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EFFECTS OF PLANT GROWTH REGULATORS AND MICRONUTRIENTS ON QUALITY PARAMETERS OF SOYBEAN (*GLYCINE MAX* L. MERRILL)

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ABSTRACT

Physiological Studies for Improving Seed Quality of Soybean (*Glycine max* (L.) *Merill*) cv. Suvarn Soya (AMS-MB-5-18) were studied during *kharif* 2023-24 at the Experimental and research field of the Department of Agricultural Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.). Experiment was conducted in Randomized block design (RBD) with three replications and seven treatments with 21 plots. seven treatments viz., T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm), T_3 (Cycocel @ 500 ppm), T_4 (Cycocel @ 750 ppm), T_5 ($ZnSO_4$ @ 0.5%), T_6 ($ZnSO_4$ @ 0.10%) and T_7 (control) were tested. The sowing was done on dated 5th July 2023 by dibbling method with a spacing of 45 cm × 10 cm. Thereafter, all required intercultural operations were done as and when required. T_6 ($ZnSO_4$ @ 0.10 %) sprayed at 50% flowering stage (40 DAS) and pod initiation stage (55 DAS) was found significantly superior in enhancing quality parameters like Seed germination and Vigour index II followed by T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm), T_3 (Cycocel @ 500 ppm), T_4 (Cycocel @ 750 ppm) and T_5 ($ZnSO_4$ @ 0.5%) over T_7 (Control).

Keywords **:** Soybean, Quality, Parameters, Seed germination, PGRs

Introduction

Soybean (*Glycine max* L.) is often designated as "Golden bean" and has become miracle crop of 20th century. It is a triple beneficial crop, which contains about 20 per cent oil, 38 to 42 per cent protein except methionine and cysteine. It is one of the important pulses and oilseeds of the world. It also contains 26 per cent carbohydrates, 4 per cent minerals and 2 per cent phospholipids (Halvankar *et al*., 1992). It is a rich source of vitamin A, B and D. The biological value of the soybean protein is as good as meat and fish protein (Quayam *et al*., 1985). Soybean is a diploid species having chromosome number 2n=40. It belongs to family "Leguminosae" and subfamily "Papilionaceae". It is annual leguminous herbaceous plant.

Recognized for its rich nutritional profile, soybean is referred to as "The protein hope of the future" and "miracle golden bean of the 21st Century" (Sarkar *et al*., 2002). Additionally, it is often referred to as "poor man's meat" due to its high protein content, catalyzing significant agricultural and economic transformations in various nations, including China, Japan, and the USA.

The top five countries that produce soybean globally are the United States (32%), Brazil (31%), Argentina (18), China (7%) and India (4%). Next to food grains, oilseed crops are the second-largest agricultural product in India and they form a significant part of the country's economy.

In addition to the essential components such as water, light, carbohydrates, minerals, and vitamins, plant growth relies on additional chemicals like hormones, which play pivotal roles in responses and metabolism. These hormones, although required in small quantities, exert significant influence over physiological processes in plants. The development of plant growth regulators stands as a remarkable achievement that has profoundly transformed agriculture. Treating various crops with growth regulators has consistently resulted in noticeable alterations in both crop growth and yield. The utilization of plant growth regulators represents a crucial tool for agriculturalists, as it is widely recognized that the application of these chemicals has substantial effects on the development and productivity of diverse crops.

Plant growth regulators are organic compounds that, even in small concentrations, can impact the physiological processes of plants. They have been used for to achieve various beneficial outcomes, such as enhancing root growth, increasing flower numbers, enlarging fruit size, and triggering early and uniform fruit ripening. Utilizing plant growth regulators, whether through foliar spray or seed treatment, has yielded remarkable results in both the yield and quality of numerous vegetable crops. However, the effects of these regulators are influenced by factors such as light, temperature, moisture, nutrients, and other environmental conditions. Additionally, the effectiveness of plant growth regulators can vary depending on their concentration, application method, and timing.

