roots which ultimately leads to increasing the vegetative growth of plant. Increasing the number of nodules per plant with micro nutrients were similarly reported by Ahmad *et al.* (2013), Meena *et al.* (2013) and Sridhar *et al.* (2021).

3.1.4 Number of branches plant^{-1}

V_1 (KKM-3) recorded highest number of branches (6.65) and lowest was recorded in V_3 (TRCRM-147) (5.84). Micro nutrient spray on number of branches per plant differs significantly among three varieties (Table.1). The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest number of branches (7.27) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (6.70), while lowest number of branches per plant was recorded in control (4.54).

The increase in the number of branches per plant might be due to application these foliar nutrients, which are involving in the shoot elongation through increasing the cell enlargement and cell division and vegetative growth there by observe the increase in number of branches. Increased level of available nutrients, which promoted the axillary bud in to new shoot leads to increasing in number of branches. The present work also improved the number of branches with the application of micro nutrients were also reported by Milan *et al.* (2021), Ali *et al.* (2013) in greengram, Muthal *et al.* (2016) and Pingoliya *et al.* (2014) in chickpea.

3.2 Yield parameters

3.2.1 Number of pods plant^{-1}

Varieties V_1 (KKM-3) recorded highest pods (12.96) and lowest was recorded in V_2 (WGG-42) (10.77). Micro nutrient spray on number of pods per plant differs significantly among three varieties. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest number of pods (14.11) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (13.38), while lowest number of pods was recorded in control (9.82) (Table.1).

Nutrient elements play a role in plants that leads to improve area index by promoting light absorption and the amount of dry matter accumulation and economic yield. Foliar application of iron and zinc sulphate at branching and flower bud initiation increased the pods per plant which might have also responsible for efficient translocation of photosynthate from source to sink, this cause higher number of pod formation. These application leads to improving number of pods in present work was conformity with Dubey *et al.* (2013), Ali *et al.* (2014), Heidarzade *et al.* (2016), Soni and Kushwaha (2020) in greengram.

3.2.2 Pod yield plant^{-1} (g)

Micro nutrient spray on pod yield per plant differs significantly among three varieties. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest pod yield per plant (12.83 g) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (12.07 g), while lowest pod yield was recorded in control (9.45 g). The varieties showed significant difference in pod yield per plant. Among three varieties V_1 (KKM-3) recorded highest pod yield (11.98 g) and lowest was recorded in V_2 (WGG-42) (10.46 g) (Table.1).

Micronutrients helps in enhancement of enzymatic activity increased the photosynthesis and ultimately translocation of assimilate to seed which helps to improve the pod yield. Foliar nutrients helps in improving pod yield in present work which is shown similarity with Mostafi (2012), Habbasha and Mohamed (2013).

3.2.3 Seed yield plant^{-1} (g)

Among three varieties V_1 (KKM-3) recorded highest seed yield (4.14 g) and lowest was recorded in V_2 (WGG-42) (3.21 g). Micro nutrient spray on seed yield per plant differs significantly among three varieties. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest seed yield (4.73 g) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (4.40 g), while lowest seed yield was recorded in control (2.26 g).

Micronutrients involved in biosynthesis of plant hormones and are components of variety of enzymes like carbonic anhydrase, alcohol dehydrogenase which plays role in nucleic acid and protein synthesis, which helps in utilisation of nutrients in flower retention, pollen tube growth, development, seed formation and seed setting which is through the proper translocation of metabolites to sink thereby increased the pod and seed yield. Application of micro nutrients increased pod and seed yield could be due to increased seed vigour leads to increasing leaf area index. It might also increased photosynthetic activity with the help of higher chlorophyll content with enhanced stomatal conductance whereas, the uptake of CO_2 increased leading to more production of carbohydrates and thereby translocation of these metabolites to root nodules which leads to increasing nitrogen assimilation might be higher thereby increased the number of branches. However, translocation of metabolites and carbohydrates from photosynthetic active branches to developing organs such as pods and in turn accumulation of these in seeds resulted to increasing test weight, which finally helps to increase the pod and seed yield (Ali *et al.,* 2014) in mungbean.

3.2.4 Seed yield plot^{-1} (g)

Micro nutrient spray on seed yield per plot differs significantly among three varieties. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest seed yield (234.18 g) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (197.26 g), while lowest seed yield was recorded in control (137.39 g) (Fig. 1). Among three varieties V_1 (KKM-3) recorded highest seed yield (204.42 g) and lowest was recorded in V_2 (WGG-42) (145.75 g).

