E-ISSN: 2618-0618
P-ISSN: 2618-060X

www.agronomyjournals.com
2024; 7(10): 172-174
Received: 14-07-2024
Accepted: 26-08-2024

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Influence of bio-stimulants on biomass production, soil properties and nutrient uptake by chilli (*Capsicum annuum* L.)

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DOI: https://doi.org/10.33545/2618060X.2024.v7.i10c.1716

Abstract
It is because of ability to support ecologically friendly and sustainable farming techniques, biostimulants are gaining more attention in contemporary agriculture. This research applied various concentration of protein based bio-stimulants on chilli. The aim of research was to find their best concentration, leading to maintain biomass production, soil properties and nutrient uptake. The experiment was in random complete block design in a research field at Indian Council of Agricultural Research Krishi Vigyan Kendra, Hadonahalli, Doddaballapura. The experimental treatments were commercial bio-stimulant (3 ml/L), seedling dip and foliar application of amino acid based bio-stimulants (2.5, 5, 7.5 ml/L) at vegetative, flowering and fruit development stage. Maximum fresh shoot weight (275.53 g), root weight (32.43 g), total biomass (308.99 g), dry shoot weight (86.03 g), root weight (20.00 g), total biomass (106.03 g) was observed with the combination of seedling dip along with foliar application of amino acid based bio-stimulants they had no significant influence on soil pH, EC and OC.

Keywords: Bio-stimulants, seedling dip, amino acid based, foliar application

Introduction
The hot-tasting tropical berry known as red chilli (*Capsicum annuum* L.), which is endemic to Mexico and Peru, has chromosomal number 2n=2x=24. The chemical capsaicin in chillies causes pungency in the placenta and pericarp of the fruit. Additionally, it is employed industrially to extract oleoresin. Chillies can be roughly classified into two species, based on their multiple races: *Capsicum frutescens* L. and *Capsicum annuum* L. (Paul *et al.*, 2013) [16]. Due to its potential antibacterial, antioxidant, anti-cancer, and other relevant medicinal characteristics, chilli is the most widely cultivated vegetable and spice in the world (Dubey *et al.*, 2015) [6].

Plants can reach height of 1.5 meters. The 6-7 sepals that make up the beautiful normal flowers are partially hooked together. Berries are considered fruit and are typically eaten when fully grown. The coloring substance known as capsanthin gives red chilies their color. Chilli ranks highest in production among all spices (22.71%), followed by turmeric (16.92%) and garlic (21.93%). According to Bhagya *et al.* (2017) [3], Andra Pradesh is the top producer with 11.88 million tonnes, followed by Karnataka in fifth place with 3.7 million tonnes. In addition to nutrients the production and quality of harvested produce are influenced by regulation of plant growth and the negative consequences of abiotic stress.

Bio-stimulants are incorporated into production in supplementary to conventional methods with the objective of modifying plant physiological processes to improve productivity. The plant biostimulants are type of compounds administered to plants or the rhizosphere, to boost natural processes and improve crop quality, intake of nutrients, nutrient efficiency, and tolerance to abiotic stress. Furthermore, this inquiry has been carried out to examine the significance and diverse applications of bio-stimulants with red chilli.

Materials and Methods

The field experiment was carried out from June to December 2021, at ICAR Krishi Vigyana Kendra in the Bengaluru Rural District using Chilli Hybrid seeds (LHC-1835) with seven treatments that were replicated three times on fairly level land that had red sandy loam soil with consistent fertility condition. Nursery was raised and seedlings and the seedlings were transplanted at 30 days after at a spacing of 90 × 45 cm. 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) @3 ml/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). At harvest, five plants (destructive plants in border rows) were removed from each plot. The plants were then divided into shoot and root sections, and the weight of each component was recorded as fresh shoot weight and root weight. The sections were then air dried until they attained a constant weight, that was recorded as dry shoot weight and root weight. They were further added, and the fresh and dried bio-mass yield was determined. Following plant samples from each treatment were dried and ground into a fine powder. To estimate the sample's intake of nitrogen, phosphate, and potassium content. Prior to the start of the experiment and following the last harvest, representative soil samples were taken from the experimental plot at a depth of 30 cm. Analysis of soil samples was done for phosphorus, potassium, available nitrogen, organic carbon (Piper, 1966) [17], pH, EC, and available nitrogen (Subbiah and Aija, 1956) [21].

Statistical analysis and interpretation of data

As the study was laid in Randomized Complete Block Design (RCBD), the data on all the biometric observations recorded were subjected to statistical analysis as outlined. Graphs were drawn using Microsoft Excel mean values were compared with Duncan's multi-range test.

Results

Biomass production

Biomass production was significantly influenced by bio-stimulant application. The maximum fresh shoot weight (275.53 g), fresh root weight (32.43 g), total fresh biomass (308.99 g), dry shoot weight (86.03 g), dry root weight (20.00 g), total dry biomass (106.30 g) was registered with Seedling dip+ foliar application of Impakt @ 5ml/L which is *at par* with RDF+ foliar application of Impakt @ 7.5ml/L. (Table 1).

