Original Research Article

Response of capsicum (*Capsicum annuum* L.) hybrids to micro-nutrients under protected conditions

ABSTRACT

The field experiment was carried out during *rabi*season of 2021-22 and 2022 at Vegetable Research Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpurto find out the response of capsicum hybrids to micronutrients under protected conditions.The experiment was laid out in Split Plot Design(SPD) with 15 treatment combinations and replicated thrice. The experiment comprised three hybrids *viz*., Indira, Swarna and Bomby and five levels ofmicronutrients *viz.*, control (no micronutrients application), soil application of Zn, Fe & B, fertigation of EDTA of Zn & Fe and solubor at 15 days interval, foliar application of vegetable special @ 5g/lit at 15 days interval and foliar application of chelated combo micronutrients @ 1g/lit at 15 days interval. Recommended package of practices for the crop were followed except treatments. Results of the experiment revealed that the hybrid Indira recorded significantly highest plant height (91.30 and 94.89 cm), number of branches (11.87 and 12.30), stem girth (4.31 and 4.60 cm), number of leaves (102.94 and 106.43), internode length (13.82 and 14.01 cm), number of flowers per plant (38.22 and 38.36), fruit set (55.10 and 55.44%), no. of fruits per plant (20.99 and 21.22), fruit weight per plant (3.69 and 3.74 kg) and fruit yield per 1000 m^2 (70.36 and 71.35 q) while fruit length (11.45 and 11.71 cm), fruit diameter (10.54 and 10.66 cm), weight of placenta (18.51 and 18.71g) and average weight of fruit (193.31 and 195.90g) were significantly highest in Swarna. In case ofmicronutrients, foliar application of vegetable special @ 5g/at 15 day recorded significantly highest value ofplant height (93.72 and 96.77cm), no. of branches (12.66 and 13.39), stem girth (4.75 and 5.12 cm), no. of leaves (105.52 and 108.68), internode length (14.75 and 15.04cm), no. of flowers per plant (41.34 and 41.95), fruit set (56.66 and 57.45%), no. fruits per plant (20.56 and 20.73), fruit length (11.85 and 12.07cm), fruit diameter (10.62 and 10.80cm), weight of placenta (18.31 and 18.46g), average fruit weight (189.03 and 191.33g), fruit weight per plant (4.12 and 4.17 kg) and fruit yield (78.64 & 79.60q/1000 m^2). Hence, hybrid Indira and foliar application of vegetable special@ 5g/at 15 ~~day~~ days may be recommended for higher productivity fromcapsicum ~~crop~~ cropsunder protected conditions.

Keywords: Capsicum hybrids, Growth, Micronutrients and Yield

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INTRODUCTION

Capsicum (*Capsicum annum* L.) is rich in vitamin A (8493 IU), vitamin C (283 mg) and minerals like calcium (13.4 mg), magnesium (14.9 mg) phosphorus (28.3 mg) and potassium, (263.7 mg) per 100 g fresh weight. From every 100 gof edible portion of capsicum, 24 kcal of energy, 1.3 g of protein, 4.3 g of carbohydrate, 0.3 g of fat along with dietary fiber, phytochemicals, etc. areprovided (Sreedhara *et al.,* 2013).The optimum temperature required by the capsicum plant is 20 to 25˚C during the day and 18 to 20˚C at night. If temperature exceeds 35°C or falls below 12°C, fruit ~~setting~~ setis affected. Among the various protected structures, polyhouse production ~~had~~ hasbeen proven as a more profitable protected technique for capsicum cultivation (Aruna and Sudagar, 2010). More (1990) ~~started~~ statedthat ~~greenhouse~~ greenhousesprotected the crops from ~~extreme~~ extremelyhigh ~~temperature~~ temperaturesand high rainfall to facilitate timely harvest as per demand and good quality of produce. Generally, the main purpose of growing high value crops in protected conditions is to give blemish free ~~high quality~~high-quality material as it is easy to control diseases and pests throughout the year. Micronutrients are needed in very little quantity but are very important for proper growth of plants (Mousavi, 2011). Zinc and boron are responsible for the enhancement of photosynthesis (Gupta, 1993)**.**Zinc is also responsible for many enzymatic activities i.e. aldolase, peptidase, isomerase and phosphohydrolase *etc*. (Rawat and Mathpal, 1984). Boron deficiency can cause small fruit size and sterility in plants. ~~Degeneration~~ The degenerationof tissues and disintegration of cambium cells may also be due to a deficiency of boron (Agarwal, 2018). ~~External~~ The externalsupply of inputs has become important because of poor fertility status of the soil which is not able to meet the entire nutrient requirement of the crop (Rajiv and Tomar, 2022).