The effect of foliar treatments on greengram enhanced the pollen prodcing capacity, enhance the pollen viability and its involvement in fertilization, which increased the pod number and pod growth, ultimately the yield, boldness, vigor and viability of seeds. (Pathak and Pandey, 2010). Use of iron and zinc at vegetative and flowering period enhances metabolic process of plant which resulted in better yield in crop (Soni and Kushwaha, 2020). Similar results of spraying of iron and zinc which improves the seed yield were also found in Singh and Dubey *et al.* (2013), Jat *et al.* (2015), Haider *et al.* (2018, 2019).

3.2.5 Seed yield ha^{-1} (q)

The varieties showed significant difference in seed yield per hectare. Among three varieties V_1 (KKM-3) recorded highest seed yield per hectare (3.24 q) and lowest was recorded in V_2 (WGG-42) (2.31 q). Micro nutrient spray on seed yield per hectare differs significantly among three varieties. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest seed yield (3.72 q) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (3.13 q), while lowest seed yield was recorded in control (2.18 q) (Table.1).

Genotype, environment and their interaction on yield attributing characters among different varieties from various areas/parental origin. Hence, these attainments of low/high yield character are genetically controlled phenomenon (Gowda *et al.*, 2018). Such variations in yield in greengram in present work have been also identified by other authors Haider *et al.* (2018, 2019) in *Phaseolus vulgaris* and Jyothi and Kushwaha (2020) in greengram,

3.2.6 Seed recovery (%)

The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest seed recovery (96.0 %) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (95.4 %) while lowest seed recovery was recorded in control (89.9 %). Among three varieties V_1 (KKM-3) recorded highest seed recovery (94.7 %) and lowest was recorded in V_2 (WGG-42) (91.8 %). Micro nutrient spray on seed recovery differs significantly among three varieties.

Zn, Fe application helps in fulfilment of pods during pod formation stage which helps in better and bold seed development leads to reducing the improper filling of seeds thereby increasing seed recovery. The balanced growth habit for seed production, which induces more flower and fruiting body production with timely supply of nutrients led to a positive effects of source-sick gradient and it might have attributed for higher seed recovery in greengram in summer seasons (Kunjammal and Sukumar, 2019).

3.2.7 Number of seeds pod^{-1}

The varieties showed significant difference in number of seeds per pod. Among three varieties V_1 (KKM-3) recorded highest number of seeds (11.67) and lowest was recorded in

V_2 (WGG-42) (10.22). Micro nutrient spray on number of seeds per pod differs significantly among three varieties. The treatment M_3 (foliar spray with 0.5 % $ZnSO_4$) recorded highest number of pods (12.09) followed by M_4 (foliar spray with 0.5 % $FeSO_4$) (11.83), while lowest number of seeds per pod was recorded in control (9.04).

Foliar nutrition enhanced the synthesis and translocation of photosynthates to sink which in turn produce more number of seeds per pod (Vignesh *et al.,* 2021). The cumulative and conjugative application of nutrients to crop with sufficient nutrients for longer period thereby allowing the plant to form more number of seeds. Zinc and iron application at same period helps to improve dry matter production by increasing the leaf are index and thereby promote yield. Similar results on foliar application of iron and zinc sulphate at branching and flower bud initiation increased the seeds per pod in present work are confirmed with Ali *et al.* (2014) in mungbean and Usman *et al.* (2014).

3.2.8 Hundred seed weight (g)

Among three varieties V_1 (KKM-3) recorded highest 100 seed weight (3.93 g) and lowest was recorded in V_2 (WGG-42) (3.77 g). Micro nutrient spray on hundred seed weight differs significantly among three varieties. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest hundred seed weight (4.16 g) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (4.12 g), while lowest 100 seed weight (g) was recorded in control (3.21 g).

Foliar application of micronutrients influenced the pollen germination, seed development, cell division, translocation of food materials such as sugar, starch from source to sink there by resulted in increasing the hundred seed weight. Greater mobilisation of photosynthates to the developing seeds by application of iron and other micro nutrients might be cause for reason to increase in seed weight. Present results are also confirmed with Ali *et al.* (2014) in mungbean.

3.3 Seed quality parameters

3.3.1 Seed germination (%)

The varieties showed significant difference in seed germination. Among three varieties V_2 (WGG-42) recorded highest seed germination (96.07 %) and lowest was recorded in V_3 (TRCRM-147) (90.47 %). Micro nutrient spray on seed germination differs significantly among three varieties. The treatment M_3 (foliar spray with 0.5 % $ZnSO_4$)

recorded highest seed germination (94.89 %) followed by M_2 (foliar spray with 0.1 % Mo) (93.56 %) while lowest seed germination was recorded in control (91.56 %) (Table.2).

