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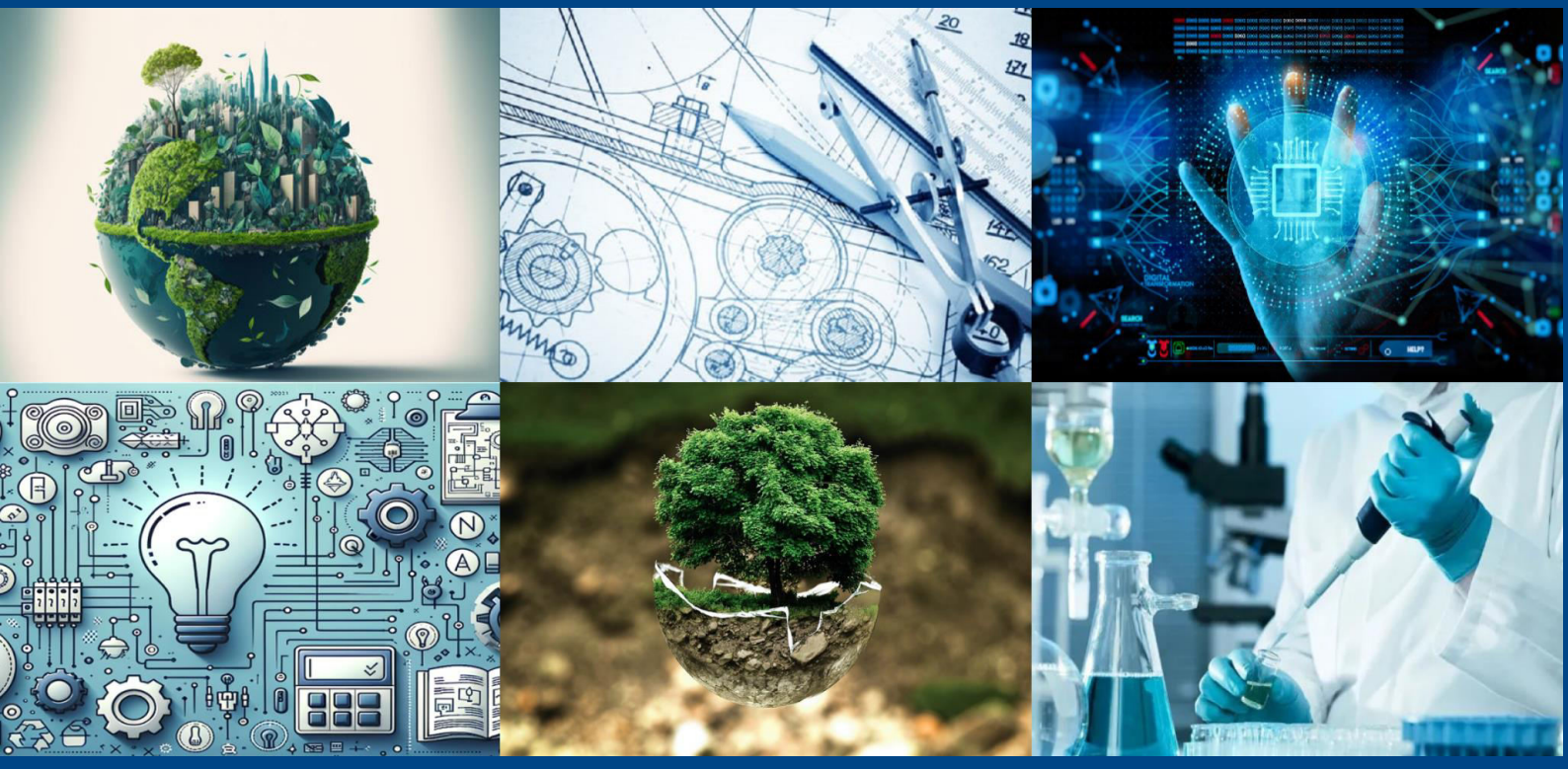

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Biostimulants for Plants – Giving Nature a Nudge

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ABSTRACT: The main aim of this project is to build a more sustainable and resilient agriculture and cropping, Climate changes are already affecting plant growth around the world. Drought and heat waves are increasing in intensity and frequency, affecting yields and the nutritional content of essential food crops. These changes are due in part to agriculture itself, through the overuse of synthetic nitrogen fertilizers and widespread soil degradation.