Nutrient uptake

Among various treatments uptake of nitrogen (180.17 kg ha $^{-1}$), phosphorous (26.20 kg ha $^{-1}$), and potassium (90.32 kgha $^{-1}$) was maximum with seedling dip+ foliar application of Impakt @ 5ml/L. While, minimum was noted in control (Table 2).

Soil properties

The plants administered with seedling dip+ foliar application of Impakt at 5ml/L resulted in higher available nitrogen (203.81 kg ha^{-1}), phosphorous (50.59kg ha^{-1}), potassium (137.81 kg ha^{-1}). While, minimum was noted in control (Table 3).

Discussion

The increase in biomass might be due to increased availability of nitrogen supply which would have promoted protein synthesis from reserved carbohydrate source leading to better biomass production Similar findings were reported by Ammar *et al.* (2020) [1] in brinjal. The maximum nutrient uptake might be due to better dissolution rates of nutrients. These findings are in line with Garai *et al.* (2021) [8] in potato, Kleiber *et al.* (2015) [11] in tomato, Osman and Gawad (2014) [15] in brinjal. The better soil properties might be due to better dissolution rates of minerals, solubilisation, chelation and release of enzymes like chitinase and cellulases that causes breakdown of minerals. These findings are similar with Megha and Shailesh (2022) [14] in brinjal; Kumar *et al.* (2018) [12] in brinjal.

Table 1: Influence of bio-stimulants on biomass production and total biomass

Treatments	Fresh shoot weight(g)	Fresh root weight (g)	Fresh biomass yield(g)	Dry shoot weight (g)	Dry root weight (g)	Dry biomass yield (g)
T_1- Control	133.13	23.53	159.66	41.53	13.51	55.19
T_2 - Commercial bio-stimulant (Isabion) at 3 ml/L	173.93	25.93	198.14	54.61	13.72	68.51
T_3-Foliar application of Impakt @ 2.5 ml/l at vegetative, flowering and fruit development stage	160.60	25.27	186.52	53.42	15.04	68.63
T_4 - Foliar application of Impakt @ 5 ml/l at vegetative, flowering and fruit development stage	182.40	24.80	207.95	57.87	15.20	73.26
T_5-Foliar application of Impakt @ 7.5 ml/l at vegetative, flowering and fruit development stage	251.53	29.93	282.31	81.34	17.60	99.16
T_6 - 75% N + Foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	230.60	24.99	256.28	69.49	16.47	86.14
T_7 -Seedling dip + foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	275.53	32.43	308.99	86.03	20.00	106.03
S.Em. ±	10.15	1.17	3.94	4.17	1.04	1.32
CD@ 5%	31.28	3.62	12.30	12.85	3.22	4.11

Table 2: Influence of bio-stimulants on nutrient uptake

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
T_1- Control	101.97	10.84	43.85
T_2 - Commercial bio-stimulant (Isabion) at 3 ml/L	114.81	12.56	48.63
T_3-Foliar application of Impakt @ 2.5 ml/l at vegetative, flowering and fruit development stage	126.34	13.73	51.61
T_4 - Foliar application of Impakt @ 5 ml/l at vegetative, flowering and fruit development stage	142.33	16.58	59.79
T_5-Foliar application of Impakt @ 7.5 ml/l at vegetative, flowering and fruit development stage	165.34	22.45	78.47
T_6 - 75% N + Foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	160.41	21.74	76.19
T_7 -Seedling dip + foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	180.17	26.20	90.32
S.Em. ±	1.54	0.49	0.81
CD@ 5%	4.76	1.52	2.48

Table 3: Soil properties influenced by biostimulants

Treatments	pH	EC (d s/m)	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)
T_1- Control	6.05	0.12	0.43	189.95	45.15	125.50
T_2 - Commercial bio-stimulant (Isabion) at 3 ml/L	6.18	0.12	0.44	190.94	46.62	131.04
T_3-Foliar application of Impakt @ 2.5 ml/l at vegetative, flowering and fruit development stage	6.18	0.12	0.43	192.28	47.44	132.62
T_4 - Foliar application of Impakt @ 5 ml/l at vegetative, flowering and fruit development stage	6.18	0.12	0.44	194.18	48.26	133.52
T_5 -Foliar application of Impakt @ 7.5 ml/l at vegetative, flowering and fruit development stage	6.12	0.12	0.43	201.57	49.58	134.84
T_6 - 75% N + Foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	6.18	0.11	0.44	197.26	48.71	134.22
T_7 -Seedling dip + foliar application of Impakt @ 5.0 ml/l at vegetative, flowering and fruit development stage	6.11	0.12	0.43	203.81	50.59	137.81
S.Em. ±	-	-	-	0.84	0.43	0.11
CD@ 5%	NS	NS	NS	2.57	1.33	3.41

Conclusion

In conclusion, the study highlights the significant impact of bio-stimulants, particularly Impakt, on the biomass production and nutrient uptake in red chilli plants. The optimal application of bio-stimulants resulted in notable increases in fresh and dry biomass, along with enhanced nutrient availability in the soil. These findings suggest that integrating bio-stimulants into conventional agricultural practices can improve crop productivity and quality, particularly under abiotic stress conditions. As red chilli continues to be a vital crop globally, such innovative approaches could enhance its cultivation efficiency and sustainability, paving the way for better agricultural practices in the future.

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