In order to enhance the quality production and productivity per unit area of vegetable crops, protected cultivation technologies may be opted. Protected cultivation offers several advantages to ~~produce~~ producingvegetables of high quality and yields, thus using the land and other resources more efficiently (Rajiv and Kumari, 2023). Protected cultivation is more sustainable as the effect of climate is minimized (Pachiyappan *et al.,* 2022). Protected cultivation of high-value crops offers higher productivity which in turn increases the profitability of the farm (Prakash *et al.*, 2022). Therefore, the current study included hybrids and the

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application of micro-nutrients under protected conditions to study its influence on productivity of capsicum in central plain zone of Uttar Pradesh.

MATERIAL AND METHODS

The field experiment was carried out during two consecutive *rabi* seasonof 2021-22 and 2022at Vegetable Research Farm, Kalyanpur of C.S. Azad University of Agriculture & Technology, Kanpur under naturally ventilated poly house.Kanpur is situated at 25.26^0 to 26.50^0 north latitude and 79.31^0 to 80.34^0 longitudes with an altitude of 125.9 m above the mean sea level. The climate of Kanpur region is typically sub-humid and sub-tropical with extreme winter and summer. The average rainfall is 800-850mm, which mostly received from June to September.

The soil was sandy loam in texture and soil pH was 7.8, which showed slightly alkaline reaction. The soil was low in organic carbon (0.40%), low in available N (162.0 kg/ha), medium in available phosphorus (15.2 kg/ha) and low in available potassium (192 kg/ha) at initiation of experiment. The experiment was laid out in split plat design (SPD) with 15 treatment combinations and replicated thrice. The experiment comprised three hybrids *viz.*, Indira, Swarna and Bomby and five levels of micronutrients *viz.*, control (no micronutrients application), soil application of Zn, Fe & B, fertigation of EDTA of Zn & Fe and solubor at 15 days interval, foliar application of vegetable special @ 5g/lit at 15 days interval and foliar application of chelated combo micronutrients @ 1g/lit at 15 days interval. The plants were planted on beds at 60×60 cm spacing in zigzag manner on 18^{th} October and 20^{th} Octoberduring 2021-22 and 2022-23, respectively. Bed size of 0.90m (width) × 4.20m (length) with height of 15 cm was maintained in the experiment. A total number of beds (plots) were 15×3= 45.Recommended package of practices for the crop were followed except treatments. The five plants were selected randomly from each plot and tagged. The observations were recorded on growth parameters,yield attributes and fruit yield and analyzed by using statistical techniques.

RESULT AND DISCUSSION

Effect of ~~capsicum~~ Capsicumhybrids on growth parameters, yield attributes and fruit yield

The entire growth parameters, yield attributes and fruit yield were influenced significantly by hybrids during both the years of capsicum experimentation (Table 1, 2 and 3). Among hybrids, Indira recorded significantly highest growth parameters*viz.*, plant height (91.30

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and 94.89 cm), number of branches (11.87 and 12.34), stem girth (4.31cm and 4.60cm), number of leaves (102.94 and 106.41), internode length (13.82 and 14.01cm) and number of flowers (38.23 and 38.36) during both the years.It was followed by Swarna while Bomby was lowest in all the above growth parameters. However, capsicum hybrids Swarna and Bomby were found statistically at par with each other in terms of plant height, number of branches, number of leaves and internode length during both years while in terms of stem girth and number of flowers during first year only. This might be due the vigour of the individual plant governed by the genetical factors. These findings are in accordance with the results ofMalshe *et al.* (2016) and Manoj and Venugopal (2018).

