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Effect of pre-harvest spray of micronutrients on growth, yield and seedling vigour in Chilli (*Capsicum annuum* L)

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ABSTRACT

Chilli (Capsicum annum L.), is the only crop grown as vegetable and spice purpose having export potential. The crop is cultivated intensively in almost all the states in our country. In crop production, micronutrients are very much essential in improving the yield of the crop as they play a crucial role in absorption of nutrients and also balancing other nutrients. However, during recent years, the deficiency of micronutrients is observed in several chilli growing areas, affecting the productivity of chilli. The causes for these nutrient deficiencies may be due to judicious use of inorganic fertilizers, intensive cropping system, loss of top soil by erosion and leaching. Therefore, proper plant nutrition along with micronutrients results in enhanced yield. In recent years, it was observed that, the micronutrients usage is increased to realize higher yield. The primary input in crop production is the good quality seed, as it plays major role in yield. Hence, the present experiment was conducted to evaluate the effect of pre harvest spray of micronutrients (Fe, Zn, Ca, B and Mg in different combinations and alone) on yield and seed quality of Chilli at HRS, Lam in a randomized block design with three replications. The foliar application of the treatments included individual spray of Zinc Sulphate (0.2%), Ferrous sulphate @ 0.2%, Calcium nitrate @ 0.2%, Magnesium sulphate, 0.2% , Boron 0.1% and a combination of all these micro nutrients was done three times i.e., at 60,90 and 120 days after transplanting. Among the treatments, spraying with combination of Zinc Sulphate (0.2%), Ferrous sulphate @ 0.2%, Calcium nitrate @ 0.2%, Magnesium sulphate @ 0.2% and Boron @ 0.1% spray recorded maximum plant height, more number of primary branches, yield (119.1 q/ha), seed yield per plant, number of seeds per pod, germination percentage, root and shoot length of seedling and seedling vigour index I and seedling vigour index II.

Keywords: *Chilli micro nutrients, growth, seedling vigour index and yield.*

Introduction

Chilli (*Capsicum annum* L.) is globally cultivated vegetable cum spice crop. The crop was introduced by the Portuguese from Brazil to India in1584 [42]. Chilli is mainly grown in Africa, USA, Japan, Mexico, India, Turkey, etc. India occupies top position in cultivation of Chilli. In India during 2023-24, Chilli was cultivated in8.09 lakh hectares with estimated production of about 29.13 lakh tones. The average productivity of chilli in India was 3273 kg/ha. Andhra Pradesh ranks first in Chilli production (14.44 lakh tones) contributing 49.57% of total production from an area of 2.47 lakh hectares (27.75% i.e. of the area).The crop is also grown in Telangana, Madhya Pradesh, Karnataka, and West Bengal states. Nearly 4,02,922 metric tons of red Chilli of chilli is being exported to Asian countries (China, Sri Lanka, Malaysia, Bangladesh, Singapore, Thailand, and the UAE). The major varieties exported are Teja S17, Kashmiri, and Byadgi chillies. Vietnam, the United States, China, Australia, Canada, etc. are the major countries for import. [5]. Chilli is grown as a commercial crop because of is demand for export. As a vegetable crop, chilli is in third important crop next to tomato and potato [31]. It is also used in the pharmaceutical industry because of its medicinal properties [9], used daily in Indian cousin due to attractive colour and pungency. [45]. Chilli is rich source of vitamin A and C [35, 36].

In view of the export potential of the crop, chilli crop is grown with excessive use of fertilizers The current scenario of intensive agriculture practices resulted in excess use of NPK fertilizers resulting in unavaibility of micronutrients; and their deficiencies. In calcareous soils, the deficiency of micronutrients, especially zinc and boron is commonly observed. [38]. Soil pH also plays important role in availability of micronutrients. High $CaCO_3$, Calcium and and pH is more than 7.0 results in to shortage of micronutrients for crops, especially zinc and boron [11,25,47]. Micro Nutrients are essential for plant growth, nutrient absorption and balancing other nutrients. [24, 39]. Earlier studies have reported that, t deficiency of micronutrients results in poor vegetative growth, reduction in yield and also poor quality of fruits in several crops [7, 8]. Hence to realize maximum yield potential from the given variety of crop, management of nutrients is crucial [6, 30]. As the demand for chili is more in view of its commercial importance, nutrient management to realize higher yield with quality is the need of the hour. Micronutrients, are also essential along with major nutrients to improve chili's growth, yield, and quality [38].