These enormous challenges are compounded by the fact that yields must increase in the coming decades as the planet adds more than 2 billion people. Plant Biostimulants offer a possible solution: a way to maintain yields using fewer resources. They can reduce fertilizer use by improving nutrient bioavailability, save water by promoting water retention, root growth, stimulates the natural processes and metabolism of plants, and give plants greater resistance against the increasingly severe abiotic stresses of heat and drought. Thus optimizing both crop quality and yield.

Biostimulants help to improve plant growth, yield and quality as well as soil condition and boron increase root quality along with macro nutrients.

The field experiment to see the "Effect of Biostimulants and boron on growth, yield and quality of carrot (Daucus carota L.) cv. Pusa Kesar" was carried out at BJR Government Degree College Terrace Garden, Narayanaguda, Hyderabad.

KEYWORDS: Biostimulants, carrot (Daucus carota L.) cv. Pusa Kesar,Boron

I. INTRODUCTION

Vegetables are rich and comparatively cheaper source of vitamins and minerals. Their consumption in sufficient quantity will provides all the nutrient components like carbohydrates, proteins, fats, vitamins, minerals which are the essential constituents of a balanced diet. Vegetables are currently recognized as an important source for maintenance of good health and beneficial in protecting against some diseases. They also play a key role in neutralizing acids produced during the digestion and also provide valuable roughages which promote digestion and help in preventing constipation. In general, for a balanced diet the daily requirement of some of the essential nutrients like proteins, minerals and vitamins can be met very well if an individual consumes 125 g leafy vegetables, 75 g other vegetables and 100 g root and tuber vegetables (Hazra and Som, 1999).

Carrot (*Daucus carota* L.) is one of the most popular vegetable crop in the world and the member crop of *Apiaceae* family. The carrot is a root vegetable, usually orange in colour, through purple, black, red, white and yellow cultivars exist.

Fresh carrots contain 8.17% free sugar, potassium is the most abundant mineral in carrots, with a range from 443 to 758 mg/100g fresh weight. Carrot contains highest amount of β-carotene among common vegetables. Raw fresh carrots contain on an average 8285 µg β-carotene/100g fresh weight. Orange-Coloured carrots contain appreciable quantity of thiamine and riboflavin. The Asiatic types have more of anthocyanin pigments and less of β-carotene and may be less nutritive. Rich β-carotene content of carrot prevents night blindness, caused due to deficiency of vitamin A. Pusa Kesar is a selection from a cross between Local red and Nantes half long. The roots develop on narrow central core which is also sufficiently red coloured. It contains high amount of carotene (38 mg/100g edible portion) than local red (26

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mg/100g). Root stay about a month longer in the field than local red without sowing any sign of bolting. The percentage of forked roots is also lower than in local red. Pusa Kesar can tolerate high temperature.