In case of earliness in flowering and fruiting, capsicum hybrid Indira recorded significantly earliest first flower appears (51.11 and 50.32 days), first fruit set (61.85 and 60.83days) and first fruit harvest(84.52 and 82.59 days) during both the years (Table 2). It was followed by Swarna while Bomby was latest in these flowering and fruiting parameters. However, Swarna and Bomby were found statistically at par with each other in terms of first flower appears, first fruit set and first fruit harvest during both the years.

In case of yield attributes and yield, Indira produced significantly highest number of fruits per plant (20.99 and 21.22), fruit weight per plant (3.69 and 3.74 kg) and fruit yield per 1000 m^2 (70.36 and 71.35 q). It was followed by Swarna while Bomby lowest in all these traits. However, Swarna and Bomby were found statistically at par with each other in terms of number of fruits per plant, fruit weight per plant and fruit yield per 1000 m^2during both the years. As far as individual fruit trait is concern, the significantly highest value of fruit length (11.45 and 11.71 cm), fruit diameter (10.54 and 10.66 cm), weight of placenta (18.51 and 18.71g) and average weight of fruit (193.31 and 195.90g) were foundin Swarnafollowed by Indira and Bomby(Table 2).It might be due to genetic makeup and environmental conditions. The results are in confirmation with the findings of Singh and Singh (2012) and Behera and Chitdeshwari (2021).

Effect of micronutrients on growth parameters, yield attributes and fruit yield

The growth parameters, yield attributes and fruit yield were influenced significantly by micronutrientsduring both the years of capsicum experimentation (Table 1, 2 and 3).The foliar application of vegetable special @ 5g/lit at ~~15 day~~15-day~~interval~~intervalsrecorded significantly

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highest growth parameters *viz.*, plant height (93.72 and 96.77cm), no. of branches (12.66 and 13.39), stem girth (4.75 and 5.12 cm), no. of leaves (105.52 and 108.68), internode length (14.75 and 15.04cm) and no. of flowers per plant (41.34 and 41.95). It was followed by foliar application of chelated combo micronutrients @ 1g/lit at 15 days interval and fertigation of EDTA of Zn & Fe and solubor at 15 ~~days interval~~day intervals in all above growth parameters.However, foliar applications of vegetable special @ 5g/lit and chelated combo micronutrients @ 1g/lit were found statistically at par with each other in terms of plant height, no. of branches, stem girth and no. of leaves.The significant improvement in growth parameters might be due to the availability of sufficient micronutrients.These results ~~are corroborates~~corroborate to findings documented by Irfan *et al.*,(2020) andMalik *et al.* (2020).

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In the case of earliness in flowering and fruiting, foliar application of vegetable special @ 5g/lit at 15 day intervalrecorded significantly earliest first flower appears (49.35 and 48.54 days), first fruit set (59.27 and 58.90 days) and first fruit harvest (85.42 and 84.51 days) during both the years (Table 2). It was followed by foliar application of chelated combo micronutrients @ 1g/lit at 15 ~~days interval~~day intervals and fertigation of EDTA of Zn & Fe and solubor at 15 days interval in all above traits. However, foliar applications of vegetable special @ 5g/lit and chelated combo micronutrients @ 1g/lit were found statistically at par with each other in terms of earliness in flowering and fruiting. Abundant supply of micronutrients might have resulted in these parameters.The results are corroborates the findings ofKaur *et al.*, (2017) and Malik *et al.*(2020).

Similar to growth parameters, the foliar application of vegetable special @ 5g/lit at 15 day intervalalso produced significantly highestno. fruits per plant (20.56 and 20.73), fruit length (11.85 and 12.07cm), fruit diameter (10.62 and 10.80cm), weight of placenta (18.31 and 18.46g), average fruit weight (189.03 and 191.33g), fruit weight per plant (4.12 and 4.17 kg) and fruit yield per 1000 m^2 (78.64 & 79.60q) during both the years (Table 3). It was followed by foliar application of chelated combo micronutrients @ 1g/lit at 15 days interval and fertigation of EDTA of Zn & Fe and solubor at 15 days interval in yield attributed and fruit yield. However, foliar applications of vegetable special @ 5g/lit and chelated combo micronutrients @ 1g/lit were found statistically at par with each other in terms offruit length, fruit diameter, weight of placenta and average fruit weight. The yield is largely governed by the yield attributes, hence

their better development reflected in the higher fruit yield. These results are ~~corroborates~~corroborating to findings documented byAgrawal (2018),Kaur *et al.*, (2017) andNaik (2018).

