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Micronutrient and Bioinoculants Mediated Effect on Morpho-Phenological Traits, Quality and Yield Attributes of Chilli

Pragya Singh, D. P. Sharma, Ankita Sharma

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ABSTRACT

The present investigation was carried out to study the "Micronutrient and Bioinoculants mediated effect on morpho-phenological traits, quality and yield attributes of Chilli" at Vegetable Farm Center, Maharajpur, Department of Horticulture, J.N.K.V.V., Jabalpur (MP). The research was laid out in Randomized Complete Block Design (RCBD-Factorial) with three replications consisting of 20 treatment combinations involving five levels of micronutrients as the first factor and four levels of bio inoculants (PGPR and *Trichoderma viride*) as another factor. The application of micronutrients and bio inoculants influenced the morpho-phenological traits, quality and yield attributes of chilli significantly. All the growth, phenological, quality and yield attributes of chilli viz., plant height at 120 DAT (58.74 cm), days to first flowering (31.33 days), days to 50% flowering (35.67 days), days taken to first picking (56.60 days), fruiting span (80.23), fruit length (9.85 cm), fruit width (1.18 cm), average fruit weight (11.05 g), fruit yield per plant (188.67 g), ascorbic acid content were recorded best in treatment combination M_5B_3 ($ZnSO_4$ - 0.2%) +TV + PF+AC (2.5 kg/ha +2.5 kg/ha +5.0 kg/ha). It was concluded that individual application of micronutrient ($ZnSO_4$ - 0.2%), bio inoculants (*Trichoderma viride, Pseudomonas fluorescence, Azotobacter chroococcum*) and their interaction M_5B_3 was effective in achieving maximum production and better growth.

Keywords: Chilli, Micronutrients, PGPR, Bioinoculants, Growth.

INTRODUCTION

Chilli is a popular fruit as well as spice crop of India. Chilli is utilized in culinary purposes and other food preparations and grown commercially in India. Chilli is very rich source of vitamin A and C. The fruits are a repository of ascorbic acid and the pungency is indicative of the presence of capsaicin found in placenta and pericarp possessing high diverse prophylactic and therapeutic uses in medicine. Arka Lohit was released as a pure line selection from IIHR 324 (local collec-

Pragya Singh [1]*
Guest Teacher
Department of Horticulture, R.V.S.K.V.V, Gwalior 474001, MP, India

D.P. Sharma[2], Ankita Sharma[3]
[2] Professor and Director Extension Services
[3] Research Scholar
Dept of Horticulture, College of Agriculture, J.N.K.V.V., Jabalpur 482004, MP, India
Email spragya455@gmail.com
*Corresponding author

tion) in 1990. Plants are tall, with straight smooth fruits with pointed tips, olive green in color changing to deep red and are highly pungent. The variety can be adequately grown in irrigated and cultivated area. Micronutrients are required in minute quantities by the plants. They are vital for the growth of healthy plants and the production of profitable crops. Micronutrients and their use in various vegetables have beneficial results in terms of growth, yield, and quality. In present scenario, it is observed that application of micronutrients play a role in improving the yield and quality of chilli. Micronutrients are present in lower concentrations in soil than macronutrients but are equally significant in plant nutrition, since, plants grown in micronutrient-deficient soils show similar reductions in productivity as those grown in macronutrient-deficient soils (Havlin *et al.* 2005). Foliar application of micronutrients enhances its availability to the plants. Micronutrients such as iron, zinc, and boron are necessary for plant growth and metabolism, and they are key elements with unique and vital physiological roles in plants that are required in small amounts for proper plant growth and development. Micronutrients play a catalytic role in nutrient absorption and balancing other nutrients (Singh and Kalloo 2000). Foliar application of micronutrients gives the highest number of fruits/ plant, green fruit yield, net income and benefit cost ratio.