Plant growth regulators are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formulation, fruit and seed development and ultimately enhance productivity of the crops. Plant Growth regulators can improve the physiological efficiency including photosynthetic ability and can enhance the effective partitioning of accumulates from source and sinks in the field crops (Solaimalai *et al.,* 2001).

In the absence of micronutrients, plants show physiological disorders which eventually lead to reduction in crop yield and quality. Foliar spraying is a new method for crop feeding in which micronutrients in the form of liquid are used into leaves (Nasiri *et al.,* 2010). Foliar application of micronutrients is more beneficial than soil application. Since application rates are lesser as compared to soil application, same quantity of nutrient application could be supplied easily and crop reacts to nutrient application immediately. Foliar spraying of micronutrient is very helpful when the roots cannot provide necessary nutrients. Crop roots are unable to absorb some important nutrients such as zinc, because of soil properties, such as high pH, lime or heavy texture, and in this situation, foliar spraying is better as compared to soil application (Kinaci and Gulmezoglu, 2007).

Micronutrients play a crucial role in maintaining balanced crop physiology, with zinc and iron assuming distinct functions in crop development, including the formation, partitioning, and utilization of photosynthetic assimilates. Zinc foliar application is particularly prioritized for crops due to its essential role in chlorophyll production and pollen function. Insufficient levels of zinc and iron can lead to growth limitations, hindered symbiosis and nodulation, impaired photosynthesis, reduced dry matter production, and nutrient disorders in plants. Consequently, there is a need to investigate the impact of foliar application of micronutrients on growth characteristics and soybean yield.

Materials and Method

The study titled "Physiological Studies for Improving Seed Quality of Soybean (*Glycine max* (L.) *Merill*)" was conducted at the experimental and research field of the Department of Agricultural Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during the Kharif season of 2023-24. Akola is located in a tropical region at an elevation of 307.4 meters above mean sea level, with coordinates of 20.42°N latitude and 77.02°E longitude. The soil in the area was identified as medium black with clay, exhibiting a fairly level and uniform topography with adequate drainage. The details of the material used and methods adopted for these studies are described in this chapter under following heads.

Inputs used for research work

1. Seeds of soybean variety Suvarn Soya (AMS-MB-5-18) were used.
2. Ethrel, Cycocel (CCC) and Zinc Sulphate ($ZnSO_4$) at different concentrations were used for spraying at 50 % flowering (40 DAS) and pod initiation stage (55 DAS) to study its effect.
3. For estimation of Seed germination between paper method were used in this experiment.
4. Vigour Index II also estimated.

Equipment’s used

Equipment’s like electronic balance, petri dish, weighing balance, hot air oven, germination paper, soybean seeds etc. were used during this experiment.

(a) Seed Germination (%)

Germination percent (%) The standard germination test was conducted using the towel paper method by taking four replications of 100 seeds for each treatment. The paper folds were kept in seed germinator in an upright position at a constant temperature of 27°C ± 2°C at 80 per cent RH. After the seventh day the samples were removed and evaluated for normal seedlings, abnormal seedlings, hard seeds and dead seeds. Normal seedlings were considered for germination percentage as described in the ISTA rules for seed testing. (Anonymous,1999).

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Number of seeds put for germination}} \times 100$$

(b) Vigour Index

The seedling vigour index was determined from germination percentage, seedling length and seedling dry weight by using the following formula (Abdul Baki and Anderson, 1973) as below and expressed in whole number.

Vigour index I= Germination (%) x average seedling length (cm)

Vigour index II = Germination (%) x average seedling dry weight (gm).

Result and Discussion

Plant height (cm)

Data pertaining to plant height as influenced by the different treatments of growth regulators and micronutrients were tabulated in Table 1 and graphically illustrated in Figure 1.