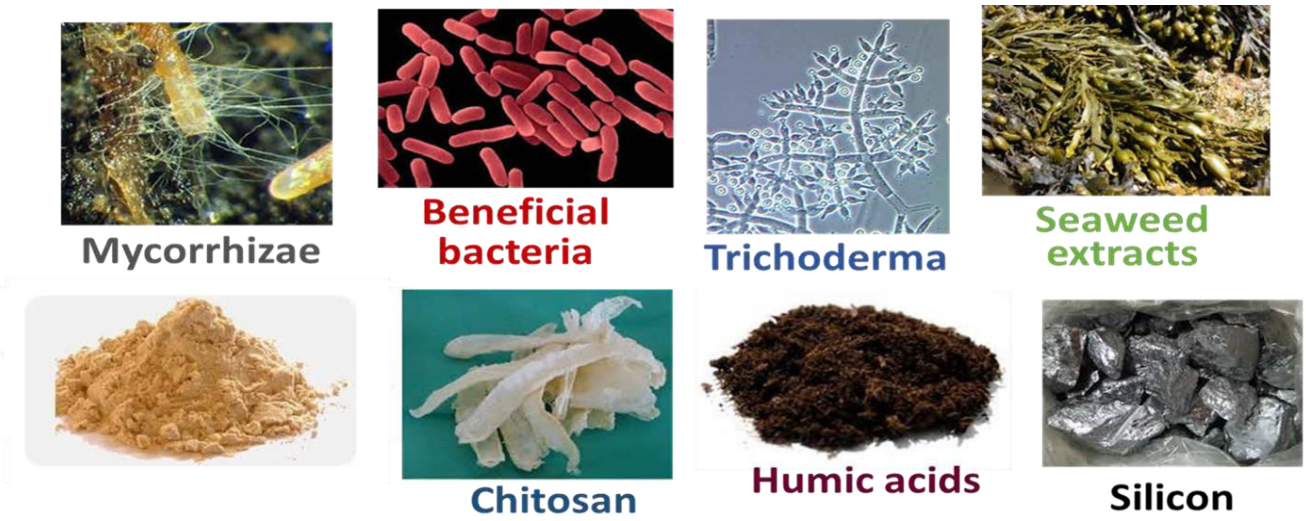
Boron

A balanced supply of essential macro and micronutrients is one of the most important factors to achieve higher crop yields. The micronutrients play specific role in the growth yield and quality of carrot. Unlike the major nutrient, micronutrient are required only in small quantities. Many soils fail to supply them in adequate quantities Boron (B) is one of eight micronutrients. It is considered as an essential element which has tremendous role in plant growth and development, physiology as well as biochemical composition. It require for cell division, sugar movement, through protoplasmic movement, hormone transport, phloem development. Boron affects the cambium and phloem tissues of storage root. Boron stimulates carotenoid synthesis (Florescu and cernea, 1961). It also helps to increase yield of carrot if used with macronutrient. Boron deficiency causes reduced root growth, brittle leaves and necrosis of shoot apex.

WHAT ARE BIOSTIMULANTS?

"A **Plant Biostimulant** is a substance or microorganism that, when applied to seeds, plants or the rhizosphere, stimulates natural processes to **improve or benefit nutrient uptake, nutrient efficiency, abiotic stress tolerance or crop quality and yield." Biostimulants has skyrocketed in recent years**. Their ability to sustainably **improve soil health, plant growth, water retention, nutrient efficiency and overall crop quality** is hard to ignore, and growers have taken notice.

Whether it's a live bacterium, a plant extract or a chemical element, if it **stimulates natural processes to the benefit of a plant, it's a Biostimulant.**



WHY USE A BIOSTIMULANT?

Biostimulants, do not provide nutrients to plants, but instead stimulate the plant's innate abilities to absorb nutrients, manage stress, and grow. They stimulate plant metabolism and improve nutrient uptake efficiency, resulting in enhanced plant vigor and resilience. In addition to reducing the impact of abiotic stress and boosting plant metabolism, biostimulants enhance nutrient uptake in plants. While fertilizers provide plants with required nutrients, biostimulants help plants use these nutrients more effectively. Moreover, biostimulants impact various metabolic, cellular, and physiological processes in plants, including respiration, photosynthetic activity, ion transport, redox reaction, and more. They promote both the quality and yield of crops.

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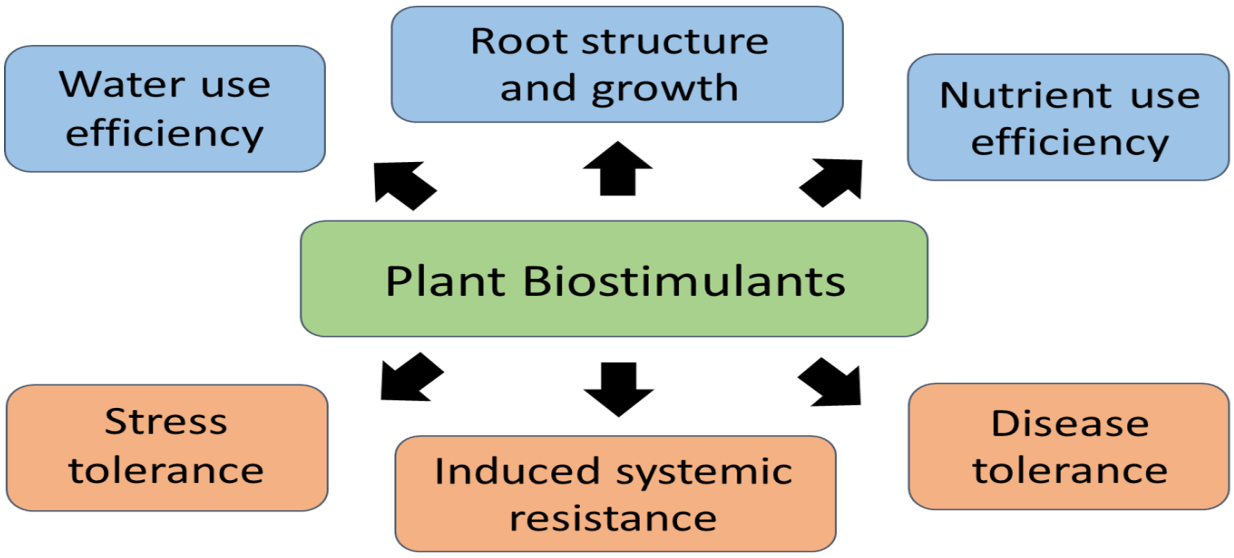
II. PLANT BIOSTIMUTANTS