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The study on the response of Capsicum (*Capsicum annuum* L.) hybrids to micro-nutrients under protected conditions holds significant scientific relevance in the context of agricultural research and food security. Firstly, it addresses a critical aspect of modern agriculture (Campos, 2023), which is the optimization of nutrient management for high-value crops (Olivares, 2022; Hernandez et al. 2020). Capsicum, being a popular vegetable crop, is not only economically important but also contributes to global nutrition. Understanding how different Capsicum hybrids respond to micro-nutrients in controlled environments can help fine-tune nutrient application practices, ultimately leading to increased crop yields and quality. This research has broader implications for sustainable agriculture by potentially reducing the need for excessive fertilizer use, which can have detrimental environmental effects (Hernandez and Olivares, 2020; Hernandez et al. 2018a).

Comparatively, this study aligns with the findings of research on soil quality and productivity of tropical crops in several ways (Hernandez et al. 2018; Hernandez and Olivares, 2019). Both areas of study share the overarching goal of enhancing agricultural output in regions where food security is a pressing concern (Olivares et al. 2021; Vega et al. 2022). Soil quality research often explores the availability of essential nutrients in tropical soils (Lobo et al. 2023; Lopez et al. 2019), and the findings can complement the results of the Capsicum study by providing insights into the nutrient status of soils in the same region. Furthermore, as micro-nutrients play a vital role in soil health and crop productivity (Araya-Alman et al. 2020; Rey et al. 2022), understanding their interaction with tropical soils is essential (Olivares and Lopez, 2019). Therefore, while the Capsicum study focuses on crop-specific responses, it should be seen as a piece of the broader puzzle in the quest for sustainable tropical agriculture, where soil quality and crop productivity are intertwined research areas aimed at improving food security and agricultural sustainability.

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CONCLUSION

From the present findings, it can be inferred that the hybrid Indira and foliar application of vegetable special @ 5g/lit at 15 days intervalwas found suitable for realizing highest fruit yield of capsicumcrop under protected conditions in central plain zone of Uttar Pradesh.

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Table 1: Effect of hybrids and micronutrients on growth parameter of capsicum

Treatments	Plant height at 120 DAT (cm)		Number of branches/ plant at 120 DAT		Stem girth at 120 DAT (cm)		Number of leaves per/ plant at 120 DAT		Internode length at 120 DAT (cm)		Number of flowers/ plant	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Capsicum hybrids												
Indira	91.30	94.89	11.87	12.34	4.32	4.61	102.94	106.44	13.82	14.01	38.23	38.36
Swarna	89.80	92.94	11.40	11.67	4.08	4.38	100.36	104.26	13.21	13.48	35.89	36.18
Bomby	88.72	91.43	11.15	11.55	4.01	4.30	99.11	102.41	12.94	13.21	35.51	35.78
SEm±	0.277	0.654	0.081	0.073	0.024	0.009	0.731	0.757	0.077	0.097	0.248	0.320
CD 5%	1.116	2.635	0.325	0.294	0.095	0.036	2.948	3.054	0.309	0.392	1.001	1.291
Micronutrients												
Control	83.45	86.48	9.84	10.21	3.04	3.23	96.25	99.75	11.62	11.79	28.67	28.78
Soil application of Zn, Fe & B	88.19	91.55	10.99	11.21	4.08	4.18	99.090	102.59	12.81	13.01	34.99	35.12
Fertigation of EDTA of Zn & Fe and solubor at 15 days interval	91.61	94.743	11.64	12.11	4.30	4.71	100.55	104.05	13.46	13.72	38.17	38.36
Foliar application of vegetable special @ 5g/lit at 15 days interval	93.73	96.78	12.67	13.39	4.75	5.13	105.52	108.69	14.75	15.04	41.34	41.95
Foliar application of chelated combo micronutrients @ 1g/lit at 15 days interval	92.74	95.89	12.22	12.49	4.52	4.88	102.61	106.78	13.97	14.26	39.55	39.68
SEm±	1.026	1.738	0.215	0.218	0.077	0.084	1.879	1.946	0.249	0.254	0.688	0.681
CD 5%	3.011	5.103	0.631	0.641	0.23	0.25	5.517	5.713	0.731	0.746	2.020	2.000