Data suggested that at 30 DAS plant height results was found non-significant because foliar spraying treatment were given from 50% flowering stage (40 DAS) and onwards while significant variation was noticed regarding plant height at 60 and 90 DAS. Plant height at 60 DAS was found significant. The range was recorded as 37.23-47.33 cm. The mean plant height was recorded as 44.22 cm. At these stages significantly maximum plant height was observed in treatment T_3 (Cycocel @ 500 ppm). However, it was at par with treatments T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm), T_4 (Cycocel @ 750 ppm) and T_5 ($ZnSO_4$ @ 0.5%). These treatments were found superior to increase plant height when compared with treatment T_7 (control) and rest of the treatments. At 90 DAS plant height was significantly influenced by different treatments. The range of plant height recorded was 39.84-50.65 cm. The mean of plant height recorded was 47.31 cm. At this stage significantly maximum plant height was noted in treatment T_3 (Cycocel @ 500 ppm). However, it was at par with treatments T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm), T_4 (Cycocel @ 750 ppm) and T_5 ($ZnSO_4$ @ 0.5%). These treatments were found superior to increase plant height when compared with treatment T_7 (control) and rest of the treatments.

Leaf Area plant^{-1} (dm^2)

Data pertaining to seed leaf area per plant as influenced by the different treatments of growth regulators and micronutrients were tabulated in Table 1 and graphically illustrated in Figure 2.

Data regarding leaf area plant-1 of soybean was recorded plot wise at three growth stages *viz*., 30, 60 and 90 DAS. The data is given in Table 2 and described in Figure 2. Data suggested that at 30 DAS result was found non-significant because foliar spraying treatment were given from 50% flowering stage (40 DAS) and onwards while significant variation with gradual increase was noticed regarding leaf area plant-1 at 60 DAS, while it decreases at 90 DAS. Leaf area plant^{-1} at 60 DAS was found significant. The range of leaf area plant^{-1} was recorded as 11.69-16.13 dm^2. The mean of leaf area plant^{-1} was recorded as 13.88 dm^2. At these stages significantly maximum leaf area plant^{-1} was observed in treatment T_3 (Cycocel @ 500 ppm). However, it was at par with treatments T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm). These treatments were found superior to increase leaf area plant^{-1} when compared with treatment T_7 (control) and rest of the treatments.At 90 DAS leaf area plant^{-1} was significantly influenced by different treatments. The range of leaf area plant^{-1} was recorded as 11.18-15.31dm^2. The mean of leaf area plant^{-1} was recorded as 13.56 dm^2. At this stage significantly maximum leaf area plant^{-1} was noted in treatment T_3 (Cycocel @ 500 ppm). However, it was at par with treatments T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm), T_4 (Cycocel @ 750 ppm) and T_5 ($ZnSO_4$ @ 0.5%). These treatments were found superior to increase leaf area plant^{-1} when compared with treatment T_7 (control) and rest of the treatments.

Leaf Area Index (LAI)

Data pertaining to seed leaf area index as influenced by the different treatments of growth regulators and micronutrients were tabulated in Table 1 and graphically illustrated in Figure 3.

Data suggested that at 30 DAS leaf area index result was found non-significant because foliar spraying treatment were given from 50% flowering stage (40 DAS) and onwards while significant variation was noticed regarding leaf area index at 60 DAS, while it decreases at 90 DAS. At 60 DAS the range of leaf area index was observed 2.61-3.65. At these stages significantly maximum leaf area index was observed in treatment T_3 (Cycocel @ 500 ppm). However, it was at par with treatments T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm) and T_4 (Cycocel @ 750 ppm). These treatments were found to be superior to increase leaf area index when compared with treatment T_7 (control) and rest of the treatments. At 90 DAS leaf area index was significantly influenced by different treatments. The range of leaf area index recorded was 2.33-3.35. The mean of leaf area index recorded was 2.87. At this stage significantly maximum leaf area index was noted in treatment T_3 (Cycocel @ 500 ppm). However, it was at par with treatments T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm) and T_4 (Cycocel @ 750 ppm). These treatments were found superior to increase leaf area index when compared with treatment T_7 (control) and rest of the treatments.