PLANT BIOSTIMULANT EFFECTS



III. MATERIAL AND METHODS

The field experiment to see the "Effect of biostimulants and boron on growth, yield and quality of carrot (Daucus carota L.) cv. Pusa Kesar" was carried out at BJR Government Degree College Terrace Garden, Narayanaguda, Hyderabad.

The details of material used and the agro technology adopted in the present investigation are presented here under following subheads.

IV. PHYSIOGRAPHIC SITUATION

Location and Experimental site
The Experiment was carried out at BJR Government Degree College Terrace Garden, Narayanaguda, Hyderabad.

Climate and Weather Condition
Experiment was conducted during rabi season of 2023-24 (October end to April),Telangana has a tropical climate with some minor variations. It's located in the central-southern part of India and is in the semi-arid region of the Deccan Plateau.

Soil
The soil of the experimental site was Red sandy loam, Soils respond well to manures and irrigations.

Crop and Variety
The experiment was carried out on carrot cv. Pusa Kesar. It is an asiatic cultivar developed at the IARI, New Delhi. It has red-colored roots and self-colored core. It can tolerate higher temperature. Suitable for sowing from August - early October and Crop matures in 90-110 days.

EXPERIMENT DETAILS
The experiment was conducted in with three replications, considering biostimulants as first factor and boron as second factor.

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Treatment Details

A. Biostimulants
A0– Water spray
A1 – Seaweed extract (3 ml / L)
A2 – Anubhav bioconsortium " Bio Gold" (2 ml / L)
A3 – Humic acid (1 g / L)
B. Boron
B0–B 0 mg/ 10 sft pot
B1–B 0.5 mg / 10 sft pot
B2–B 1 mg / 10 sft

V. OBSERVATIONS RECORDED

Growth Attributes
Three plants were tagged at random in each treatment of respective replication for recording vegetative growth parameters.

Initial plant stand
Initial plant stand was recorded at 20 days after sowing.

Plant height (cm)
Plant height was measured in centimeter from ground level to the growing tip of the plant at 30, 60 days after sowing and harvest time by measuring the top ,As well as mean plant height was worked out from the heights recorded from random selected plants

Root fresh weight (g)
A weigh balance was used to record the weight of the harvested carrot for root fresh weight. All leaves were removed from the plant by a sharp knife and weight of the roots was taken in gram from each Three sample plants.

Root dry matter (g)
After harvest, roots were oven dried for 36 hours at 60°C temperature. After oven drying, with electrical balance the root dry matter was weighted in gram.

Shoot fresh weight (g)
Leaves were detached by sharp knife and fresh weight of leaves was taken by weight balance at time of harvest.

Shoot dry matter (g)
After harvest, leaves were oven dried for 36 hours at 60°C temperature. After oven drying, with electrical balance shoot dried matter was weighted in gram.

YIELD ATTRIBUTES
Root yield per plant (g)
A weigh balance was used to record the weight of the harvested carrot. All leaves were removed from the plant by a sharp knife and weight of the roots was taken in gram from each three sample plant.