The requirement of micronutrients is (boron, iron, copper, zinc, manganese, calcium) is only in traces, but they are effectively as important as macronutrients. Among the micro nutrients, Zinc is a vital element as it is a part of dehydrogenase, aldolase, isomerases, proteinase, peptidase, and phosphohydrolase enzymes. It plays critical role in various physiological processes like photosynthesis, protein synthesis, cell membrane integrity, chlorophyll synthesis, pollen development, seed development and also in disease resistance in plant tissues [22, 28]. Iron is essential for chlorophyll production, activation of enzymes, including in the oxidation /reduction processes of

photosynthesis, respiration. Iron is vital for chlorophyll synthesis and photosynthesis, and is particularly important for red chilli carotenoid synthesis, indirectly enhancing the quality of red chillies. One more important micronutrient is boron needed for cell wall development, cell wall strength, fruit enlargement, seed development, cell division, sugar transport and hormone production. Boron is believed to have a key role in the growth of plant cell walls by altering certain metabolic pathways, [1, 2, 3, and 48]. In association with calcium, affects pollination, fruit development and can affect the normal development of fruit resulting in fruit cracking and misshapened fruits. Copper is necessary for photosynthesis, plays key role in several enzymes, seed development and lignin synthesis which gives physical strength to shoots and stems. The deficiency of copper results into poor growth and die back of twigs. Manganese is also required in chlorophyll synthesis, photosynthesis, respiration, nitrate assimilation.

Chilli is a very exhaustive crop and needs proper nutrient management strategies to get the maximum yield from a given variety. Deficiency of micronutrient may play an impact on crop yield even though the recommended dose of fertilizers is applied [23]. Hence, to realize higher yields, micronutrients application is crucial. The beneficial role in plant growth and yield with the application of micronutrients might be due to the enhancement in physiological and metabolic processes in plants [6, 21]. In recent years, the usage of these micronutrients is increased, particularly in commercial crops. Foliar application of micronutrients in small quantity gives higher yield, better quality seed in vegetable crops compared to their requirement as soil application. [26]. Hence, the present experiment on the effect of pre-harvest spray of micro nutrients on the yield and quality of chillies was conducted to know their influence on vegetative characters, yield and seed parameters.

Materials and Methods

An experiment was conducted to evaluate the effect of pre harvest spray of micronutrients on growth, yield and seed with thirteen treatments *viz;* Control (T_1), Spraying with Zinc Sulphate @ 0.2% (T_2), Spraying with ferrous sulphate @ 0.2% (T_3), Spraying with calcium nitrate @ 0.2% (T_4), Spraying with Magnesium sulphate @ 0.2% (T_5), Spraying with Boron @ 0.1% (T_6), Mixture with all the micronutrients (T_7), Spraying T_7 without Zinc sulphate @ 0.2% (T_8), Spraying T_7 without Ferrous sulphate @ 0.2% (T_9), Spraying T_7 without Calcium nitrate @ 0.2% (T_{10}), Spraying T_7 without Magnesium Nitrate (T_{11}), Spraying T_7 without Boron (T_{12}), Spraying with Commercial formulation (T_{13}) consisting of the micro nutrients mixture in Randomized block design with three replications at Horticulture Research station, Lam Dr.YSRHU in randomized block design replicated thrice on chilli crop variety LCA – 620. The soil status for available nutrients was medium with 314 Kg N/ha and 24 Kg/P_2O_5, and 605 Kg K_2O/ha. The organic percentage was low (0.46%). Each treatment was replicated thrice to minimize experimental errors. Healthy 45 day old seedlings were transplanted adopting 75 cm spacing between rows and 30cm spacing within the row in the experimental plots. Foliar sprays of micronutrients were applied at three stages of plant growth: 60, 90, and 120 days after transplanting. The treatments were imposed as per schedule at 60, 90 and 120 days after planting. Necessary agronomic and crop protection procedures were taken up as per the recommendation of the crop. In each plot, five randomly selected plants were tagged to collect biometric data and the mean value was calculated so as to test the significance of variation in observed characters. F test at 5 percent level of significance was used to test the significance of difference in the treatment effect and CD (critical difference) was calculated, wherever the results found significant at a 5% probability level [15]. Seed parameters were recorded on germination percentage, Seed vigour index-I and Seed vigour index-II. The germination percentage of seeds was calculated by the guidelines of ISTA using paper towels. The germination count of chilli seedlings was recorded on seventh and fifteenth day and the percentage of germination was calculated based on survival of normal seedlings. The Seedling Vigour index I was calculated by multiplying the germination percentage with the seedling length (cm) Seedling Vigour index II was calculated by multiplying the germination percentage with the seedling dry weight (g). Overall, the experimental setup and data collection procedures were conducted meticulously to evaluate the effect of micronutrients on seed yield and seed quality of chilli. The analysed data were presented in tables 1 and 2.