Plant Growth Promoting Rhizobacteria (PGPR) are crucial for the healthy growth and yield improvement of different crops. The use of PGPR includes various groups of bacteria that live freely in the soil and have the ability to boost the growth of various crops through diverse mechanisms. Plant Growth Promoting Rhizobacteria (PGPR) actively colonize in the plant roots and increase growth and productivity by producing phytohormons, through asymbiotic N_2 fixation, protecting plants from phytopathogenic microorganisms by production of siderophores, antibiotics, enzymes and fungicidal compounds and also help in solubilization of mineral phosphates and other nutrients (Gholami *et al,* 2009). PGPR is being used as biofertilizers and bio enhancer for different crop plant as an alternative source of chemical fertilizer. In present scenario, different bacterial isolates have been reported as efficient PGPR which belong to *Azotobacter, Pseudomonas* (Glick BR1995). The use of beneficial microorganisms such as PGPR can reduce the cost of production and chemical fertilizers use. The genus *Trichoderma* has its own significance in the agricultural industry due to its varied activities ranging from being a valuable antagonist against the soil-borne pathogens to acting as a provider of nutrition to the soil as well. Hence an investigation on the influence of micronutrient and bioinoculants (*Trichoderma viride,* PGPR) on growth, yield and quality of chilli was initiated.

MATERIALS AND METHODS

An experiment was conducted during *rabi* season in 2017-18 and 2018-19 at Vegetable Farm Center, Maharajpur, Department of Horticulture, JNKVV and Jabalpur (MP). The field experiment consisted of three replications along with twenty treatments. The plant protection measures were taken up to control pest and diseases as and when required along with intercultural operations. The experiment consisted of 20 treatment combinations involving five levels of micronutrients as the first factor and four levels of bio inoculants (PGPR and *Trichoderma viride*) as another factor. Factor- I included Micronutrient spray (M)-M_1 :Control (Water spray), M_2: Ferrous sulphate ($FeSO_4$) (0.2%),M_3 : Calcium nitrate $(CaNO_3)_2$ (0.2%), M_4 :Borax ($Na_2B_2O_7.2H_2O$) (0.1%), M_5 :Zinc sulphate ($ZnSO_4$) (0.2%) and Factor– II : Bio-inoculants B_0:Control, B_1:*Trichoderma viride* (TV) @ 2.5 kg/ha, B_2 : *Trichoderma viride* (TV) @ 2.5kg/ha + *Pseudomonas fluorescence* (PF) @ 2.5 kg/ha, B_3 : *Trichoderma viride* (TV) @ 2.5kg/ha + *Pseudomonas fluorescence* (PF) @ 2.5 kg/ha + *Azotobacter chroococcum* (AC) @ 5 kg/ha. Five plants were randomly selected and tagged to record biometric observations on growth and yield parameters from each plot. All the treatments were applied as a foliar spray of micronutrients at three stages of plant growth as 30, 60, 90 days after transplanting. Data was recorded for plant height, days to first flowering, days to 50% flowering, days taken to first picking days, fruiting span, fruit length, fruit width, average fruit weight, fruit yield per plant, ascorbic acid and TSS has been presented in this paper in the form of pooled data. The data was analyzed using the procedure suggested by Fisher (1937).

Table 1. Individual and interaction effect of different micronutrients and bio-inoculants on morpho-phenological traits, quality and yield attributes of chilli (Pooled data of 2017-18 and 2018-19).

