

Dynamics of bell pepper using bio nutrient sources in the northwestern Himalayas

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ABSTRACT

Bionutrients play a vital role in enhancing soil productivity and sustainable agricultural production. In vegetable crops, limited information is available on the relevance of bionutrients in solanaceous crops under protected conditions. Therefore, an experiment was planned to study the response of bionutrients under the modified naturally ventilated polyhouse in mid-hill conditions of Himachal Pradesh for two consecutive years. Various bell pepper varieties, viz., Mekong, Orobelle, Indra and DPCY1, were subjected to a set of bionutrient sources (*beejamrit*, *ghanjeevamrit*, *jeevamrit* and mulching). The results showed that there was a substantial increase in yield parameters in the treatment module, i.e., Mekong + *beejamrit*@ 200 ml/kg + *ghanjeevamrit*@5q/ha + *jeevamrit* @ 500 lt/ha at 21-day intervals + mulching @ 10 t/ha. This treatment exhibited a minimum number of days to 50% flowering (24.16), maximum number of marketable fruits per plant (28.40), fruit length (7.68 cm), fruit breadth (7.70 cm), pericarp thickness (9.15 mm), average fruit weight (109.53 g), plant height (84.06 cm) and marketable yield per plant (3.11 kg). However, Mekong + *beejamrit* @ 200 ml/kg + *ghanjeevamrit* @5q/ha + *jeevamrit*@ 500 lt/ha at 28-day intervals + mulching @ 10 t/ha treatment proved best for total soluble solids (4.58 °Brix), ascorbic acid (166.50 mg/100 g), capsaicin content (6.64%) and carotenoid content (2.43 mg/100 g). Horticultural and biochemical traits were appreciably enhanced after bionutrient application in bell pepper. Therefore, outcomes from the study point out that it is a feasible and economical approach for farmers.

Introduction

Modern chemical-based crop growing is increasing radically to meet the demands of the ever-growing population by enhancing crop productivity. The use of these chemicals in agriculture leads to enormous environmental and health issues. Considering these facts, various alternative and ancient farming techniques were developed for sustainable agriculture. Sustainable agriculture practices enable

food production without compromising the needs of future generations (World Bank, 2017). Among all the techniques, natural farming is a neoteric approach to improve both traditional and modern agricultural practices, which aims to safeguard the environment, public health and communities (Mishra, 2013). Zero-budget natural farming (ZBNF) is also an agroecological approach that has

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attained popularity because it increases agricultural production without any expenses and eliminates the cost of production. *Jivamrit*, *beejamrit*, mulching and *whapasa* –aeration are the main pillars of ZBNF (Khadse and Rosset, 2019). In vegetables, bionutrients help in the conversion of nutrients from unavailable to available forms in the plant rhizosphere, act as antagonists to pathogens and provide toxic free food to consumers. The demand for fresh vegetables is increasing owing to the growth of a health-conscious population and, more generally, through enhanced income (Ramesh *et al.*, 2005; Sharma *et al.*, 2021). *Capsicum* or bell pepper (*Capsicum* spp.) is a very important vegetable as well as spice crop belonging to the family Solanaceae. It is also known as night shade and nontraditional vegetable (Kalloo and Pandey, 2002). Bell pepper is thought to have originated in the American tropics, i.e., tropical South America (Hunziker, 2001). *Capsicum* is cultivated all over the world for fresh, dried, and processed products (Kurubetta and Patil, 2009; Bijalwan *et al.*, 2022a, b). The crop has attained an important status and special significance in the mid-hills of Himachal Pradesh and is also cultivated as an off-season crop during the summer months (Bijalwan *et al.*, 2021). The genus *Capsicum* includes over 30 species, five of which (*C. annuum*, *C. frutescens*, *C. chinense*, *C. baccatum*, and *C. pubescens*) are domesticated and mainly grown for consumption purposes (Tripodi and Kumar, 2019). It is a high-value and low-volume crop suitable for open fields as well as protected environments in India (Hernandez-Aranda *et al.*, 2021). In both developed and developing countries, there is a need to adopt new approaches to increase food supplies while protecting the resources on which they depend (FAO, 2017). The application of *jeevamrit*, *ghanjeevamrit*, *beejamrit* and mulching enhances soil fertility and increases microorganism activity in soil, which ultimately boosts crop yield. The application of bionutrients improves the total soluble solids, vitamin C, and capsaicin contents and increases the production of bell pepper (Malawadi *et al.*, 2003; Sharma *et al.*, 2022). In vegetable crops, very limited research has documented the effect of different combinations of bionutrients on horticultural and biochemical parameters in *Capsicum*. Therefore, the present study was investigated to identify the best