The effect of foliar Zn treatments on greengram enhanced the zinc concentration in seeds which helps in activation of enzymatic metabolic pathways during germination, availability of higher energy during germination of seed helps in increased germination percentage. Increasing the germination could be leads to activation of cells, which results in enhancement of mitochondrial activity leading to formation of high energy compounds and bio molecules which were available during early phase of germination and stimulates the germination with increase in seed cytokinin and enhances the metabolic. Similar results on germination improvement in present study were also reported by Mohammadi *et al.* (2016), Shinde *et al.* (2017) in chick pea and Ramagiry *et al.* (2019).

3.3.2 Abnormal seedlings (%)

Among three varieties V_2 (WGG-42) recorded lowest abnormal seedlings (3.93 %) and highest was recorded in V_3 (TRCRM-147) (9.53 %). Micro nutrient spray on abnormal seedlings differs significantly among three varieties. The treatment M_3 (foliar spray with 0.5 % $ZnSO_4$) recorded lowest abnormal seedlings (5.11 %) followed by M_2 (foliar spray with 0.1 % Mo) (6.44 %) while highest was recorded in control (8.44 %). Few seeds are not fully developed during their growth, which leads to formation of abnormal seeds due to improper allocation of nutrients in seeds (Table.2).

3.3.3 Mean seedling length (cm)

Among three varieties V_3 (TRCRM-147) recorded highest seedling length (33.70 cm) and lowest was recorded in V_2 (WGG-42) (29.30 cm). Micro nutrient spray on mean seedling length differs significantly among three varieties. The treatment recorded highest seedling length M_1 (foliar spray with 0.1 % B) (34.90 cm) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (33.89 cm) while lowest seedling length (30.37 cm) was recorded in M_4 (foliar spray with 0.5 % $FeSO_4$) (Fig. 2).

The increase in length of shoot and root due to seeds with more test weight shall have higher potential and seedling growth, thus in turn increase the metabolic activity through micronutrients and its translocation leading to early germination, cell division and elongation of cells leading to improving seedling length. The foliar spray improved the seed quality parameters which may be due auxin metabolism plays a vital role in seed set, seed size and quality. Similar results on application of micro nutrients improved the seedling length were also recorded Shinde *et al.* (2017) in chick pea, Ashok *et al.* (2019), and Movahhed *et al.* (2019) in safflower.

3.3.4 Mean seeding dry weight (mg)

The treatment recorded highest seedling dry weight M_4 (foliar spray with 0.1 % $FeSO_4$) (220 mg) followed by M_1 (foliar spray with 0.5 % B) (217 mg) while lowest seedling dry weight (212 mg) was recorded in control. Among three varieties V_2 (WGG42) recorded highest mean seedling dry weight (220 mg) and lowest was recorded in V_3 (TRCRM-147) (211 mg). Micro nutrient spray on mean seedling dry weight differs significantly among three varieties (Table.2).

When the application of micro nutrient increased the seedling length and fresh weight automatically leads to increase in dry weight which is also supported by in onion by Ashok *et al.* (2019), Shinde *et al.* (2017) in chick pea and Movahhed *et al.* (2019) in safflower.

3.3.5 Seeding vigour index-I

Micro nutrient spray on seedling vigour index-I differs significantly among three varieties. The treatment recorded highest seedling vigour index-I M_3 (foliar spray with 0.1 % $ZnSO_4$) (3217) followed by M_1 (foliar spray with 0.5 % B) (3201) while lowest seedling vigour index-I (2904) was recorded in control. Among three varieties V_3 (TRCRM-147) recorded highest seedling vigour index-I (3046) and lowest was recorded in V_2 (WGG-42) (2820) (Fig. 3).

Increasing germination and seedling length which helps to improving vigour index. Similar results were recorded in onion by Ashok *et al.* (2019), Ramagiry *et al.* (2019) in chilli and Movahhed *et al.* (2019) in safflower.

3.3.6 Seeding vigour index-II

Among three varieties V_2 (WGG-42) recorded highest seedling vigour index-II (2111) and lowest was recorded in V_3 (TRCRM-147) (1906). Micro nutrient spray on seedling vigour index-II differs significantly among three varieties. The treatment recorded highest seedling vigour index-II M_4 (foliar spray with 0.1 % $FeSO_4$) (2049) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (2044) while lowest seedling vigour index-II (1929) was recorded in control.

Increasing germination and seedling dry weight which helps to improving vigour index (Fig. 3). Similar results were recorded in onion by Ashok *et al.* (2019), Ramagiry *et al.* (2019) in chilli and Movahhed *et al.* (2019) in safflower.