Treatments	120 DAT plant height (cm)	Days to first flowering	Days to 50% flowering	Days to first picking	Fruiting span	Fruit length (cm)	Fruit width (cm)	Aaverage fruit (g)	Fruit yield per plant (g)	Ascorbic acid (mg/100 g) weight	TSS (^{0}Brix)
Micronutrients											
M_1 No micronutrient	50.63	38.25	47.04	62.62	70.76	7.95	0.67	4.61	79.96	116.82	6.51
M_2 $FeSO_4$ (0.2%)	53.95	34.75	40.38	60.66	77.36	8.74	0.95	6.54	126.33	143.91	7.42
M_3 $(CaNO_3)_2$ (0.2%)	54.25	34.38	39.63	60.33	77.80	8.85	0.97	6.89	132.79	146.22	7.56
M_4 Boron (0.1%)	55.02	34.08	39.00	60.12	78.13	9.04	1.01	7.53	136.75	149.64	7.70
M_5 $ZnSO_4$ (0.2%)	55.36	33.67	39.13	59.80	78.39	9.11	1.03	7.81	145.21	152.36	7.90
SEm±	0.11	0.09	0.12	0.08	0.15	0.02	0.006	0.13	1.14	0.89	0.04
CD 5% level	0.32	0.28	0.36	0.24	0.44	0.05	0.018	0.38	3.29	2.56	0.11
Bioinoculants											
B_0 No bioinoculant	51.47	37.00	44.83	62.12	74.26	8.21	0.81	5.57	100.73	128.17	6.91
B_1 TV (2.5 kg/ha)	53.17	35.57	41.00	61.01	75.32	8.50	0.90	6.02	116.97	137.05	7.28
B_2 TV + PF (2.5 kg/ ha +2.5 kg/ha)	54.51	34.43	39.53	60.43	77.62	8.95	0.94	6.55	125.53	146.82	7.48
B_3 TV + PF+AC (2.5 kg/ha + 2.5 kg/ha +5.0 kg/ha)	56.23	33.10	38.77	59.26	78.75	9.30	1.04	8.57	153.60	155.12	8.02
SEm ±	0.1	0.09	0.11	0.07	0.14	0.01	0.006	0.12	1.02	0.80	0.03
CD 5% level	0.28	0.26	0.32	0.21	0.40	0.04	0.016	0.34	2.94	2.29	0.09
Interaction											
M_1 B_0	49.88	39.67	48.17	63.33	66.60	7.77	0.63	4.33	71.67	114.24	6.34
M_1 B_1	50.64	38.33	47.17	62.45	66.83	7.94	0.67	4.44	79.67	115.46	6.45
M_1 B_2	50.92	37.83	46.67	62.39	74.43	8.03	0.67	4.64	82.50	116.70	6.52
M_1 B_3	51.1	37.17	46.17	62.32	75.17	8.07	0.70	5.02	86.00	120.87	6.73
M_2 B_0	51.33	36.67	45.33	62.20	75.50	8.17	0.80	5.65	97.67	128.58	6.79
M_2 B_1	52.94	35.50	41.17	60.95	76.88	8.48	0.94	6.33	124.00	138.95	7.38
M_2 B_2	55.18	34.17	38.00	60.34	78.06	8.92	0.98	6.83	131.33	146.49	7.63
M_2 B_3	56.34	32.67	37.00	59.14	79.00	9.40	1.07	7.36	152.33	161.61	7.89
M_3 B_0	51.78	36.33	44.00	62.01	76.09	8.29	0.84	5.76	104.00	130.49	6.96
M_3 B_1	53.18	34.83	39.67	60.73	77.42	8.56	0.96	6.34	125.83	142.21	7.44
M_3 B_2	55.23	34.00	38.00	59.95	78.39	9.08	1.00	6.84	133.33	150.23	7.66
M_3 B_3	56.81	32.33	36.83	58.65	79.31	9.45	1.10	8.64	168.00	161.95	8.19
M_4 B_0	52.15	36.33	43.67	61.89	76.44	8.37	0.90	5.91	110.33	133.51	7.13
M_4 B_1	54.24	34.83	38.67	60.53	77.51	8.73	0.97	6.39	127.00	143.30	7.52
M_4 B_2	55.54	33.17	37.67	59.78	78.51	9.34	1.02	7.05	136.67	159.40	7.77
M_4 B_3	58.15	32.00	36.00	58.27	80.05	9.74	1.14	10.79	173.00	162.34	8.39
M_5 B_0	52.19	36.00	43.00	61.16	76.66	8.43	0.91	6.22	120.00	134.02	7.33
M_5 B_1	54.84	34.33	38.33	60.40	77.95	8.79	0.98	6.59	128.33	145.34	7.59
M_5 B_2	55.66	33.00	37.33	59.70	78.73	9.36	1.05	7.37	143.83	161.27	7.81
M_5 B_3	58.74	31.33	37.83	57.93	80.23	9.85	1.18	11.05	188.67	168.81	8.89
SEm±	0.22	0.20	0.25	0.17	0.31	0.03	0.01	0.27	2.29	1.78	0.07
CD 5% level	0.63	0.57	0.72	0.48	0.88	0.09	0.03	0.78	6.58	5.12	0.21