Seed Germination (%)

Data pertaining to seed germination as influenced by the different treatments of growth regulators and micronutrients were tabulated in Table 2 and graphically illustrated in Figure 4.

Data suggested that at initial (Before sowing) stage seed germination percentage results was found non-significant because foliar spraying treatment were given from 50% flowering stage (40 DAS) and onwards while significant variation was noticed regarding seed germination percentage at final (After harvesting) stage.

Seed germination percentage in seeds differed significantly among different treatments. However, treatment T_6 ($ZnSO_4$ @ 0.10%) recorded the highest seed germination percentage i.e., 86.66 %, while control (T_7) treatment recorded minimum i.e., 83.00 % germination percentage. The mean of seed germination percentage is 85.43 %. Significantly the highest seed germination percentage was found in treatment T_6 ($ZnSO_4$ @ 0.10%). However, it was at par with treatments T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm), T_3 (Cycocel @ 500 ppm), T_4 (Cycocel @ 750 ppm) and T_5 ($ZnSO_4$ @ 0.5%). These treatments were found superior to increase seed germination percentage when compared with treatment T_7 (control) and rest of the treatments.

Vigour Index II

Data pertaining to vigour index as influenced by the different treatments of growth regulators and micronutrients were tabulated in Table 2 and graphically illustrated in Figure 5.

Vigour index II differed significantly among different treatments. However, treatment T_6 ($ZnSO_4$ @ 0.10%) recorded the highest vigour index II i.e., 81.56, while control (T_7) treatment recorded minimum i.e., 73.23 vigour index II. The mean vigour index II is 78.35. Significantly the highest vigour index II was found in treatment T_6 ($ZnSO_4$ @ 0.10%). However, it was at par with treatments T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm), T_3 (Cycocel @ 500 ppm) and T_5 ($ZnSO_4$ @ 0.5%). These treatments were found superior to increase vigour index II when compared with treatment T_7 (control) and rest of the treatments.

Table 1 : Effect of foliar application of ethrel, cycocel (CCC) and zinc sulphate on plant height, leaf area plant^{-1}, leaf area index (LAI), seed germination and vigour index in soybean.

Treatments	Plant Height (cm)			Leaf Area plant-1 (dm2)			Leaf Area Index (LAI)			Seed Germination (%)		Vigour Index II
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	Initial	Final	
T1 (Ethrel @200 ppm)	30.20	47.20	50.50	6.43	15.36	14.23	2.89	3.38	3.23	85.66	85.66	78.98
T2 (Ethrel @250 ppm)	30.17	46.20	49.43	6.50	15.10	13.97	2.72	3.19	3.06	85.00	86.00	78.60
T3 (Cycocel @500 ppm)	30.70	47.33	50.65	6.53	16.13	14.54	2.98	3.65	3.35	84.33	85.33	78.51
T4 (Cycocel @750 ppm)	29.53	45.87	49.08	6.37	13.48	13.04	2.67	3.17	3.01	83.66	84.66	76.77
T5 ($ZnSO_4$ @0.5%)	29.33	45.33	48.51	6.40	13.08	12.80	2.58	2.84	2.53	86.00	86.66	80.78
T6 ($ZnSO_4$ @0.10%)	28.80	40.37	43.19	6.27	12.32	12.03	2.57	2.78	2.58	86.33	86.66	81.56
T7 (Control)	28.47	37.23	39.84	6.33	11.69	11.18	2.45	2.61	2.33	82.33	83.00	73.23
GM	29.60	44.22	47.31	6.40	13.88	13.11	2.69	3.09	2.87	84.76	85.43	78.35
S.E. (m) ±	0.52	2.05	2.19	0.12	0.85	0.67	0.17	0.20	0.14	1.07	0.66	1.15
CD at 5 %	**NS**	6.31	6.75	**NS**	2.62	2.07	**NS**	0.61	0.43	**NS**	2.05	3.56