Results and Discussion

Significant results were observed in growth, yield attributes and yield among the treatments. [7,8]. The results revealed that plant height at harvest was significantly influenced by pre-harvest spray of micro nutrients. The combined application of micronutrient spray (T_7) resulted in the tallest plants (95.5 cm), and it did not differ significantly from T_{13} (92.9 cm) , and from the treatments in which individual nutrients were omitted from the mixture T_8 (84.3cm), T_9 (85.4cm), T_{10}(84.9) T_{11} (86.5cm) and T_12 (86.5cm). This pattern indicates that chilli plants respond more consistently to a balanced mixture of micronutrients than to isolated nutrient application. A similar trend was observed in other growth characters of Chillies. Spraying with a mixture of all the micro nutrients recorded significantly more number of primary branches (4.8), number of fruits (228.2) being on par with T_{13} (4.5,201.7 respectively), T_8 (4.3,195.5 respectively), T_9(4.5,193.7 respectively), T_{10} (4.1,195.7 respectively), T_{11} (4.1,190.7 respectively), and T_{12} (4.7,199.2 respectively). The results indicated that, the foliar application of all the micro nutrients have a significant effect on the plant height, primary branches per plant and number of fruits per plant in chilli. Similar results of an increase in growth parameters due to spraying of micro nutrients were reported earlier [19, 28, 33]. The increase in the growth of chilli shows the key role of micronutrients in plant vegetative growth, even though they are required in relatively small quantities. The combined application of micronutrients resulted in more number of branches than applying each nutrient alone and contributed to the growth-attributing characteristics. The improvement in plant growth of chilli suggest that, multiple micronutrients act synergistically to support continuous vegetative development, likely through their collective roles in enzymatic activity, membrane stability, auxin-related growth processes, and chlorophyll formation. Previous research in chilli supports this type of coordinated physiological response to micronutrient supplementation [24, 33, 41].

Reproductive traits were also showed similar trend by the application of micro nutrient mixture. Among the treatments, T_7 (Spraying with all the micro nutrients) recorded more no. of seeds per pod (97.0), maximum seed yield per plant (116.9gm/pl) and ripe yield (119.1 q/ha/h) being on par with T_{13} (117.5q/ha), T8 (106.1q/h), T_9 (110.7q/h), T_{10} (108.8q/h), T_{11} (105.0q/h) and T_{12}(102.2Q /h).

The increase in reproductive characters under T_7 may be attributed to the role of these micro nutrients in improved nutrient mobility, better pollen viability and more efficient assimilate transport to developing fruits. These micronutrients influence cell division, tissue differentiation, pigment development, and enzymatic regulation of flowering and fruit set, contributing cumulatively to higher yield. The present study confirms that, chilli requires a balanced supply of multiple micronutrients to fully express its yield potential. Zinc may have contributed by supporting auxin biosynthesis and protein synthesis, while iron likely increased chlorophyll concentration and accelerated physiological processes linked to flowering and fruit growth, improved carbohydrate distribution, a consequence of a better source–sink relationship, receiving the complete mixture [12,19,29,32,37,42,44,45].

Among the treatments, T_{13} spraying with a combination of micro nutrients (Zinc sulphate, Ferrous sulphate, Calcium ammonium nitrate and magnesium sulphate and boron recorded maximum seed yield per plant (116.9gm.pl) and more number of seeds per pod (116.9gm/pl) followed by T_{12} (102.9gm/pl and 87.5 respectively). Similar results of increase in the number of fruits per plant, yield per plant, seed yield and number of seeds were reported [43] in Chillies. Speeding up the process of photosynthesis and increased photosynthates (CH_2O) resulted in increase in the vegetative growth, preventing flower and fruit drop, by the result of which it increased the number and weight of fruits and ultimately increased the yield in chillies. Almost similar results of an increase in growth and yield by application of micronutrients were reported earlier [9, 12, 16, 21, 45].

Seed quality traits exhibited a similar response pattern. The germination %, root and shoot length, seedling vigour index –I and seedling vigour index –II were significantly increased with pre harvest foliar spray of mixture of micro nutrients (Table: 2). Seed germination %, root and shoot length, seed vigor index –I and seed vigour index –II were significantly highest in treatment T_{13} (91.0, 10.4, 4.4, 1342.6 and 140.5 respectively) being on par with T_{12}, (90.0, 9.9, 4.3, 1279.5 and 137.7 respectively) T_8 (89.7, 9.9,4.3,1279.5 and 137.7 respectively) , T_{12}, T_9, T_{10}, T_{11}, T_{12}. Seeds from the control treatment (T_1) consistently showed the lowest germination and seedling vigour. The improvement in seed quality parameters may be due to increased metabolic activity during seed formation, as micronutrients function as cofactors in several enzyme systems which are associated with respiration, nutrient translocation, and embryo development. Enhanced root and shoot growth indicates that the seeds developed under improved physiological conditions results in better seedling vigour. The results are in accordance with earlier reports with regard to seedling characters. [14, 17, 40].