Quality Parameters
Total sugar (%)
The total sugars of the filtrate were estimated by standardized Fehling's solution A and B using methylene blue indicator.

$$\text{Glucose equivalent } (0.052) \times \text{Total volume made up} \times \text{Volume made up after inversion} \times 100$$

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Total sugar (%)= _____
Titre value × Weight of sample × Aliquot taken for inversion

VI. RESULTS AND DISCUSSION

GROWTH ATTRIBUTES

Plant Height (cm) :-The data pertaining to the plant height (cm) of carrot as influenced by biostimulants and boron at **30 Day, 60** Day and at harvest presented

Effect of biostimulants

The data revealed that there was non-significant response found with the application of biostimulants on plant height at 30 Days. The plant height significantly influenced by application of biostimulants at 60 Day and at harvest. Treatment A3 (Humic acid 1g / L) recorded significantly maximum plant height at 60 Day (81.09 cm) and at harvest (84.65 cm) respectively and minimum plant height at 60 Day (55.77) and at harvest (70.89 cm) were recorded with treatment A0 (Water spray) respectively.

Treatment A3 (Humic acid 1g / L)

Effect of boron

The plant height significantly influenced by application of boron at 30, 60 Day and t harvest. Treatment B2 (Boron 1mg /10sft) recorded significantly maximum plant height at 30 day (12.63 cm), at 60 DAS (73.48 cm) and at harvest (82.98 cm) respectively. However minimum plant height at 30 DAS (10.08 cm), at 60 DAS (65.38 cm) and at harvest (73.02 cm) respectively was recorded with treatment B0 (Boron 0 mg/ 10sft).

Treatments	Plant height (cm)		
	30 Day	60 Day	At harvest
A. Biostimulants			
A_0 :Water spray	11.20	55.77	70.89
A_1 : Seaweed extract (3 ml / L)	11.24	74.28	79.13
A_2 : Anubhav bioconsortium (2 ml / L)	11.25	66.30	78.01
A_3 : Humic acid (1 g / L)	**11.35**	**81.09**	**84.65**
Sem ±	0.192	1.408	1.652
C.D. at 5%	**NS**	4.13	4.85
B. Boron			
B_0 : Boron 0 mg / 10 Sft	10.08	65.38	73.02
B_1 : Boron 0.5 mg / 10Sft	11.07	69.22	78.51
B_2 : Boron 1 mg / 10/Sft	**12.63**	**73.48**	**82.98**
S.Em. ±	0.166	1.219	1.430
C.D. at 5%	0.49	3.58	4.20
A x B Interaction	**NS**	**Sig.**	**Sig.**
C.V. %	5.12	6.09	6.34

Table-1 Effect of biostimulants and boron on plant height of *carrot cv. Pusa Kesar*

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Treatment combinations	Plant height (cm)		
	30 DAS	60 DAS	At harvest
A_0B_0	10.10	49.86	59.70
A_0B_1	11.04	58.30	75.01
A_0B_2	12.48	59.15	77.97
A_1B_0	9.98	74.71	77.88
A_1B_1	10.77	74.35	79.03
A_1B_2	12.98	73.78	80.49
A_2B_0	9.71	60.03	76.99
A_2B_1	11.33	63.22	77.94
A_2B_2	12.69	75.65	79.11
A_3B_0	10.51	76.91	77.52
A_3B_1	11.16	81.02	82.07
A3B2	**12.38**	**85.35**	**94.36**
S.Em. ±	0.333	2.438	2.861
C.D. at 5%	**NS**	7.15	8.39
C.V. %	5.12	6.09	6.34

Table-2 Interaction effect of biostimulants and boron on plant height of *carrot cv. Pusa Kesar*

Interaction effect (A x B)

The highest plant height was found with interaction effect of humic acid 1 g / L and boron 1 mg might be due to humic acid is rich source of essential nutrient and boron induce biosynthesis of endogenous hormones which promote plant growth.