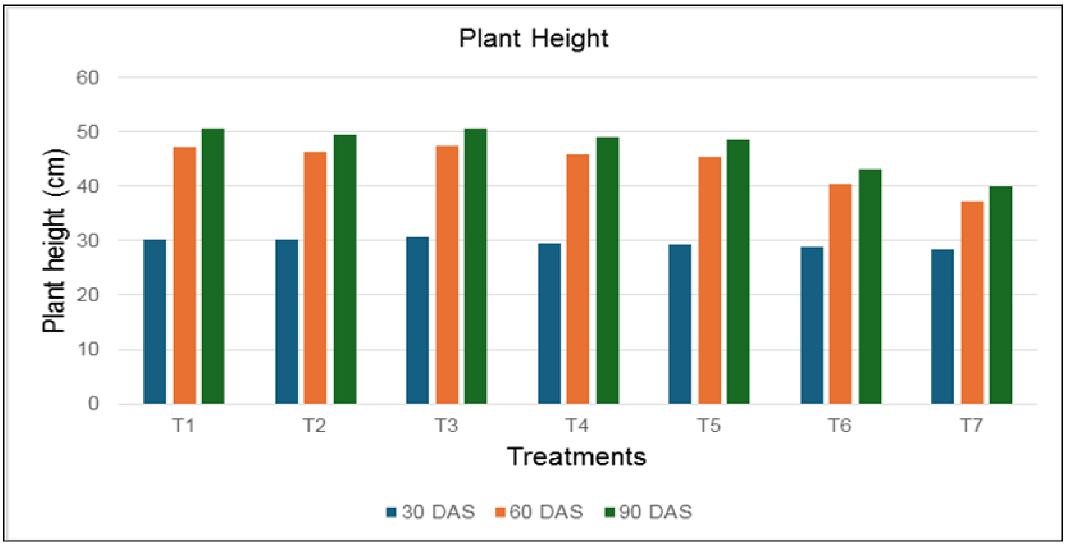

Fig. 1 : Effect of foliar application of ethrel, cycocel (CCC) and zinc sulphate on plant height in soybean

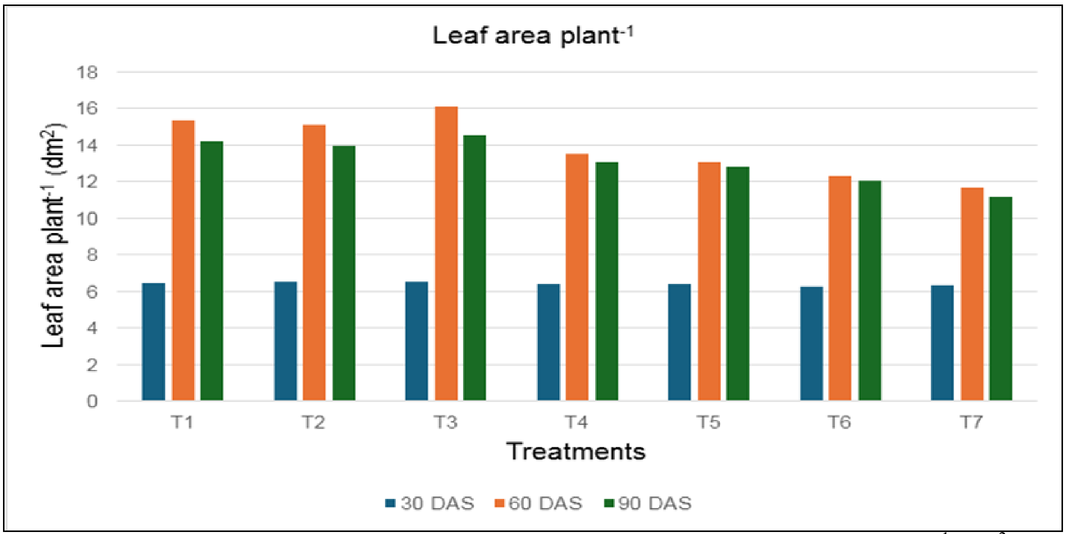

Fig. 2 : Effect of foliar application of ethrel, cycocel (CCC) and zinc sulphate on Leaf area plant^{-1} (dm^2) in soybean

