Original Research Article

Effect of Bio-stimulants on growth, yield, quality and biotic resistance in Chilli (*Capsicum annuum* L.)

ABSTRACT

A field experiment was conducted during *kharif* season of 2021 to study the effect of bio-stimulants on growth, yield and quality in chilli (*Capsicum annuum* L.)" at ICAR-Krishi Vigyana Kendra, Bengaluru Rural District, Karnataka state.The results showed that,RDF along with seedling dip and foliar application of amino acid based bio-stimulant recorded maximum plant height (87.80 cm), primary branches (9.13), secondary branches (18.27), root length (27.07 cm), number of fruits plant^{-1} (58.33), fruit length (16.82 cm), fruit diameter (1.31 cm),fresh fruit yield (25.31 t ha^{-1}), dry chilli yield (6.69 t ha^{-1}), chlorophyll content (60.08), pericarp:seed ratio (1.31), capsaicin content (0.45%), vitamin C content (117.5 mg 100 g^{-1})and less incidence of pest and diseases as compared to the other treatments.

Keywords:Red chilli, bio-stimulants, seedling dip, foliar application,yield

1. INTRODUCTION

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

Red chilli (*Capsicum annuum* L.) belongs to the family Solanaceae, native of Peru and Mexico. It is one of the most valuablespice crop and grown throughout the country. 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

Comment [FT1]: Add the name of the country

Comment [FT2]: A paragraph on the methodology used should be added here

Comment [FT3]: What is this?

Comment [FT4]: How has the number with dismals?

Comment [FT5]: What type?

Comment [FT6]: The abstract is too weak. Add a few on the method and what is the story from your finding. What does in address and gaps left behind. What do you recommend based on this work

Comment [FT7]: ref

Comment [FT8]: ref

Comment [FT9]: ref

Comment [FT10]: ref

kg/ha. Major chilli cultivating districts in Karnataka are Haveri, Dharwad, Belgaum, Kolar, Chikkaballapuraand Shivamogga(Bindu and Nayak, 2021).

The 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. 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. 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. To overcome such constraints, bio-stimulants acts as promising approach tofulfill the need for developing sustainable agriculture.

Apart from nutrients application, regulation of plant growth and negative effects of abiotic stress determines yield and quality of harvested produce. In addition to traditional approaches, bio-stimulants are integrated in to production with the aim to modify physiological processes in plants to optimize productivity. Plant biostimulants 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 present investigation has been conducted.

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 (Baranowska, 2018).

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

Comment [FT11]: name the plant

Comment [FT12]: ref

Comment [FT13]: a figure would be better

Comment [FT14]: ref

Comment [FT15]: ref

Comment [FT16]: small letter

Comment [FT17]: this should be part of paragraph 2

Comment [FT18]: There is a need to add in more information in the introduction.

1.What necessitated this study
2.Who will benefit from this work
3.What gap is been addressed
4. What method will be used in this work.
5.Research ethics, if need be.
6.Novelity of the work
7.....
8.Read more on similar work

Comment [FT19]: There is need of the a detailed map triangulating the study area

Also observe the space between word in the document

was carried out at ICAR Krishi Vigyana Kendra, Bengaluru Rural District during June to December 2021.

Comment [FT20]: Add
1. Justification of the study area
2. Justification of the study time

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.

Comment [FT21]: The statement is verge.

What are you communicating here?

Comment [FT22]: Same as above. Please be explicit in communicating

2.3 Crop Establishment and Agronomic Practices

The fairly levelled land of red sandy loam soil with uniform fertility status. 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 main crop. The treatment details includes: (T_1)-RDF(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.

Comment [FT23]: Explain this.

Comment [FT24]: The sentence is not complete

Comment [FT25]: Name it

Comment [FT26]: The verbs usage in not consistent. Use past tense

Comment [FT27]: What does this stand for

Comment [FT28]: What guided these choices ???

Comment [FT29]: Respectively

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 byNiles,1980. Diseases scoring was done for murdacomplex 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(Sundararaj*et al*.,1972).

Comment [FT30]: What guided this?

Comment [FT31]: Using what method? And justify

3.RESULTS

3.1 Growth parameters

Significant increase inplant 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.* (2009) in chilli; Ruban *et al.* (2019) in brinjal; Johari *et al.* (2020) in okra; and Sharaya *et al.* (2022) in Mucuna.

Comment [FT32]: How do u know this?

Comment [FT33]: The sentence is too long and difficult to undersatnd

Comment [FT34]: What did all found? Say it the compere. Were they doing the same work? Were? Hoe is it different from your work?