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Table 2:Effect of hybrids and micronutrients on earliness in flowering and fruiting of capsicum

Treatments	Days to first flower appears (days)		Days to first fruit set (days)		Days to first harvest	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Capsicum hybrids						
Indira	51.11	50.32	61.85	60.84	84.52	82.60
Swarna	52.68	51.81	63.36	62.78	90.63	89.71
Bomby	53.23	52.69	64.29	63.36	92.75	91.29
SEm±	0.382	0.375	0.465	0.381	0.655	0.533
CD 5%	1.538	1.512	1.876	1.535	2.640	2.148
Micronutrients						
Control	56.29	55.17	68.19	67.14	94.26	92.41
Soil application of Zn, Fe & B	53.79	52.63	65.20	64.48	91.35	90.09
Fertigation of EDTA of Zn & Fe and solubor at 15 days interval	51.87	51.48	62.32	61.06	88.47	86.67
Foliar application of vegetable special @ 5g/lit at 15 days interval	49.35	48.54	59.27	58.90	85.42	84.51
Foliar application of chelated combo micronutrients @ 1g/lit at 15 days interval	50.41	49.78	60.83	60.05	86.99	85.66
SEm±	0.976	0.963	1.178	1.162	1.665	1.570
CD 5%	2.866	2.828	3.458	3.410	4.890	4.609

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Table 3:Effect of hybrids and micronutrients on yield attributes and yield of capsicum

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Treatments	Number of fruits per plant		Fruit length (cm)		Fruit diameter (cm)		Weight of placenta(g)		Average fruit weight(g)		Fruit weight per plant(kg)		Fruit yield (q/1000m^2)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Capsicum hybrids														
Indira	20.99	21.22	11.01	11.22	9.60	9.79	17.15	17.20	176.31	179.83	3.69	3.74	70.36	71.35
Swarna	17.82	18.01	11.45	11.72	10.54	10.66	18.51	18.71	193.32	195.91	3.42	3.46	65.32	65.97
Bomby	17.51	17.62	10.38	10.64	8.97	9.30	14.84	15.00	146.99	149.03	3.38	3.41	64.48	65.06
SEm±	0.137	0.130	0.075	0.103	0.066	0.069	0.118	0.146	0.470	1.233	0.023	0.023	0.484	0.413
CD 5%	0.553	0.525	0.304	0.415	0.266	0.277	0.478	0.590	1.893	4.970	0.093	0.092	1.950	1.665
Micronutrients														
Control	17.45	17.59	9.56	9.80	8.33	8.53	15.00	15.22	151.30	152.88	2.94	2.99	56.12	57.01
Soil application of Zn, Fe & B	17.73	17.90	10.45	10.71	9.22	9.44	16.17	16.35	164.67	167.87	3.13	3.16	59.56	60.19
Fertigation of EDTA of Zn & Fe and solubor at 15 days interval	18.57	18.76	11.31	11.58	10.06	10.30	17.08	17.05	174.61	177.82	3.49	3.52	66.62	67.13
Foliar application of vegetable special @ 5g/lit at 15 days interval	20.56	20.73	11.86	12.07	10.63	10.80	18.32	18.47	189.03	191.33	4.12	4.17	78.65	79.60
Foliar application of chelated combo micronutrients @ 1g/lit at 15 days interval	19.57	19.77	11.55	11.79	10.29	10.52	17.61	17.77	181.43	184.71	3.81	3.85	72.66	73.36
SEm±	0.352	0.349	0.205	0.205	0.178	0.182	0.316	0.327	3.248	3.293	0.065	0.065	1.254	1.265
CD 5%	1.032	1.025	0.602	0.601	0.522	0.535	0.928	0.921	9.537	9.669	0.195	0.192	3.683	3.715