RESULTS AND DISCUSSION

Effect on growth parameter (Plant height)

The data presented in Table 1 revealed that among different treatments of micronutrients and bio inoculants on the plant height at (120 DAT) during harvest was found to be significantly superior in the treatment combination M_5B_3 (58.74 cm). These observations are in conformity with those of workers who have

reported that Zinc serve as a source of energy for synthesis of auxin and helps stem elongation. Zinc acts as enzymes activators rather than their direct affecting the cell elongation and cell division that is responsible for plant height. Fungus *Trichoderma* frequently increases plant height. Whereas *Azotobacter* (nitrogenous biofertilizers) converts atmospheric nitrogen into an ammonical form which is made available to plants and because of better nitrogen fixation as a result of accelerated bacterial activity and better root system found. *Pseudomonas fluorescence* can produce plant growth-promoting substances and secondary metabolites which enhance nutrient uptake and plant growth. So it could be concluded from the result that combined application of micronutrients, bioinoculant significantly increases the plant height. The result obtained in the present investigation are in accordance with Hatwar *et al.* (2003), Harris and Mathuma (2015) and Haleema *et al.* (2017).

Effect on phenological parameters

Days to first flowering and days to 50% flowering

The result obtained and presented in Table 1 revealed that interaction effects of micronutrients and bio-inoculants (*Trichoderma viride* and PGPR) had a significant effect on days to first flowering.

Minimum days to first flowering were recorded in a treatment combination of M_5B_3 (31.33 days), while maximum days were recorded in treatment combination for M_1B_0 (Control) (39.67 days). Interaction effects of micronutrients and bio-inoculants had shown significant effect on days to 50% flowering. Minimum days to 50% flowering was recorded in treatment combination of M_5B_3 (35.67 days) while maximum days were recorded in combination for M_1B_0 (48.17 days).

Days taken to first picking and fruiting span

The data from Table 1 revealed that the combination of different micronutrients and bio inoculants give a significant effect on days taken to first picking and fruiting span of chilli. Among various combinations, the effects of micronutrients and bio-inoculants gave a significant effect on days to first picking and minimum days to first picking was recorded in a treatment combination of M5B3 (56.00 days).The combined effects of micronutrients and bio-inoculants (*Trichoderma viride* and PGPR) M_5B_3 had superior effect on fruiting span (80.23).

Early flowering is due to the beneficial role of zinc enhancing the translocation of carbohydrates, minerals, water and amino acids from the site of synthesis to the storage tissue especially on flowers which turn to maximize early flowering. The application of bio-inoculants (*Trichoderma viride* and PGPR) increases the microbial activity in the root zone which ultimately enhances the nutrient uptake better nitrogen fixation and found better root system development and possible synthesis of plant growth hormones because of this improvement in Phenological parameters takes place. The present investigation in accordance with the findings of Sharma and Thakur (2001) and Sudhakar and Purushottam (2008), Ali *et al*. (2013) and Kalroo *et al*. (2014).