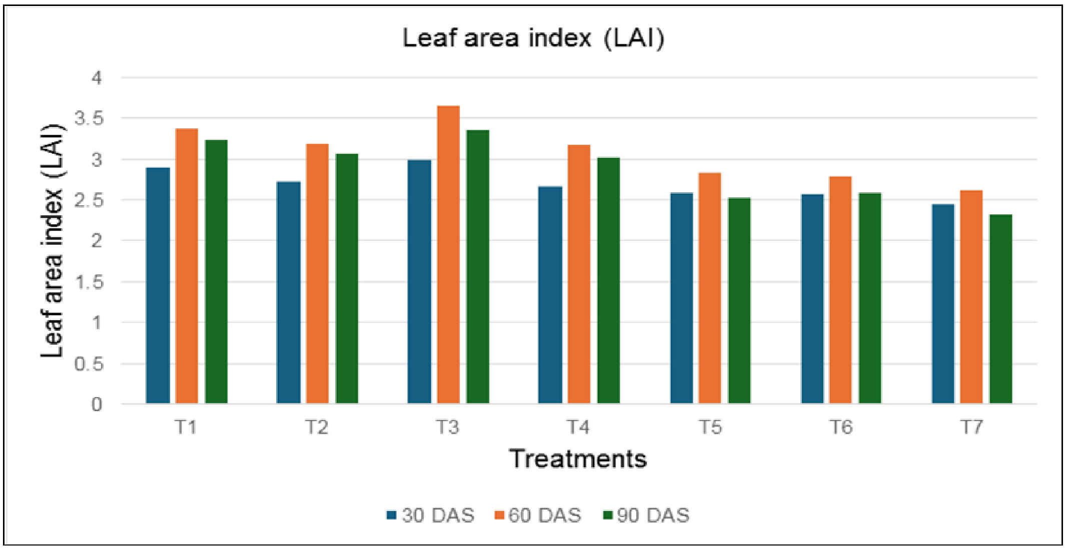

Fig. 3 : Effect of foliar application of ethrel, cycocel (CCC) and zinc sulphate on leaf area index in soybean

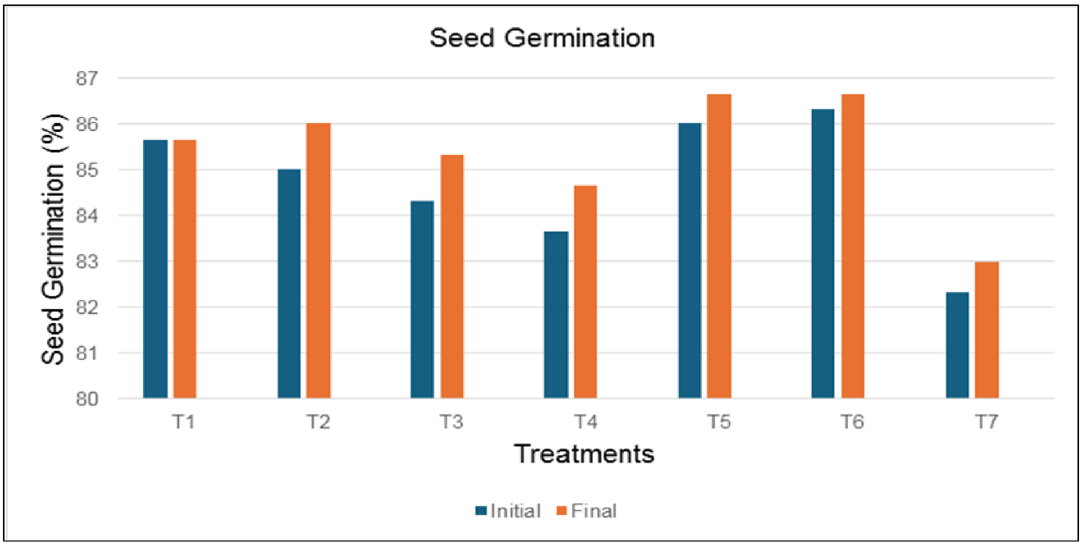

Fig. 4 : Effect of foliar application of ethrel, cycocel (CCC) and zinc sulphate on seed germination (%) in soybean