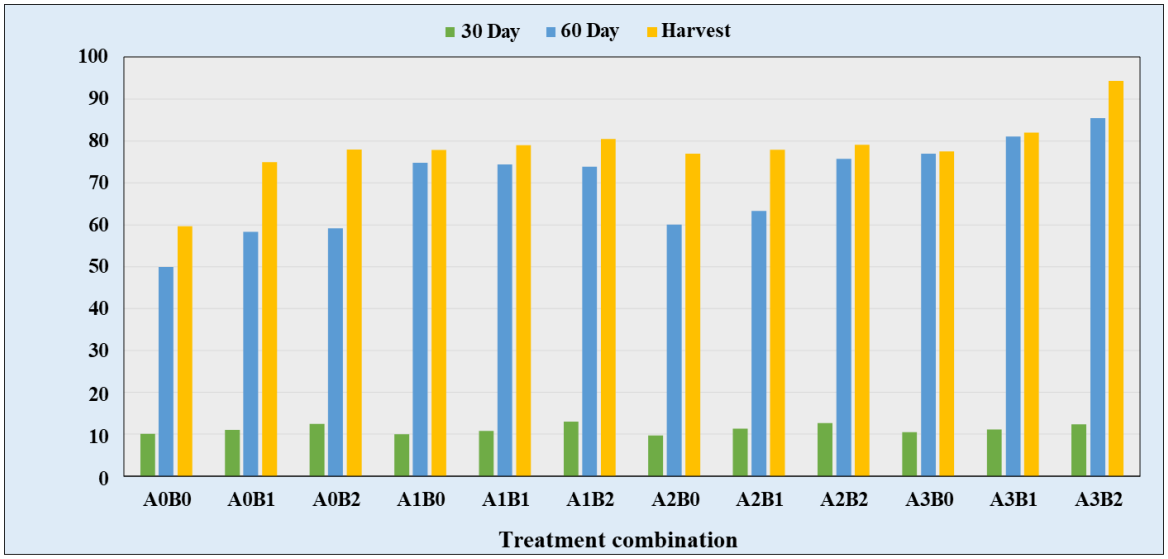

Fig-1 Interaction effect of biostimulants and boron on plant height of *carrot cv.Pusa Kesar*

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Fig -2 Recording Plant height (cm)

Fresh Root Weight (g) and Root Dry Matter (g) at Harvest

The data pertaining to the fresh root weight (g) and root dry matter (g) of carrot as influenced by biostimulants and boron are presented

Effect of biostimulants

The fresh root weight and root dry matter at harvest significantly influenced by pplication of biostimulants. Treatment A3 (Humic acid 1g / L) recorded significantly maximum fresh root weight (131.05 g) and root dry matter (14.59 g). While minimum fresh root weight (96.74 g) and root dry matter (10.45 g) were recorded with treatment A0 (Water spray).

It might be due to humic acid is a rich source of many essential nutrients including, nitrogen, as well as many other nutrients which encourage plant growth (Akinichi *et al*., 2009). Similar results were found with El-Helaly (2018) in carrot, Omar and Ramadan (2018) in carrot.

Effect of boron

The fresh root weight and root dry matter at harvest significantly influenced by application of boron. Treatment B2 (Boron 1 mg / 10sft) recorded significantly maximum fresh root weight (121.56 g) and root dry matter (13.53 g). Fresh root weight was statistically at par with treatment B1 (Boron 0.5 mg / 10sft). While minimum fresh root weight (109.06 g) and root dry matter (11.82 g) were recorded with treatment B0 (Boron 0 mg / 10sft).

Its might be due to promotive effect of boron may be interpreted in terms of manufacturing more carbohydrates and protein along with its role in enhancing the translocation from the site of synthesis to the storage organs (Solanki *et al*. 2018). This results were in accordance with findings of Alam *et al*. (2010) in onion, Noman (2015) and Imkongyapang *et al*. (2018) in carrot.

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Treatments	Fresh root weight (g)	Root dry matter (g)
A. Biostimulants		
A0 :Water spray	96.74	10.45
A1 : Seaweed extract (3 ml / L)	121.40	13.11
A2 : Anubhav bioconsortium (2 ml / L)	113.03	12.23
A3 : Humic acid (1 g / L)	**131.05**	**14.59**
Sem ±	3.035	0.376
C.D. at 5%	8.90	1.11
B. Boron		
B0 : Boron 0 mg / 10sft	109.06	11.82
B1 : Boron 0.5 mg / 10Sft	116.03	12.44
B2 : Boron 1 mg / 10sft	**121.56**	**13.53**
S.Em. ±	2.629	0.326
C.D. at 5%	7.71	0.96
A x B Interaction	**Sig.**	**Sig.**
C.V. %	7.88	8.98

Table-3 Effect of biostimulants and boron on root weight of *carrot cv. Pusa Kesar*