Effect on yield and quality parameters

Fruit length (cm) and fruit width

The result given in Table 1 indicated that the combined application of micronutrients and bio inoculants had shown a significant effect on fruit length and fruit width. The maximum fruit length was recorded on treatment combination M_5B_3 (9.85 cm) and maximum fruit width was found in M_5B_3 (1.18 cm). Zinc application may be attributed to enhanced photosynthetic activity, resulting in increased production and accumulation of carbohydrates and the favourable effect of vegetative growth which may increase length and size of the fruit and application of this may improve cell size or cell number. This result might be due to the higher amount of nutrient uptake and more synthesis of plant growth regulators by the associative nature of the bio-inoculants significantly increase the width of the fruit. The present findings collaborate with the observations recorded by Gowda (2002), Ali *et al.* (2013), Saravaiya *et al.* (2014), Thriveni *et al.* (2015), Pandav *et al.* (2016) and Singh *et al.* (2018).

Average fruit weight (g)

The result indicated that the combined effect of mi-

cronutrient and bioinoculant were highly significant in enhancing the weight of chilli fruit. Highest fruit weight was recorded in the treatment combination of M_5B_3 (11.05 g). The application of zinc to increase fruit weight might be due to better mineral utilization of plants with the enhancement of photosynthesis, metabolic activity and greater diversion of food material to fruit. Along with this, the application of bio-inoculants (Trichoderma PGPR) increases the microbial activity in the root zone which ultimately enhances the nutrient uptake better nitrogen fixation and found better root system development and possible synthesis of plant growth hormones which increases fruit weight. Similar findings have been reported by Elabdeen and Metwally (1982), Ramakrishnan and Selvakumar (2012), Kanchana *et al.* (2014), Thriveni *et al.* (2015) and Pandav *et al.* (2016).

Fruit yield per plant (g)

Maximum fruit yield per plant was recorded in a treatment combination of M_5B_3(188.67 g). In case of fruit yield, this might be increased due to Zinc sulphate and boron (micronutrient) application may be attributed to enhanced photosynthesis activity, resulting in the increased production and accumulation of carbohydrates, which respond to an increase in yield of chilli. The inoculation of bio-inoculants increases nutrients uptakes such as phosphorus, nitrogen, potassium by the synergistic effect of both *Trichoderma viride* and *Pseudomonas fluorescence.* The *Trichoderma viride* and plant interaction might produce secondary metabolites such as auxin that resulted in improved yield. The present findings collaborated with earlier observations recorded by Davis *et al*. (2003), Yadav *et al.* (2003), Basavarajeswari *et al.* (2008), Khan *et al.* (2011), Ali *et al.* (2013), Garikapati and Sivasakthivelan (2013), Shil *et al.* (2013), Tanwar *et al.* (2013), Kalroo *et al.* (2014), Kanchana *et al.* (2014) and Ahirwar *et al.* (2015).

Quality parameters of chilli fruit

Ascorbic acid (mg/100 gm) and total soluble solids (TSS) (^{0}Brix)

It is observed that the ascorbic acid content of the fruits, influenced significantly due to treatments are presented in Table 1. Combined effects of micronutrients and bio-inoculants (*Trichoderma viride* and PGPR) had shown a significant effect and maximum ascorbic acid content and maximum TSS recorded for treatment combination M_5B_3(168.81mg/100 gm), (8.39 ^{0}Brix) respectively. Zinc increased the ascorbic acid content by enhancing the enzymatic activity of ascorbic acid oxidase in fruits. Micronutrients were involved in carbohydrate metabolism with this ascorbic acid form. TSS content in chilli fruit increased due to growth-promoting substances which accelerated the synthesis of carbohydrates, vitamins and other quality characters. The results obtained conformto the findings of Gowda (2002),Tamilselvi *et al.* (2002), Kumari (2012), Tiyagi *et al.* (2015), Thriveni *et al.* (2015) and Bade *et al.* (2017).

CONCLUSION

Based on the results obtained from the present study clearly indicate the combined effect of micronutrient and bioinoculant were highly beneficial for enhancing growth, yield and quality parameters besides effecting a reduction in harmful effect of chemical fertilizers and increase the soil fertility, soil beneficial microbes and increase the uptake of nutrients from soil.

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