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Effect of Bio-stimulants on Growth, Yield, Quality and Biotic Resistance in Chilli (*Capsicum annuum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

In 2021, a field experiment was conducted out at ICAR-Krishi Vigyana Kendra in Bengaluru Rural District, Karnataka state, India, to investigate the impact of bio-stimulants on the growth, yield, and quality of chillies (*Capsicum annuum* L.). The company supplied Lakshmi Hybrid Inputs Seeds Pvt. Ltd. with Chilli Hybrid seeds (LHC-1835), that were utilized to produce the seedlings. In the present investigation, the application of amino acid-based biostimulants was carried out employing a randomized complete block design with seven treatments being replicated three times and spaced 90 by 45 cm apart. The results indicated that the maximum plant height (87.80 cm), primary

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branches (9.13), secondary branches (18.27), root length (27.07 cm), number of fruits per plant (58.33), fruit length (16.82 cm), and fruit diameter (1.31) with less incidence of pests such as white fly, thrips and murda complex were recorded with seedling dip and foliar application of amino acid-based bio-stimulant.

Keywords: Red chilli; bio-stimulants; seedling dip; foliar application yield; nutritional benefits; spice crop.

1. INTRODUCTION

Vegetables are rich source of vitamins, minerals and anti-oxidants that provides various health benefits to humans [1]. Regular consumption *of recommended amount of vegetables leads to better health while, insufficient intake causes several mineral deficiency* symptoms [2]. *Apart from nutritional benefits, the production of*vegetables plays an important role in economy of small and marginal farmers [3].

Red chilli (*Capsicum annuum* L.) belongs to the family Solanaceae, native of Peru and Mexico. It is one of the most valuable spice crop and grown throughout the country. Kamal et al [4].

India is the world's largest producer, consumer and exporter of chilli after China which is followed by Thailand, Ethiopia and Indonesia. In India, leading dry chilli producing states are Andhra Pradesh, Telangana, Tamil Nadu, Karnataka and Madhya Pradesh. Karnataka covers an area of 65,331 hectares with a production of 173712.14 tonnes and an average productivity of 2658.95 kg/ha. Major chilli cultivating districts in Karnataka are Haveri, Dharwad, Belgaum, Kolar, Chikkaballapura and Shivamogga [5]. Bio-stimulants increase plant growth and resistance to abioticstresses, improves performance of plant's vital processes hence favours higher yield and quality. In addition, bio-stimulants enhance nutrition efficiency or plant quality traits regardless of its nutrient contents apart from providing biotic resistance [6].

The chilli plants have a green cylindrical herbaceous main stem that is semi-woody at the base and slightly pubescent, grow up to 1.5 m in height [7]. Flowers are perfect, regular and composed of 6-7 sepals partially fused together. The fruit is a berry, usually consumed when they reach maturity. Red chillies get their colour from a colouring compound called capsanthin [4]. The commercial cultivation of red chilli is influenced by climate change, soil fertility status and other external factors that induce impaired plant performance and thereby reduces crop productivity [8]. To overcome such constraints, bio-stimulants acts as promising approach tofulfill the need for developing sustainable agriculture.

The quantity and quality of harvested produce are determined by factors other than the delivery of nutrients, such as the management of plant growth and the adverse effects of abiotic stress. Bio-stimulants are incorporated into production in addition to conventional methods with the goal of altering plant physiological systems to maximize yield. Plant bio-stimulants contain substance(s) and/or micro-organisms whose function when applied to plants or the rhizosphere is to stimulate natural processes to enhance nutrient uptake, nutrient efficiency, tolerance to abiotic stress and improve crop quality. Further, looking into the importance and application of red chilli, the current inquiry has been carried out with a view to examining the significance and uses of red chilli.

2. MATERIALS AND METHODS

2.1 Geographical Location

The experimental site is located at an altitude of 896 m above MSL at 12° 58'North latitude and 77° 35' East longitude lying in the Eastern Dry Zone of Karnataka (Zone-V).Field experiment was carried out at ICAR Krishi Vigyana Kendra, Bengaluru Rural District during June to December 2021.