bionutrient combination and variety to maximize the yield under protected conditions in mid-hill conditions.

Material and Methods

Experimental location, plant material and detail of bio nutrient treatments

This study was conducted at the Research Farm, Department of Vegetable Science and Floriculture (N 32°6', E 76°3'), CSK HPKV Palampur, from 2019-2020. Agro-climatically, it is located in the mid-hill region and has a humid subtemperate climate with 2,500 mm of annual rainfall. The experiment consisted of twelve treatments of foliar application of *jeevamrit*, soil application of *ghanjeevamrit*, seed treatment with *beejamrit* and soil application of mulching (Table 1), and the effects of twelve combinations of bio nutrients on the horticultural and biochemical traits of four *Capsicum* genotypes (Mekong, Orobelle, Indra and DPCY1) were studied. The experiment was conducted under a randomized complete block design inside a modified naturally ventilated polyhouse (25 m × 10 m) and replicated three times. The plants of each treatment were planted at a spacing of 70 × 30 cm and trained on four stems in each replication.

Observations of horticultural traits

Observations were recorded from five selected plants in each replication in each treatment on various horticultural traits, viz., days to 50% flowering, number of marketable fruits per plant, fruit length (cm), fruit breadth (cm), pericarp thickness (mm), average fruit weight (g), marketable yield per plant (kg) and plant height (cm). All these parameters were taken as suggested by Shilpa *et al.* (2022).

Observations of biochemical traits

Examination of various biochemical traits, viz., total soluble solids (°brix), ascorbic acid (mg/100 g), capsaicin content (%) and carotenoid content (mg/100 g), was performed in the laboratory by Shilpa *et al.* (2022). Total soluble solids (°Brix) were determined using a hand refractometer. The ascorbic acid contents were estimated using 2,6-dichlorophenol indophenol as suggested by Ranganna (1979) and used by Shilpa *et al.* (2022). Capsaicin content was estimated in fresh fruits using Folin-Cicalteau reagent as described by Gougoulis, (2017).

Table 1: Details of treatment combinations

Treatment code	Treatment combinations
T ₁	Mekong + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 14 days interval + Mulching @ 10 t/ha
T ₂	Orobelle + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 14 days interval + Mulching @ 10 t/ha
T ₃	Indra + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 14 days interval + Mulching @ 10 t/ha
T ₄	DPCY1+ Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 14 days interval + Mulching @ 10 t/ha
T ₅	Mekong + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 21 days interval + Mulching @ 10 t/ha
T ₆	Orobelle + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 21 days interval + Mulching @ 10 t/ha
T ₇	Indra + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 21 days interval + Mulching @ 10 t/ha
T ₈	DPCY1 + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 21 days interval + Mulching @ 10 t/ha
T ₉	Mekong + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 28 days interval + Mulching @ 10 t/ha
T ₁₀	Orobelle + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 28 days interval + Mulching @ 10 t/ha
T ₁₁	Indra + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 28 days interval + Mulching @ 10 t/ha
T ₁₂	DPCY1 + Beejamrit @ 200 ml/kg + Ghanjeevamrit @5q/ha + Jeevamrit @ 28 days interval + Mulching @ 10 t/ha

Carotenoid analysis was performed by HPLC as suggested by Cervantes-Paz *et al.* (2014).