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	87.80	9.13	18.27	18.27

Comment [FT35]: Are this average numbers? How did you arrive at them?

application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage				
S.Em. ±	**2.11**	**0.17**	**0.43**	**0.43**
CD@ 5%	**6.50**	**0.51**	**1.32**	**1.32**

3.2 Yield parameters

Number of fruits per plant (141.59),fruit length (Fig1-16.82 cm), fruit diameter (Fig 2-1.31 cm), fresh fruit yield (25.31 t ha^{-1}), dry chilli yield (6.69 t ha^{-1}) was maximum with RDF + seedling dip + foliar application of Impakt @ 5ml/L (Table 2).While,minimumnumber of fruits per plant (105.93), fruit length (13.31 cm), fruit diameter (1.14 cm), fresh fruit yield (14.77 t ha^{-1}) and dry chilli yield (3.92 t ha^{-1}) was foundin control.Similar results were reported byFathima and Denesh (2013) in chilli and andSheetal *et al*. (2021) in tomato.

Comment [FT36]: Improve in how the results are presented. They are difficult to follow.

Comment [FT37]: How was this done?

Comment [FT38]: Show them so appreciate the deviations

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**

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 bySugandhika*et al*. (2021) in chilli; Rajendran *et al*. (2022) in sweet pepper and Sultana *et al*. (2012) in tomato.

Comment [FT39]: Same comments as section 3.2

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 developmentstage	4.14	5.44	2.96
T_5-Foliar application of Impakt @ 7.5 ml/l	2.94	3.50	2.12

at vegetative, flowering and fruit development stage			
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**

3.4 Quality parameters

RDF +Seedling dip + foliar application of Impakt at 5ml/L significantly elevated the chlorophyll content (60.08 SPAD unit), pericarp to seed ratio (1.31), capsaicin content (0.45%), vitamin C (117.5 mg/100g)(Table 4).Paradikovic*et al*. (2011) in sweet pepperJaafar*et al*. (2012) in hot pepper; Mahmood *et al*. (2017) in bellpepper; Helaly*et al*. (2018) in tomato reported similar results.

Comment [FT40]: Sema comments as above

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

Treatments	Chlorophyll content	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**

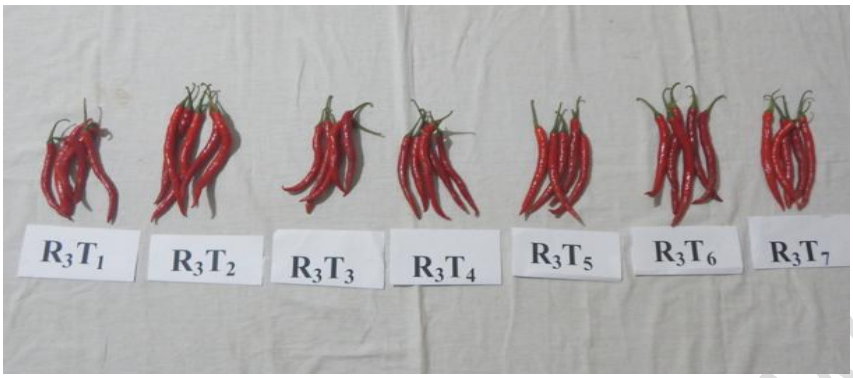

Fig 1: Fruit characterstics as influenced by bio-stimulants

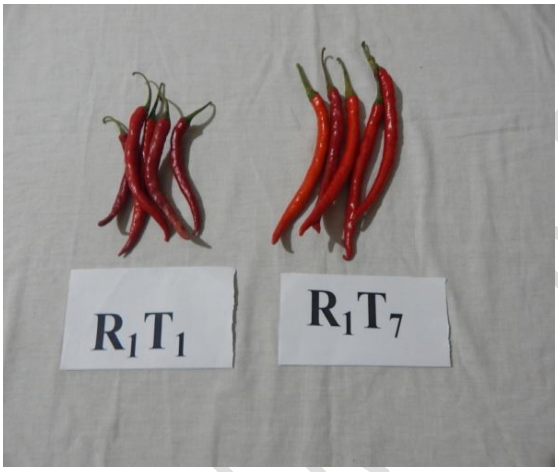

Fig 2: Fruit characteristics in comparison with bio-stimulants and control

4. Discussions

This positive effect might be due to increased cell division, cell elongation and presence of auxin or auxin like components which directly or indirectly influence physiological processes. Combined effect of seedling dip and foliar application supply nutrients and other growth stimulating compounds that enhances the vegetative growth. These components in the plant act as a food mover towards growing regions (sinks) thus, improve plant growth. 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 ascribed role of amino acids has enhanced better availability of nutrients with the application of bio-stimulants. The bio-stimulants contain

Comment [FT41]: Which one?

Comment [FT42]: Proven by your work?