Treatment combinations	Fresh root weight (g)	Root dry matter (g)
A0B0	95.93	10.24
A0B1	96.14	10.41
A0B2	98.14	10.71
A1B0	117.20	12.63
A1B1	115.76	12.78
A1B2	131.24	13.92
A2B0	113.79	12.06
A2B1	115.99	12.45
A2B2	109.29	12.17
A3B0	109.33	12.34
A3B1	136.25	14.13
A3B2	**147.58**	**17.32**
S.Em. ±	5.258	0.652
C.D. at 5%	15.42	1.91
C.V. %	7.88	8.98

Table-4 Interaction effect of biostimulants and boron on root weight of *carrot cv. Pusa Kesar*

Interaction effect

Maximum fresh root weight and root dry matter were found with interaction effect of humic acid 1 g / L and boron 1 mg / 10Sft, might be due to humic acid provide essential nutrients like nitrogen to plant and boron induce synthesis and

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translocation of carbohydrates to root tissue which encourage root growth (Akinichi et al., 2009 and Solanki et al., 2018).

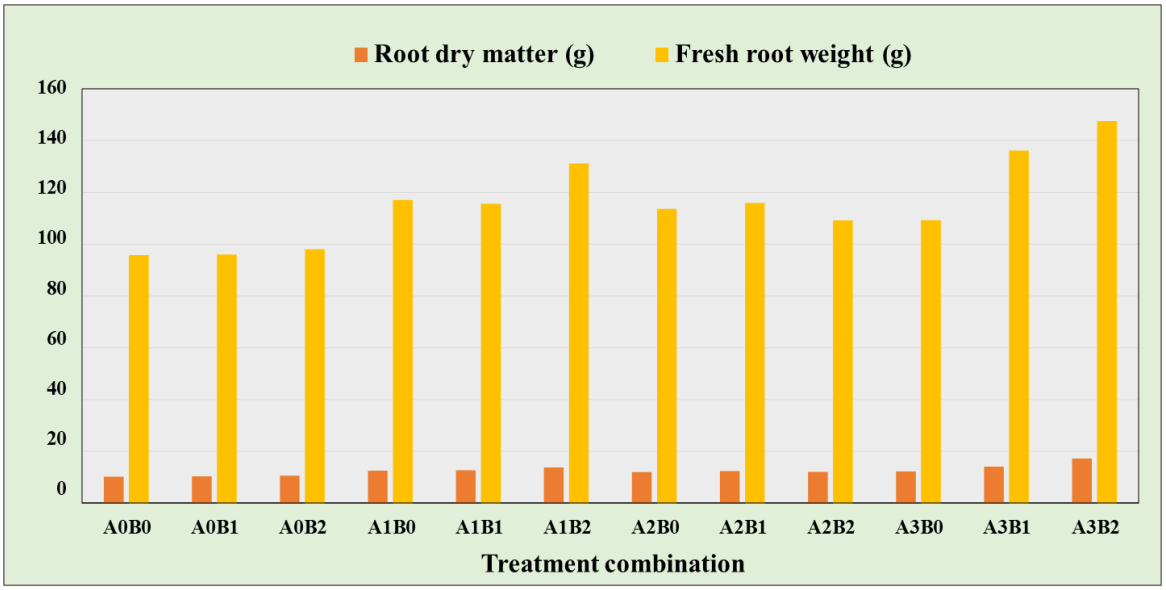

Fig-3 Interaction effect of biostimulants and boron on fresh root weight and root dry matter of *carrot cv. Pusa Kesar*