2.2 Experimental Design

A randomized complete block design (RCBD) with 7 treatments replicated thrice using Chilli Hybrid seeds (LHC-1835). The gross plot size was 5.4m × 3.2 m with the spacing of 90 cm between the row and 45 cm between plants.

2.3 Crop Establishment and Agronomic Practices

The fairly levelled land of red sandy loam soil. Nursery was raised and seedlings and the

seedlings were transplanted at 30 days after. The recommended dosage of fertilizers and manures (150:75:75kg N: P_2O_5 : K_2O ha^{-1} and 25 t FYM ha^{-1}) was applied for the chilli crop. The treatment details included (T_1)-Recomended dose of fertilizer (control), (T_2)- foliar application of Isobion(commercial bio-stimulant) @3ml/L, (T_3)-Impakt @ 2.5 ml/L, (T_4)-Impakt @ 5ml/L, (T_5)-Impakt @7.5 ml/L, (T_6)- 75% nitrogen+ Impakt @ 5ml/L was given during vegetative stage, flowering stage and fruit development stage. Seedling dip was done with Impakt @ 5ml/L as per treatment schedule before transplanting (T_7). Spraying was done with a Knapsack sprayer of 20 L capacity in the morning during less wind to avoid drifting of spray droplet to adjoining plots**.**

The weight of pericarp and seeds were calculated and computed as pericarp to seed ratio**.** Spectrophotometric method as suggested by (Palacios et al., 1997) was used to analyse capsaicin content. Fresh fruits were used for analysing Vitamin C content by visual titration method (Annon.,1975). White fly and thrips incidence was measured as outlined by Niles,1980. Diseases scoring was done for murda complex according to guidelines provided by Sawant et al., 1986.

2.4 Data Collection and Analysis

The observations on growth and yield parameters were recorded from five randomly selected plants and the data were statistically analyzed [9].

3. RESULTS

3.1 Growth Parameters

Significant increase in plant height (87.80cm), primary branches (9.13), secondary branches (18.27) and root length (27.07 cm) was observed with RDF + seedling dip + foliar application of Impakt @ 5ml/L which was *on par* with RDF + foliar application of Impakt @ 7.5ml/L (Table 1). These findings are in similar line with Sarojnee et al*.* [10] where, amino acid stimulants (Perfectose™ Powder and Perfectose™ Liquid) at two different doses on hot pepper plants (*Capsicum annum* L.) cv. 'F1 Asha Jyothi'. Perfectose™ Powder applied at 0.45g/plant and perfectose liquid @ 1.6ml/l produced a significant increase in plant height, canopy diameter, number of branches and shoot dry matter; Ruban et al. [11] in brinjal; Johari et al. [12] in okra; and Sharanya et al. [13] in Mucuna.

Table 1. Effect of bio-stimulants on growth of chilli at Harvesting stage

Treatments	Plant height (cm)	primary branches	Secondary branches	Root length(cm)
T_1- Control	66.13	6.93	16.07	16.07
T_2 - Commercial bio-stimulant (Isabion) at 3ml/L	76.27	7.47	16.87	16.87
T_3 -Foliar application of Impakt @ 2.5 ml/l at vegetative, flowering and fruit development stage	77.33	7.67	15.93	15.93
T_4- Foliar application of Impakt @ 5 ml/l at vegetative, flowering and fruit development stage	78.40	7.80	17.67	17.67
T_5-Foliar application of Impakt @ 7.5 ml/l at vegetative, flowering and fruit development stage	82.40	8.27	18.00	18.00
T_6 - 75% N + Foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	76.20	7.80	17.07	17.07
T_7 . Seedling dip + foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	87.80	9.13	18.27	18.27
S.Em. ±	**2.11**	**0.17**	**0.43**	**0.43**
CD@ 5%	**6.50**	**0.51**	**1.32**	**1.32**

3.2 Yield Parameters

The highest fresh fruit output (25.31 t ha^{-1}) and dried chilli production (6.69 t ha^{-1}) were achieved with RDF + seedling dip + foliar application of Impakt @ 5 ml/L. Each plant produced 141.59 fruits in total. In contrast, the control group had the lowest fruit yields (105.93), longest fruit (13.31 cm), largest fruit (1.14 cm), fresh fruit yield (14.77 t ha^{-1}), and dried chilli production (3.92 t ha^{-1}). Fathima and Denesh [14] showed similar outcomes with chillies, and Sheetal et al. [15] with tomatoes.