3.3.7 Electrical conductivity (dSm^{-1})

The varieties showed significant difference in electrical conductivity. Among three varieties V_1 (KKM-3) recorded lowest electrical conductivity (0.301 dSm^{-1}) and highest was recorded in V_3 (TRCRM-147) (0.357 dSm^{-1}). Micro nutrient spray on electrical conductivity differs significantly among three varieties. The treatment recorded lowest electrical conductivity M_4 (foliar spray with 0.1 % $FeSO_4$) (0.240 dSm^{-1}) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (0.264 dSm^{-1}) while highest electrical conductivity (0.428 dSm^{-1}) was recorded in control (Table.2).

Foliar nutrition helps in improving vigour of seeds. High vigorous seeds having greater membrane stability which release more leachate. Similar results were recorded in onion by Ashok *et al.* (2019) and Movahhed *et al.* (2019) in safflower.

3.3.8 Total dehydrogenase activity (A_{480}nm)

The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest dehydrogenase activity (1.939) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (1.770) while lowest seed dehydrogenase activity was recorded in control (1.674). Among three varieties V_1 (KKM-3) recorded highest dehydrogenase activity (1.836) and lowest was recorded in V_2 (WGG-42) (1.703) (Table.2). Micro nutrient spray on dehydrogenase activity differed significantly among three varieties. Dehydrogenase and vigour are positively related with each and improved with nutrition. Similar results were recorded in onion by Ashok *et al.* (2019).

3.3.9 Protein content (%)

The varieties showed significant difference in protein content. Among three varieties V_1 (KKM-3) recorded highest protein content (24.01) and lowest was recorded in V_2 (WGG-42) (23.47 %). Micro nutrient spray on protein content differed significantly among three varieties (Fig. 4). The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest protein content (24.24) followed by M_1 (foliar spray with 0.01 % B) (24.05) lowest protein content was recorded in control (23.26 %).

Increase in protein content might be due to application of iron and zinc involved in amino acid synthesis ultimately protein synthesis and thereby increase in protein content in seeds. These results are also confirmed with Reshma *et al.* (2018) in soybean, Bhagavat *et al.* (2018), Malek *et al.* (2018), Ali *et al.* (2014) in mungbean.

3.3.10 Malate dehydrogenase activity (μ mol min^{-1} mg^{-1} protein)

Among three varieties V_1 (KKM-3) recorded highest malate dehydrogenase activity (0.71 μ mol min^{-1} mg^{-1} protein) and lowest was recorded in V_3 (TRCRM-147) (0.23 μ mol min^{-1} mg^{-1} protein). Micro nutrient spray on malate dehydrogenase activity differed significantly among three varieties. The treatment M_4 (foliar spray with 0.5 % $FeSO_4$) recorded highest malate dehydrogenase activity (0.89 μ mol min^{-1} mg^{-1} protein) followed by M_3 (foliar spray with 0.5 % $ZnSO_4$) (0.54) while lowest activity was recorded in control (0.13) (Table.2).

Interaction of varieties and foliar micro nutrients were significantly differed for malte dehydrogenase activity. The highest malate dehydrogenase activity was recorded in V_1M_4 (1.40). Whereas, lowest was recorded in V_3M_3 (0.04). Presence of protein content in mungbean after imbibition of seed malate dehydrogenase activity was increased, this is due to active synthesis of enzyme protein and synthesis seemed to be regulated by availability of translated mRNA for enzyme. The results were conformity with Sugimoto and Morohasi (1989) in mungbean.

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Table. 1 Response of popular varieties on foliar application of micronutrients on growth and seed yield in green gram