Statistical analysis

The statistical analysis was carried out using analysis of variance (ANOVA) by using SPSS Statistical Computer Package (SPSS for Windows, Standard Version 20.0).

Results and Discussion

Effect of bionutrients on horticultural traits of bell pepper

In the current study, pooled data reflect the growth and yield of capsicum, as depicted in Table 2. From the point of view of bionutrient application, beejamrit, ghanjeevamrit, jeevamrit and mulching have significant effects on the growth and yield characteristics of bell pepper. The results shown in Table 2 indicate that the treatment combination comprising Mekong + beejamrit @ 200 ml/kg + ghanjeevamrit@5q/ha + jeevamrit@ 21 days interval + mulching @ 10 t/ha significantly influenced all the evaluated horticultural traits of bell pepper. The application of jeevamrit at 21-day intervals along with other bionutrient sources for the Mekong variety has a significant effect on yield parameters. The analysis of variance showed that the T₅ treatment had a significant effect on the minimum number of days for 50% flowering (24.16), maximum number of marketable fruits per plant (28.40), average fruit weight (109.53 g), fruit length (7.68 cm), fruit breadth (7.70 cm), pericarp thickness (9.15 mm), marketable yield per plant (3.11 kg) and plant height (84.06 cm). Similarly,

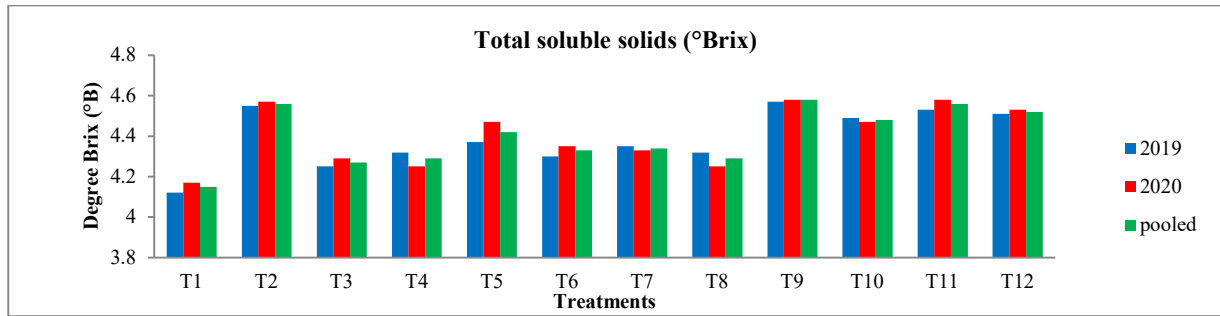
foliar application of jeevamrit at 21-day intervals for the variety Indra resulted in the second highest yield (3.05 kg/ha), minimum number of days for 50% flowering (25.75), maximum number of marketable fruits per plant (27.94), average fruit weight (109.18 g), fruit length (7.39 cm), fruit breadth (7.42 cm), pericarp thickness (9.11 mm), marketable yield per plant (3.05 kg) and plant height (82.58 cm) in the T₇ treatment.