Overall, the results demonstrate that spraying with mixture of micronutrients at fruit development and maturation stages contributes substantially to both vegetative and reproductive performance of chilli, as well as to the quality of the seed.

Table 1: Effect of micro nutrients on growth, yield attributing characters and yield in chillies

Treatment Details	Plant height (cm)	No. of primary branches	No. of fruits	No. of seed/pod	Ripe yield (Q/h)
1. Control	73.2	3.4	154.3	68.3	86.4
2. Spraying of Zinc Sulphate (0.2%)	77.9	4.1	162.1	74.5	97.7
3. Spraying of Ferrous sulphate @ 0.2%	81.7	4.1	181.7	73.3	100.8
4. Spraying Calcium nitrate @ 0.2%	81.9	3.8	174.3	70.3	99.1
5. Spraying magnesium Nitrate @ 0.2%	81.9	3.9	179.5	76.1	97.5
6. Spraying Boron @ 0.1%	79.7	4.4	179.1	80.1	92.2
7. Spraying with mixture of all	95.5	4.8	228.2	97.0	119.1
8. Spraying T7 without Zinc Sulphate (0.2%)	84.3	4.3	195.5	84.6	106.1
9. Spraying T7 without Ferrous sulphate @ 0.2%	85.4	4.5	193.1	86.1	110.7
10. Spraying T7 without Calcium nitrate @ 0.2%	84.9	4.1	195.7	85.7	108.8
11. Spraying T7 without Magnesium Nitrate @ 0.2%	83.7	4.1	190.7	85.2	105.0
12. Spraying T7 without Boron @ 0.1%	86.5	4.7	199.2	85.8	102.2
13. Commercial formulation with micronutrient mixture	92.9	4.5	201.7	87.5	117.5
CD	8.8	0.6	26.0	10.5	14.1
CV %	6.3	8.1	8.3	7.7	8.1

Table 2: Effect of micro nutrients on seed yield , root length, shoot length and seedling vigour index

Treatment Details	Seed yield/pl (gm)	Germination%	Root length (cm)	Shoot length (cm)	SVI-I %	SVI-II
1. Control	69.9	85.7 (67.8)	7.9	3.3	954.8	115.0
2. Spraying of Zinc Sulphate (0.2%)	75.4	86.7 (68.6)	8.7	3.5	1057.7	119.5
3. Spraying of Ferrous sulphate @ 0.2%	84.5	86.0 (68.1)	9.5	3.6	1128.2	120.7
4. Spraying Calcium nitrate @ 0.2%	80.5	86.7 (68.3)	8.8	3.5	1068.7	125.7
5. Spraying magnesium Nitrate @ 0.2%	82.8	87.3 (69.2)	9.0	3.7	1105.8	121.4
6. Spraying Boron @ 0.1%	83.0	86.3 (68.4)	8.7	3.6	1066.4	121.2
7. Spraying with mixture of all	116.9	91.0 (72.6)	10.4	4.4	1342.6	140.5
8. Spraying T7 without Zinc Sulphate (0.2%)	93.7	89.7 (71.3)	10.0	4.2	1273.3	135.7
9.Spraying T7 without Ferrous sulphate @ 0.2%	96.4	88.0 (69.7)	9.3	4.2	1187.6	131.1
10.Spraying T7 without Calcium nitrate @ 0.2%	95.7	88.3 (70.1)	10.2	4.0	1255.3	133.6
11. Spraying T7 without Magnesium Nitrate @ 0.2%	92.0	89.7 (71.3)	9.1	4.1	1183.8	133.3
12. Spraying T7 without Boron @ 0.1%	99.0	89.0 (70.6)	8.5	4.1	1120.5	132.3
13. Commercial formulation with micronutrient mixture	102.9	90.0 (71.6)	9.9	4.3	1279.5	137.7
CD	12.3	2.3	1.1	0.6	99.2	15.27
CV %	8.1	1.9	7.4	9.2	5.1	7.08

Conclusion

The present study was conducted to evaluate the effect of pre-harvest spray of micronutrients (Zinc sulphate, ferrous sulphate, Calcium nitrate, magnesium sulphate @ 0.2% and boron @ 0.1% in different combinations and alone) on yield and seed quality of Chilli at HRS, Lam, Dr.YSRHU in randomised block design replicated three times. The micronutrients spray was done at 60, 90 and 120 days after planting significantly influenced the vegetative growth parameters, yield attributes, ripe yield, seed yield and seeding vigour index of chilli. The study revealed that, pre harvest spraying with a combination of micro nutrients (Zinc sulphate, ferrous sulphate, Calcium nitrate, magnesium sulphate @ 0.2% and boron @ 0.1% resulted in increase in growth, yield, seed yield and seedling vigour index.

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