Comment [FT43]: How is this originating from your work?

elaborate secondary metabolites that play major role in the defense of the host against insect and diseases, which offer a potential novel approach to control incidence of insects and diseases on plant. Bio-stimulants acts as growth boosters by influencing positive effects on soil and plant characterstics. It produces dominating effects on plants by stimulating enzyme activity, membrane permeability, photosynthesis, maintaining transpiration rate and thereby provides considerable amount of macro-and micronutrients, amino acids, vitamins and hormonal like activities, that possibly increased quality parameters.

5. Conclusion: RDF along with seedling dip and foliar application of amino acid based bio-stimulants resulted in better growth, maximum yield and enhanced quality apart from providing effective biotic resistance.

REFERENCES

Anonymous, Official method of analysis. Association of Official Analytical Chemists (AOAC).Washington, D.C. 1975; 12:554-829.

BaranowskaAJ, Impact of growth biostimulators and herbicide on edible potato yield. Acta Agroph. 2018 ;25:385-396.

Bindu HA & Nayak M, Growth and instability in area, production and productivity of dry chilli in Karnataka.J. Pharm. Innov. 2021;10: 43-8.

Fathima PS. &Denesh, GR, Influence of humic acid spray on growth and yield of chilli (*Capsicum annum L.*). Int. J. Agril. Sci.2013; 9: 542-546.

Helaly MN, Arafa AA, HebaM., Ibrahim &Ghoniem KH, Improving growth and productivity of tomato by some bio-stimulants and micronutrients with or without mulching. J. Phytol. 2018;10: 15-23.

Jaafar H.Z, Aroiee H, AziziM., Nemati H &Aminifard M, Effect of humic acid on antioxidant activities and fruit quality of hot pepper (*Capsicum annuum* L.). J.herbsspices med.plants. 2012:18: 360-369.

Johari NS, Asilah, AM, Zalina, I, Fazhana, I, Ab-latif, Z., Shaibatul, Islamiah,et al. CM. &Tang J R, Effect of fish amino acid foliar application on growth and development of okra

Comment [FT44]: These are well known fact. How/ and what has your work established?

Comment [FT45]: Conclude the out comes of all the objective of your work. Have you address the research gap? What would you recommend then.

Comment [FT46]: The are lucking consistence in both style and formatting.

(*Abelmoschus esculentus*) at different sampling times. J. Vocatinal Edu. Studies. 2020: 3: 35-42.

Mahmood N, Abbasi NA, Hafiz, IA, Ali, I &Zakia, S, Effect of bio-stimulant on growth, yield and quality of Bell Pepper *cv.* Yolo Wonder. Pak. J. Agri. Sci.2017: 5: 311-317.

Niles GA., Plant breeding and improvement of the cotton plant. Outlook on Agriculture. 1980; 10: 152-158

Palacios, MA, Gomez M, Camara C &Lopez MA, Stability studies of arsenate, monomethylarsonate,dimethylarsinate, arsenobetaine and arsenocholine in deionized water, urine and clean-up dry residue from urine samples and determination by liquid chromatography with microwave-assisted oxidation-hydride generation atomic absorption spectrometric detection. Analytica Chimica Acta.1997; 340: 209-220.

Paradikovic N, VinkovicT, VinkovicVrcek I, Zuntar I, Bojic M &Medicsaric, M, Effect of natural biostimulants on yield and nutritional quality: an example of sweet yellow pepper (*Capsicum annuum* L.) plants. J. Sci. Food Agric. 2011; 91: 2146-2152.

Ruban SJ, Priya MR., Barathan, G & Suresh Kumar SM Effect foliar application of bio-stimulants on yield of brinjal (*Solanum melongena* L.). Pl.Arch.2019;19: 2118-2120.

Sarhan ZT, Effect of humic acid and seaweed extracts on growth and yield of potato plant *(Solanum tuberosum* L.) *cv*. Desiree. Mesopotamia J. Agric.2011; 39: 19-25.

Sarojnee DY, Navindra B & Chandrabose S, Effect of naturally occurring amino acid stimulants on the growth and yield of hot peppers. J. Animal & Plant Sci. 2009; **5**: 414-424.

Sawant, DM, Memane, SA, Joi MB & kale PN.Screening of varieties against leaf curl complex of chilli. Veg. Sci. 1986

Sharanya, B.R., AP, M.G. and Srinivasappa, K.N., Impact of bio-stimulants on growth and yield of cowhage (*Mucuna pruriens* L.).J. Pharm.Inov. 2022; 11: 398-402

Sheetal P, Dewang& Usha devi C, Efficacy of Organic Bio-stimulant (Fish Protein Hydrolyzate) on The Growth and Yield of Tomato (*Solanum lycopersicum*)J. Agri., Animal and Vet. Sci.2021; 53: 1-6.

Sundararaj N, Nagaraju S, CS Venkataramu&jaganath MK Design and analysis of field experiment. *University of Agricultural Science, Technical Series*, Bangalore. 1972;