Effect of bionutrients on biochemical traits

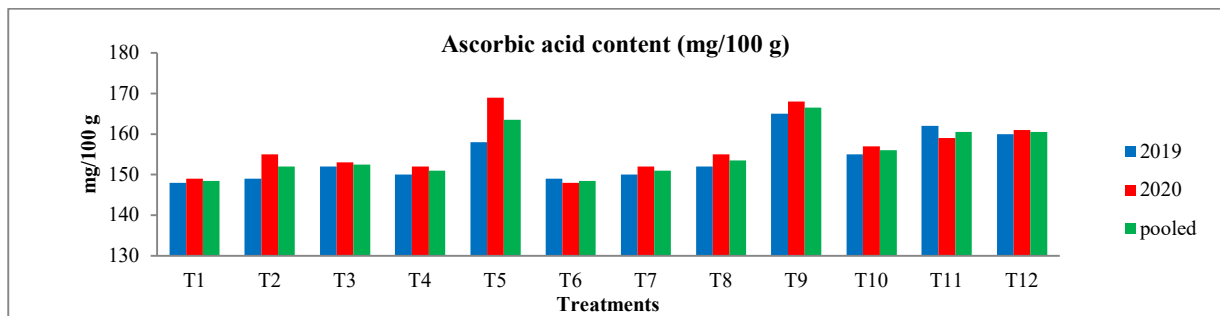
Fig. 1 shows the effects of bionutrient application on total soluble solids, ascorbic acid content, capsaicin content and total carotenoids in bell pepper. From the perspective of the application of bionutrients in the four different varieties, the application of jeevamrit at 28-day intervals for the variety Mekong (T₉) had a significant effect on the biochemical parameters of bell pepper along with other sources of nutrients. Under the conditions of bionutrient spray and drenching, the analysis of variance showed that the T₉ treatment had a significant effect on the total soluble solids (4.58 °Brix), ascorbic acid content (166.50 mg/100 g), capsaicin content (6.64%) and carotenoid content (2.43 mg/100 g) of bell pepper. Bionutrients play a vital role in plant growth and yield in vegetable crops. It is an agroecological-based diversified farming approach attaining popularity due to harmony in nature (Rosset and Martinez-Torres, 2012; Kumar *et al.*, 2019; Shilpa *et al.*, 2023; Shilpa *et al.*, 2020). It allows functional biodiversity by reducing the use of agrochemicals

Table 2: Days to 50% flowering, number of marketable fruits per plant, fruit length, fruit breadth, pericarp thickness, average fruit weight, marketable yield per plant (kg) and plant height (cm) of Bell Pepper as influenced by the application of bionutrients.