	Plant height at 30 DAS (cm)	Plant height at 60 DAS (cm)	Number of branches/pt	Number of nodules/pt	Pods/ pt	Pod yield/pt (gm)	Seed yield/pt (g)	Number of seeds/pod	Seed yield/plot (kg)	Seed yield (Kg ha-1)	Seed recovery (%)
Varieties (V)											
V_1: KKM-3	14.55	30.83	6.65	28.43	12.96	6.76	4.14	11.67	0.204	324.47	94.7
V_2: WGG-42	13.24	28.21	6.20	24.32	10.77	5.23	3.21	10.22	0.146	231.36	91.8
V_3: TRCRM-147	13.61	29.03	5.84	26.28	11.76	5.62	3.62	11.24	0.180	285.60	93.4
Mean	**13.80**	**29.36**	**6.23**	**26.34**	**11.83**	**5.87**	**3.66**	**11.04**	**0.18**	**280.47**	**93.30**
SEm±	**0.36**	**0.71**	**0.17**	**0.71**	**0.33**	**0.15**	**0.10**	**0.25**	**0.008**	**12.35**	**0.8**
CD (P=0.05)	**1.04**	**2.05**	**0.48**	**2.06**	**0.97**	**0.43**	**0.29**	**0.74**	**0.023**	**35.79**	**2.2**
Micronutrients (M)											
M_1: Boran	13.78	30.19	6.08	24.96	11.27	5.50	3.50	11.33	0.160	253.53	93.2
M_2:Molybdenum	13.49	29.36	6.56	24.62	10.58	5.20	3.40	10.91	0.155	245.94	92.0
M_3: Zinc	14.67	30.89	6.70	28.19	13.38	6.84	4.40	12.09	0.197	313.11	95.4
M_4: Iron	15.31	31.49	7.27	32.10	14.11	7.60	4.73	11.83	0.234	371.71	96.0
M_5: Control	11.76	24.87	4.54	21.84	9.82	4.22	2.26	9.04	0.137	218.08	89.9
Mean	**13.80**	**29.36**	**6.23**	**26.34**	**11.83**	**5.87**	**3.66**	**11.04**	**0.18**	**280.47**	**93.30**
SEm±	**0.46**	**0.91**	**0.21**	**0.92**	**0.43**	**0.19**	**0.13**	**0.33**	**0.010**	**15.95**	**1.0**
CD (P=0.05)	**1.34**	**2.64**	**0.62**	**2.65**	**1.25**	**0.56**	**0.37**	**0.95**	**0.029**	**46.20**	**2.9**
Interaction (V×M)											
V_1M_1	14.33	31.57	5.57	28.13	13.07	5.96	3.81	11.80	0.182	288.46	95.8
V_1M_2	13.93	30.07	6.67	24.53	11.80	5.55	3.66	11.47	0.154	243.81	94.2
V_1M_3	15.20	31.73	7.56	31.80	14.07	7.48	4.81	12.07	0.259	411.59	96.2
V_1M_4	16.60	32.73	7.53	35.40	15.67	9.50	5.53	12.17	0.286	453.41	96.4
V_1M_5	12.67	28.07	5.90	22.27	10.20	5.29	2.92	10.83	0.142	225.10	91.0

V_2M_1	13.27	29.07	7.00	22.80	9.87	5.10	3.27	10.60	0.143	227.30	92.4
V_2M_2	13.00	28.93	6.53	26.00	9.33	4.86	3.22	10.13	0.142	224.83	90.7
V_2M_3	14.47	29.53	6.47	25.57	12.40	6.31	4.08	12.40	0.143	227.28	93.3
V_2M_4	14.53	30.00	7.27	26.03	12.93	6.45	4.24	11.27	0.177	280.91	94.7
V_2M_5	10.93	23.53	3.73	21.20	9.33	3.45	1.23	6.70	0.124	196.46	87.8
V_3M_1	13.73	29.93	5.67	23.93	10.87	5.43	3.42	11.60	0.154	244.84	91.4
V_3M_2	13.53	29.07	6.47	23.33	10.60	5.20	3.33	11.13	0.170	269.18	91.2
V_3M_3	14.33	31.40	6.07	27.20	13.67	6.73	4.31	11.80	0.189	300.45	96.8
V_3M_4	14.80	31.73	7.00	34.87	13.73	6.85	4.43	12.07	0.240	380.82	97.0
V_3M_5	11.67	23.00	4.00	22.07	9.93	3.91	2.63	9.60	0.147	232.68	90.7
Mean	**13.80**	**29.36**	**6.23**	**26.34**	**11.83**	**5.87**	**3.66**	**11.04**	**0.18**	**280.47**	**93.30**
SEm±	**0.80**	**1.58**	**0.37**	**1.59**	**0.75**	**0.33**	**0.22**	**0.57**	**0.017**	**27.62**	**1.7**
CD (P=0.05)	**2.33**	**4.58**	**1.08**	**4.60**	**2.16**	**0.97**	**0.65**	**1.65**	**0.050**	**80.02**	**4.9**
CV (%)	**10.08**	**9.32**	**10.36**	**10.43**	**10.92**	**9.83**	**10.58**	**8.92**	**17.058**	**17.06**	**3.2**

Table. 2 Response of popular varieties on foliar application of micronutrients on seed quality in green gram