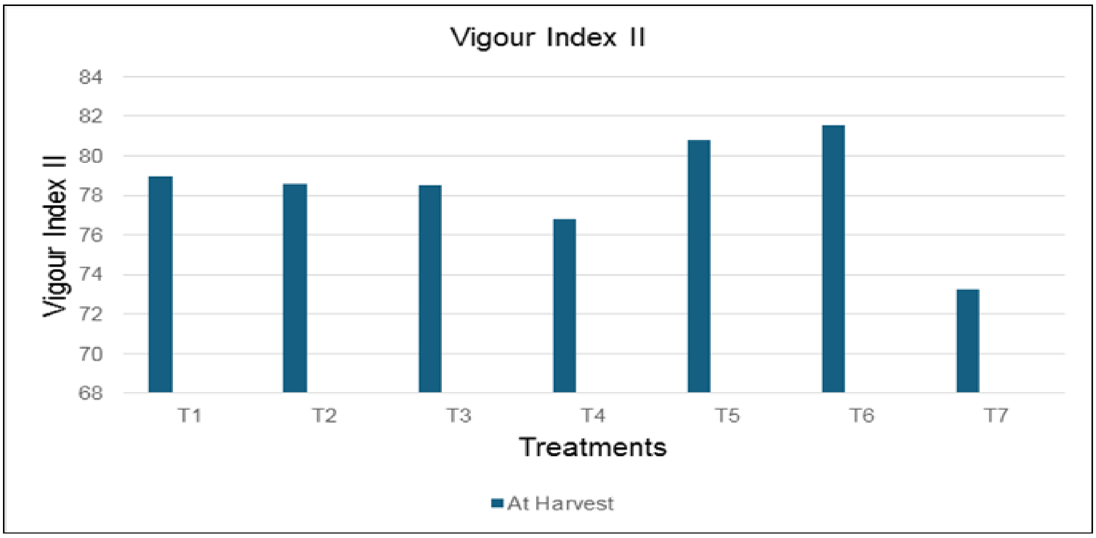

Fig. 5 : Effect of foliar application of ethrel, cycocel (CCC) and zinc sulphate on vigour index II in soybean

Conclusions

On the basis of findings reported in present investigation, the response of plant growth regulators and micronutrients on morphological and quality parameters of soybean following conclusion could be drawn. The effect of plant growth regulators and micronutrients on growth and yield attributes was found to be significant. T_3 (Cycocel @ 500 ppm) sprayed at 50% flowering stage (40 DAS) and pod initiation stage (55 DAS) was found significantly superior in enhancing morphological characters like Plant height, Leaf Area plant^{-1} and Leaf Area Index (%) followed by T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm), T_4 (Cycocel @ 750 ppm), T_5 ($ZnSO_4$ @ 0.5%), T_6 ($ZnSO_4$ @ 0.10 %) and T_7 (Control).

T_6 ($ZnSO_4$ @ 0.10 %) sprayed at 50% flowering stage (40 DAS) and pod initiation stage (55 DAS) was found significantly superior in enhancing quality parameters like Seed germination and Vigour index II followed by T_1 (Ethrel @ 200 ppm), T_2 (Ethrel @ 250 ppm), T_3 (Cycocel @ 500 ppm), T_4 (Cycocel @ 750 ppm), T_5 ($ZnSO_4$ @ 0.5%) and T7 (Control).

These conclusions were based on the finding of one season study. However, an extensive trial may be conducted to confirm these results.

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