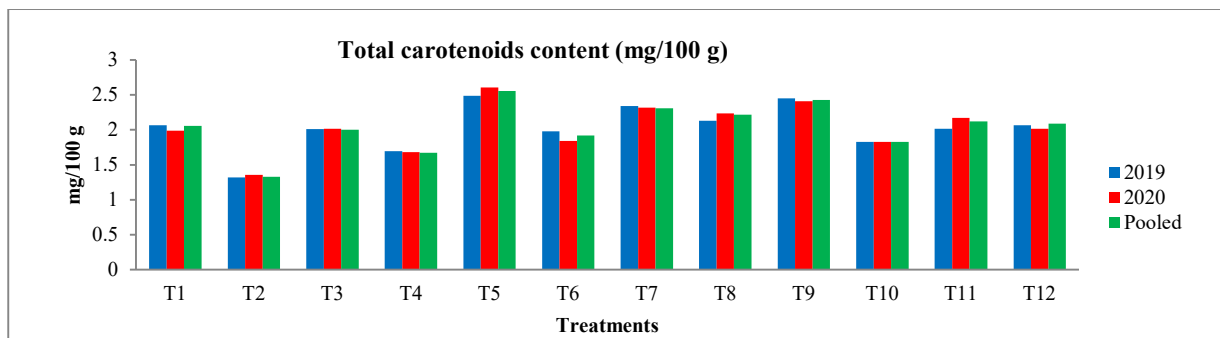
Sr No.	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled	
Treatments	Days to 50% flowering			Number of marketable fruits per plant			Fruit length (cm)			Fruit breadth (cm)			Pericarp thickness (mm)			Average fruit weight (g)			Marketable yield per plant (kg)			Plant height (cm)			
T ₁	34.13	31.16	32.65	22.63	23.76	23.20	6.77	6.79	6.78	6.89	6.98	6.94	8.46	8.58	8.52	87.96	87.54	87.95	1.99	2.08	2.04	74.25	76.52	75.39	
T ₂	36.49	35.23	35.86	21.13	21.69	21.41	6.44	6.54	6.49	6.59	6.61	6.60	8.21	8.27	8.24	75.74	82.55	79.42	1.60	1.79	1.70	71.25	72.25	71.75	
T ₃	35.17	32.18	33.68	22.08	22.61	22.34	6.64	6.56	6.60	6.66	6.87	6.77	8.35	8.44	8.40	85.62	87.59	86.84	1.89	1.98	1.94	73.78	75.58	74.68	
T ₄	36.11	34.00	35.06	21.56	22.14	21.85	6.53	6.60	6.57	6.58	6.68	6.63	8.22	8.35	8.29	82.10	84.91	83.75	1.77	1.88	1.83	72.81	73.38	73.10	
T ₅	24.32	24.00	24.16	28.17	28.63	28.40	7.58	7.77	7.68	7.55	7.85	7.70	9.12	9.17	9.15	108.29	110.74	109.53	3.05	3.17	3.11	82.23	85.89	84.06	
T ₆	27.71	26.16	26.94	27.06	27.56	27.31	7.02	7.21	7.12	7.11	7.25	7.18	8.88	8.85	8.87	104.23	108.15	106.21	2.82	2.98	2.90	79.00	79.85	79.43	
T ₇	26.26	25.24	25.75	27.87	28.00	27.94	7.32	7.45	7.39	7.38	7.45	7.42	9.10	9.11	9.11	107.64	110.71	109.18	3.00	3.10	3.05	81.87	83.28	82.58	
T ₈	27.04	26.11	26.58	27.74	27.99	27.87	7.25	7.42	7.34	7.28	7.38	7.33	8.97	8.98	8.98	107.45	102.54	105.15	2.98	2.87	2.93	80.25	81.10	80.68	
T ₉	27.84	26.54	27.19	26.59	27.00	26.80	7.00	7.20	7.10	7.09	7.25	7.17	8.75	8.84	8.80	104.19	106.30	105.24	2.77	2.87	2.82	78.45	79.98	79.22	
T ₁₀	30.12	28.98	29.55	25.04	25.50	25.27	6.82	6.87	6.85	6.98	7.00	6.99	8.56	8.67	8.62	106.23	105.49	106.05	2.66	2.69	2.68	75.58	76.68	76.13	
T ₁₁	28.37	27.98	28.18	26.13	26.62	26.38	6.98	7.00	6.99	7.05	7.11	7.08	8.68	8.77	8.73	103.71	104.06	103.89	2.71	2.77	2.74	77.49	78.87	78.18	
T ₁₂	29.41	28.63	29.02	25.58	26.13	25.85	6.85	6.98	6.92	7.00	7.20	7.10	8.62	8.71	8.67	104.79	103.35	104.06	2.68	2.70	2.69	76.58	77.58	77.08	
CD (0.05)	0.75			0.40			0.07			0.07			0.04			1.57				0.07			0.71		



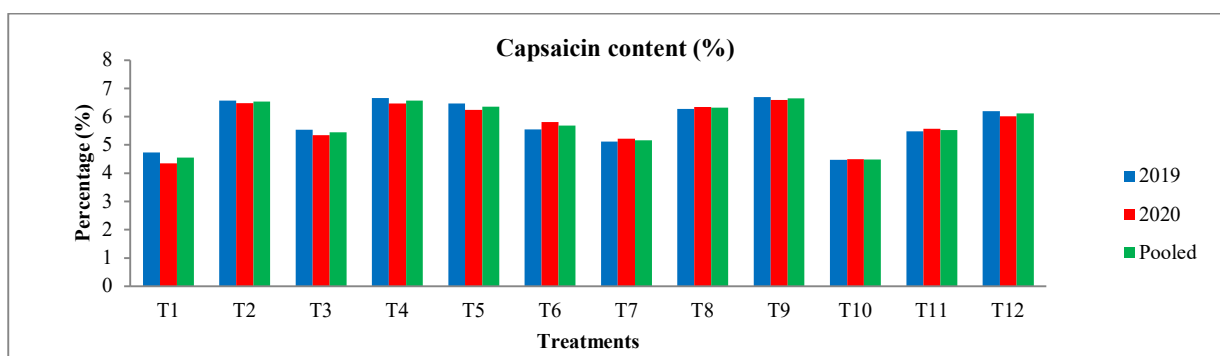
(a)