	100 seed weight (g)	Germination (%)	Abnormal seedlings (%)	Mean seedling length (cm)	Mean seedling dry weight (mg)	Seedling vigour index-I	Seedling vigour index-II	Electrical conductivity (dSm^{-1})	Total dehydrogenase activity (A_{480nm})	Protein (%)	Malate dehydrogenase activity (μ mol min^{-1} mg^{-1} protein)
Varieties (V)											
V_1: KKM-3	3.93	92.33	7.67	30.94	212	2855	1961	0.301	1.836	24.01	0.71
V_2: WGG-42	3.77	96.07	3.93	29.30	220	2820	2111	0.345	1.703	23.47	0.38
V_3: TRCRM-147	3.90	90.47	9.53	33.70	211	3046	1906	0.357	1.734	23.90	0.23
Mean	**3.87**	**92.96**	**7.04**	**31.31**	**214**	**2906.86**	**1992.78**	**0.33**	**1.757**	**23.79**	**0.44**
SEm±	**0.04**	**0.45**	**0.45**	**0.39**	**2.08**	**39.60**	**21.71**	**0.01**	**0.03**	**0.39**	**0.04**
CD (P=0.05)	**0.12**	**1.30**	**1.30**	**1.12**	**6.01**	**114.72**	**62.90**	**0.04**	**0.09**	**1.14**	**0.11**
Micronutrients (M)											
M_1: Boran	3.97	91.89	8.11	34.90	217	3201	1991	0.345	1.705	24.05	0.14
M_2:Molybdenum	3.88	93.56	6.44	25.62	206	2387	1929	0.395	1.698	23.77	0.51
M_3: Zinc	4.12	94.89	5.11	33.89	215	3217	2044	0.264	1.770	23.65	0.54
M_4: Iron	4.16	92.89	7.11	30.37	220	2826	2049	0.240	1.939	24.24	0.89
M_5: Control	3.21	91.56	8.44	31.78	212	2904	1951	0.428	1.674	23.26	0.13
Mean	**3.87**	**92.96**	**7.04**	**31.31**	**214**	**2906.86**	**1992.78**	**0.33**	**1.757**	**23.79**	**0.44**
SEm±	**0.06**	**0.58**	**0.58**	**0.50**	**2.68**	**51.13**	**28.03**	**0.02**	**0.04**	**0.51**	**0.05**
CD (P=0.05)	**0.16**	**1.68**	**1.68**	**1.44**	**7.76**	**148.10**	**81.20**	**0.06**	**0.12**	**1.47**	**0.15**
Interaction (V×M)											
V_1M_1	4.03	93.00	7.00	33.62	223	3125	2071	0.286	1.718	23.56	0.11
V_1M_2	4.02	93.00	7.00	20.74	208	1930	1938	0.307	1.711	24.63	0.21
V_1M_3	4.12	95.00	5.00	33.07	213	3141	2021	0.265	1.832	23.50	0.77
V_1M_4	4.15	90.67	9.33	34.18	213	3100	1928	0.232	2.234	25.42	1.40

V_1M_5	3.34	90.00	10.00	33.08	205	2978	1848	0.412	1.683	22.94	0.07
V_2M_1	3.81	92.00	8.00	23.23	213	2136	1956	0.394	1.691	23.39	0.16
V_2M_2	3.55	97.33	2.67	22.80	207	2220	2015	0.448	1.689	23.16	0.06
V_2M_3	4.19	97.33	2.67	34.83	229	3391	2226	0.277	1.732	23.45	0.81
V_2M_4	4.24	97.00	3.00	32.86	226	3187	2189	0.263	1.743	24.80	0.60
V_2M_5	3.06	96.67	3.33	32.76	224	3166	2169	0.342	1.658	22.54	0.26
V_3M_1	4.06	89.67	10.33	38.48	217	3450	1945	0.353	1.706	25.20	0.15
V_3M_2	4.07	90.33	9.67	33.31	203	3009	1835	0.430	1.694	23.50	0.25
V_3M_3	4.05	92.33	7.67	33.76	204	3119	1886	0.248	1.747	23.84	0.04
V_3M_4	4.08	91.00	9.00	24.07	223	2191	2029	0.224	1.838	25.48	0.67
V_3M_5	3.23	89.00	11.00	38.87	206	3459	1836	0.531	1.682	21.47	0.06
Mean	**3.87**	**92.96**	**7.04**	**31**	**214**	**2906.86**	**1992.78**	**0.334**	**1.757**	**23.79**	**0.44**
SEm±	**0.10**	**1.00**	**1.00**	**0.86**	**4.64**	**88.55**	**48.55**	**0.03**	**0.07**	**0.88**	**0.09**
CD (P=0.05)	**0.28**	**2.91**	**2.91**	**2.50**	**13.45**	**256.52**	**140.64**	**0.10**	**0.21**	**2.54**	**0.27**
CV (%)	**4.29**	**1.87**	**24.68**	**4.76**	**3.75**	**5.28**	**4.22**	**17.19**	**6.98**	**6.38**	**4.64**