3.3 Biotic Resistance

Among different treatments, RDF + seedling dip+ foliar application of Impakt at 5ml/L showed lesser incidence of whitefly, thrips and murda (1.61, 2.61 and 1.96, respectively). While, maximum incidence was reported in untreated plants (Table 3). Seedling dip and foliar application has showed significant effect on biotic resistance. Similar results were found by Sugandhika et al. [16] in chilli; Rajendran et al. [17] in sweet pepper and Sultana et al. [18] in tomato.

3.4 Quality Parameters

The chlorophyll content (60.08 SPAD unit), pericarp to seed ratio (1.31), capsaicin content (0.45%), and vitamin C (117.5 mg/100g) were all considerably increased by RDF + Seedling dip + foliar application of Impakt at 5ml/L (Table 4). In sweet pepper, Paradikovic et al*.* [19] research on bell pepper, tomatoes, and jaafar et al*.* [20] Mahmood et al. [21], and Helaly et al*.* [22] found comparable outcomes.

4. DISCUSSION

This positive effect of bio-stimulants might be due to increased cell division, cell elongation and presence of auxin or auxin like components which directly or indirectly influence physiological processes. The combined action of foliar treatment and seedling dip supplies nutrients and other growth-stimulating substances that improve vegetative growth. These plant parts facilitate better plant growth by moving nutrients toward growing areas, or sinks [23,24].

Table 2. Influence of bio-stimulants on yield of chilli

Treatments	Number of fruits $plant^{-1}$	Fruit length (cm)	Fruit diameter (cm)	Fresh fruit yield ha^{-1}(t)	Dry chilli yield ha^{-1} (t)
T_1- Control	105.93	13.31	1.14	14.77	3.92
T_2 - Commercial bio-stimulant (Isabion) at 3ml/L	121.8	15.41	1.24	16.73	4.44
T_3 -Foliar application of Impakt @ 2.5 ml/l at vegetative, flowering and fruit development stage	116.66	15.73	1.24	15.97	4.24
T_4 - Foliar application of Impakt @ 5 ml/l at vegetative, flowering and fruit development stage	125.87	15.01	1.27	18.50	4.92
T_5-Foliar application of Impakt @ 7.5 ml/l at vegetative, flowering and fruit development stage	132.19	16.51	1.29	20.88	5.53
T_6 - 75% N + Foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	124.2	16.20	1.21	17.04	4.52
T_7 . Seedling dip + foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	141.59	16.82	1.31	25.31	6.69
S.Em. ±	**2.92**	**0.41**	**0.03**	**1.29**	**0.32**
CD@ 5%	**9.11**	**1.26**	**0.09**	**3.97**	**0.97**

Table 3. Pest and disease incidence against different treatments

Treatments	Pest and disease incidence (%)		
	White fly	Thrips	Murda
T_1- Control	8.42	8.79	5.41
T_2 - Commercial bio-stimulant (Isabion) at 3ml/L	7.12	7.71	3.83
T_3 -Foliar application of Impakt @ 2.5 ml/l at vegetative, flowering and fruit development stage	6.11	6.94	3.57
T_4 - Foliar application of Impakt @ 5 ml/l at vegetative, flowering and fruit development stage	4.14	5.44	2.96
T_5-Foliar application of Impakt @ 7.5 ml/l at vegetative, flowering and fruit development stage	2.94	3.50	2.12
T_6 - 75% N + Foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	3.76	4.11	2.64
T_7 . Seedling dip + foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	1.61	2.61	1.96
S.Em. ±	**0.04**	**0.04**	**0.03**
CD@ 5%	**0.12**	**0.12**	**0.09**