(b)



(c)



(d)

Figure 1. Application of bionutrients on biochemical traits (a) Total soluble solids (degree Brix) (b) Ascorbic acid content (mg/100 g) (c) Total carotenoid content (mg/100 g) (d) Capsaicin content (%)

for sustainable crop production. *Beejamrit*, *heghanjeevamrit*, *jeevamrit* and mulching stimulate microflora, microfauna and nutrient bioavailability and therefore act as antagonists for fungal pathogens (Palekar, 2006; Vasanthkumar, 2006; Devakumaret al., 2008; Lorimer, 2017; Khadse and Rosset, 2019). Very little information is available regarding the application of different bionutrients with varied concentrations at different intervals of days and genotypes, which could enhance yield and improve fruit quality.

The present study demonstrated that the application of *beejamrit* (@ 200 ml/kg), *ghanjeevamrit* (@5q/ha), *jeevamrit* applied at 21-day intervals and mulching (@ 10 t/ha) in the Mekong variety proved best for horticultural traits, viz., number of days for 50% flowering, number of marketable fruits per plant, average fruit weight, fruit length, fruit breadth, pericarp thickness, marketable yield per plant and plant height due to the large amount of beneficial microbes present in *jeevamrit*, higher decomposition of organic matter, availability of nutrients and their utilization by plants from the soil, resulting in better growth and development. Among all the treatments, the combination of *beejamrit* (200 ml/kg), *Ghanjeevamrit* (5 q/ha), and *Jeevamrit* at 28-day intervals and mulching (10 t/ha) in the Mekong variety significantly improved biochemical parameters in terms of total soluble solids, ascorbic acid content, capsaicin content and total carotenoids.

Earlier scientists have also documented increased growth, yield and biochemical traits with augmentation of various bionutrients in vegetable crops (Aranconet al., 2005, Shwetha and Babalad, 2008; Joshi and Pal Vig, 2010; Ramesh *et al.*, 2015; Adhikari *et al.*, 2016; Boraiah *et al.*, 2017; Bairwaet al., 2018; Hameedi, 2018; Kumar *et al.*, 2021; Shilpa *et al.* 2022a, b, c). The probable reason for improved quality includes efficient use of nutrients at different growth stages of a plant, higher source to sink ratio and carbohydrate accumulation in the plant tissues. Bionutrients constitute smaller quantities of plant growth regulators (IAA and GA), which create stimuli in plant systems, which

in turn enhance growth and development, leading to better fruit yield and quality (Chandrakala *et al.*, 2011 and Vij *et al.*, 2022). Cow urine rich in uric acid, a source of nitrogen, is a readily soluble and liquid form, one of the important compounds in bionutrients that is readily available to plants and directly influences the nitrogen content (Patel *et al.*, 2018). Mulching includes live mulch, soil mulch and straw mulch, which helps to alter the environment surrounding the plant rhizosphere. Mulches have additional utilization, as after their degradation, nutrients are incorporated into the soil; therefore, plant-based residue mulch material ensures a significant enhancement in yield (Jilani *et al.*, 2016; Awalet *et al.*, 2016; Sarochet *et al.*, 2016; Bairwaet al., 2018; Hernandez-Aranda *et al.*, 2021; Shilpa *et al.*, 2021a,b,c,d)

Conclusion

In the present study, various bionutrients showed significant variation in horticultural and biochemical traits in bell pepper. The presence of beneficial microorganisms, synthesis of phytohormones, conversion of unavailable forms of nutrients to available forms and higher organic carbon content in bionutrients predominantly marked satisfactory responses. Therefore, bionutrients meritoriously increased the yield potential and are recommended as an alternative natural farming practice for the cultivation of bell pepper under protected conditions in the northwestern Himalayan region.

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Conflict of interest

The authors declare that they have no conflict of interest.

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