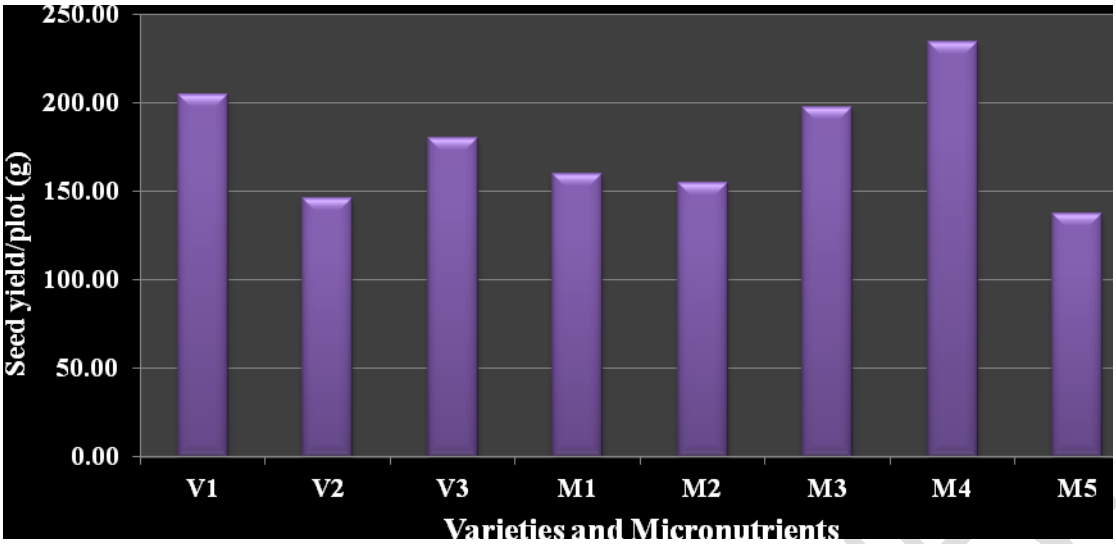

Fig. 1. Influence of foliar application of nutrients on seed yield per plot (g) in greengram

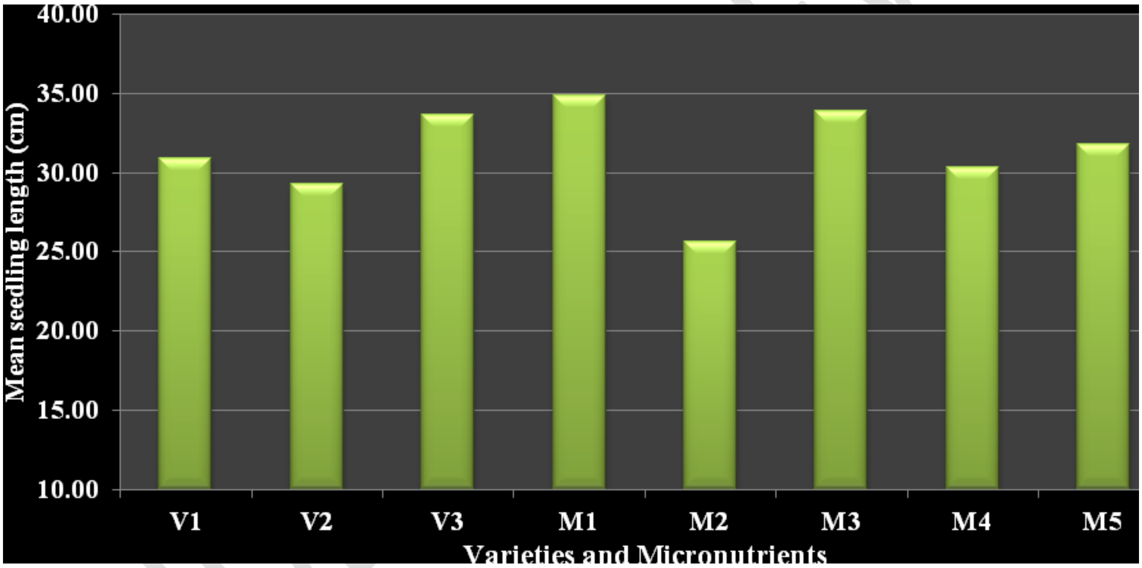

Fig. 2. Influence of foliar application of nutrients on mean seedling length (cm) in greengram

Varieties:
V_1: KKM-3
V_2: WGG-42
V_3: TRCRM-147
Treatments:
M_1: Foliar application of 0.1 % Boran at 25 and 45 DAS
M_2: Foliar application of 0.05 % Molybdenum at 25 and 45 DAS
M_3: Foliar application of 0.5 % $ZnSO_4$ at 25 and 45 DAS
M_4: Foliar application of 0.5 % $FeSO_4$ at 25 and 45 DAS
M_5: Control