Table 4. Effect of bio-stimulants on quality of chilli

Treatments	Chlorophyll content (SPAD UNIT)	Pericarp: seed ratio	Capsaicin content (%)	Vitamin C (mg 100 g $^{-1}$)
T_1- Control	50.10	0.79	0.33	110.5
T_2 - Commercial bio-stimulant (Isabion) at 3ml/L	48.32	0.81	0.38	112.8
T_3 -Foliar application of Impakt @ 2.5 ml/l at vegetative, flowering and fruit development stage	52.57	0.92	0.36	113.3
T_4- Foliar application of Impakt @ 5 ml/l at vegetative, flowering and fruit development stage	50.76	1.06	0.40	112.4
T_5-Foliar application of Impakt @ 7.5 ml/l at vegetative, flowering and fruit development stage	50.08	0.79	0.39	115.2
T_6 - 75% N + Foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	47.66	1.16	0.41	114.3
T_7 . Seedling dip + foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	60.08	1.31	0.45	117.5
S.Em. ±	**2.30**	**0.06**	**0.01**	**1.36**
CD@ 5%	**7.09**	**0.18**	**0.03**	**4.21**

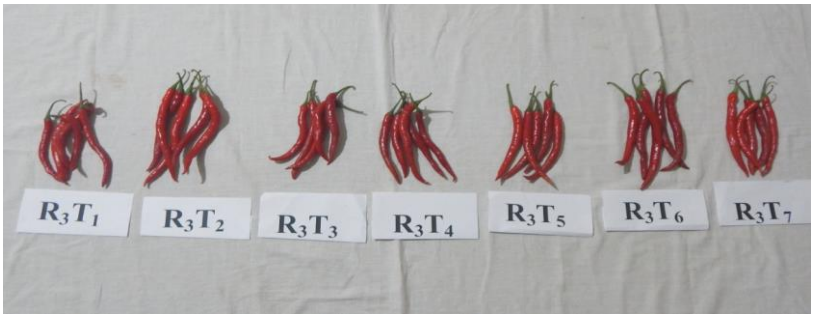

Fig. 1. Fruit characterstics as influenced by Impakt

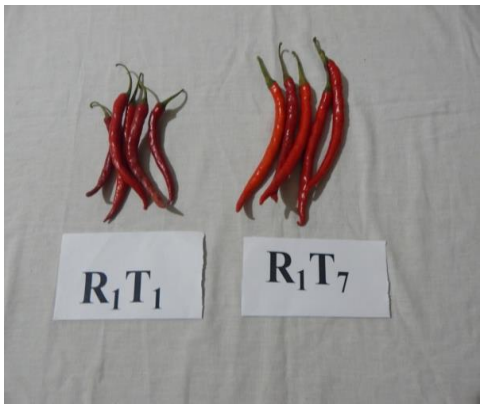

Fig. 2. Fruit characteristics in comparison with impakt and control

This might be due to increased pollen tube ovule penetration and delayed ovule senescence that led to retention of fruit, enhanced efficiency of plants to carry photosynthesis and translocation of assimilates to the points of fruit set**.** The role that amino acids are regarded to possess has improved nutrient availability when biostimulants are used. The complex secondary metabolites found in biostimulants contribute significantly to the host's defense against insects and diseases, potentially providing a unique means of reducing the number of insects and diseases that affect plants. Biostimulants have a good influence on soil and plant characteristics, which promotes growth. By fostering enzyme activity, membrane permeability, photosynthesis, and transpiration rate maintenance, it has a predominant impact on plants and supplies a significant amount of macro- and micronutrients, vitamins, amino acids, and hormone-like compounds that might improve quality parameters [25,26].

5. CONCLUSION

Apart from efficiently providing biotic resistance, it is found that application of recommended dose of fertilizers when combined with seedling dip and foliar spray of amino acid-based bio-stimulants, resulted to enhanced growth, maximum yield, and higher quality of chilli.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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