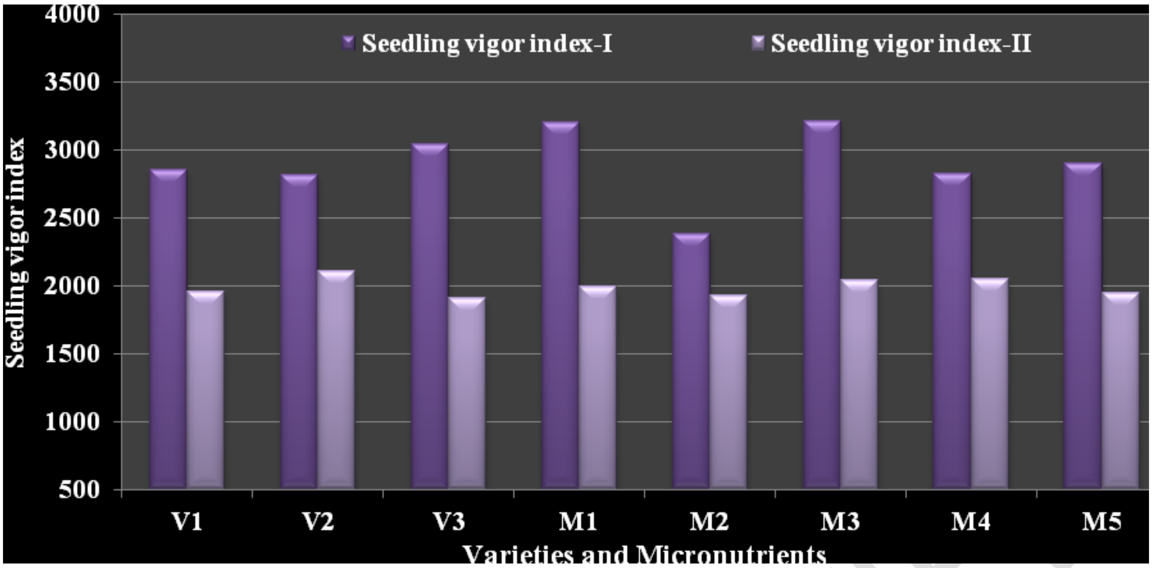

Fig. 3 Influence of foliar application of nutrients on seedling vigor index-I and seedling vigor index-II in greengram

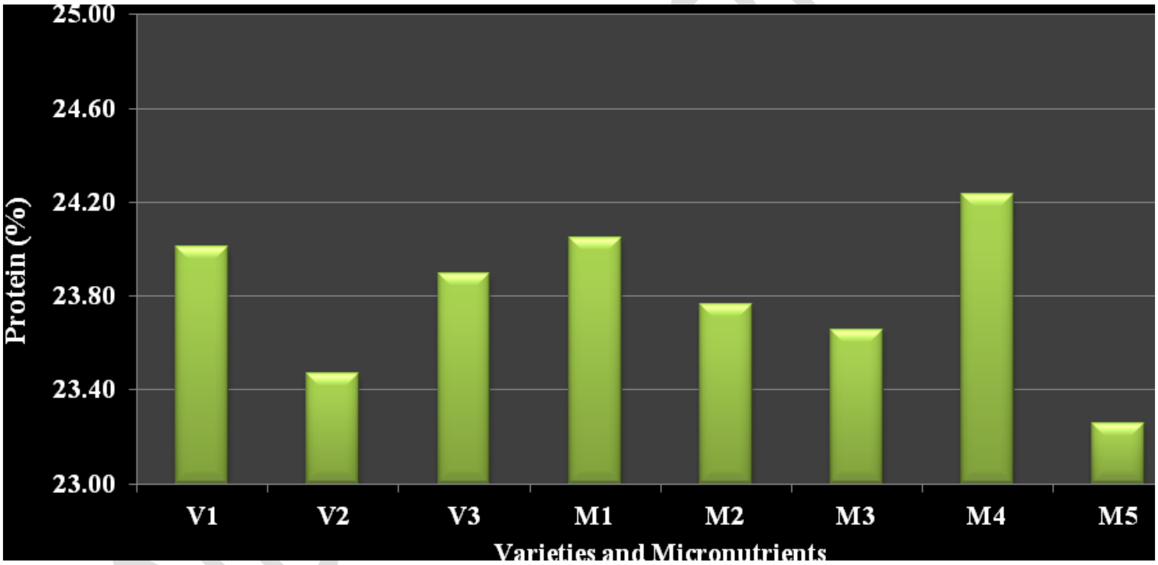

Fig. 4 Influence of foliar application of nutrients on protein (%) in greengram

Varieties:

V_1: KKM-3

V_2: WGG-42

V_3: TRCRM-147

Treatments:

M_1: Foliar application of 0.1 % Boran at 25 and 45 DAS

M_2: Foliar application of 0.05 % Molybdenum at 25 and 45 DAS

M_3: Foliar application of 0.5 % $ZnSO_4$ at 25 and 45 DAS

M_4: Foliar application of 0.5 % $FeSO_4$ at 25 and 45 DAS

M_5: Control