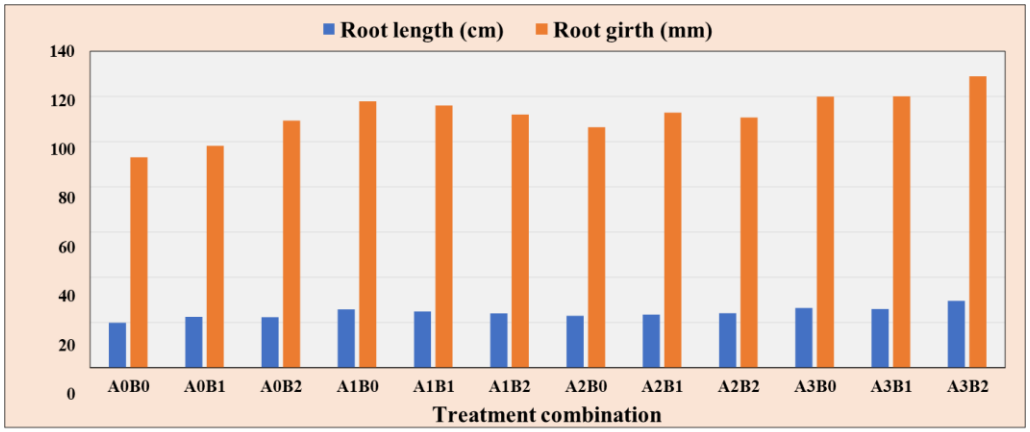

Fig-5 Interaction effect of biostimulants and boron on root length and root girth of *carrot cv. Pusa Kesar*

Interaction effect

Maximum root length and root girth were found with interaction effect of humic acid 1 g / L and boron 1 mg might be due to humic acid stimulate photosynthetic process and boron increase activity of certain enzymes essential for cell division and regulation of potassium calcium ratio in plant which induce root growth (Liu et al., 1998).

Total Sugar (%)

The data pertaining to the total sugar (%) of carrot as influenced by biostimulants and boron presented

Effect of biostimulants

Data from the table with regards to total sugar revealed significant influenced of biostimulants. Treatment A3 (Humic acid 1g / L) recorded significantly maximum total sugar (6.76 %) and it was statistically remained at par with treatment A1 (Seaweed extract 3 ml / L). While minimum total sugar (5.35 %) was noted in treatment A0 (Water spray).

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Significantly highest increase in total sugar was observed in treatment A3 (Humic acid 1g / L) might be due to the humic acid application caused an increase in the content of dry matter, starch, total carbohydrates and elemental values in the tubers tissues (Rajendiran and Tapan, 2015). This results confirmed finding of Mohmoud *et al*. (2018) in potato and Omar and Ramadan (2018) in carrot.

Effect of boron

The total sugar significantly influenced by application of boron. Among the treatments, treatment B2 (Boron 1 mg / 10Sft) recorded significantly maximum total sugar (7.95 %). While minimum total sugar (4.58 %) was recorded with treatment B0 (Boron 0 mg / 10Sft).

The significant increase in the total sugar might be due to soil or foliar application of boron might have increased carbohydrate production through increased rate of photosynthesis. The similar results were reported by Dewdar *et al*. (2015) in sugar beet, Pagar (2018) in carrot and Patel *et al*. (2017) in broccoli.

Treatments	Total sugar (%)
A. Biostimulants	
A0 :Water spray	5.35
A1 : Seaweed extract (3 ml / L)	6.50
A2 : Anubhav bioconsortium (2 ml / L)	5.86
A3 : Humic acid (1 g / L)	**6.76**
Sem ±	0.126
C.D. at 5%	0.37
B. Boron	
B0 : Boron 0 kg / ha	4.58
B1 : Boron 0.5 kg / ha	5.83
B2 : Boron 1 mg / ha	**7.95**
S.Em. ±	0.109
C.D. at 5%	0.32
A x B Interaction	**Sig.**
C.V. %	6.20

Interaction effect

The interaction effect between biostimulants and boron application was found significant on total sugar (%). Treatment A3B2 (Humic acid 1 g / L + Boron 1 mg / 10Sft) recorded significantly maximum total sugar (8.87 %) and it was statistically remained at par with treatment A1B2 (Seaweed extract 3 ml / L + Boron 1 mg / 10Sft). While minimum total sugar (3.52 %) was recorded with treatment A0B0 (Water spray + Boron 0 mg / 10Sft).

Maximum total sugar was found with interaction effect of humic acid 1 g / L and boron 1 mg / 10 Sft might be due to humic acid and boron increase carbohydrates and starch in root tissue by induce in rate of photosynthesis in plant (Rajendiran and Tapan, 2015).

VII. CONCLUSION

Biostimulants reduces the impact of abiotic stress and boosting plant metabolism, they enhance nutrient uptake in plants more effectively. Moreover, biostimulants impact various metabolic, cellular, and physiological processes in plants, including respiration, photosynthetic activity, ion transport, redox reaction, and more. They promote both the quality and yield of crops.Boron (B) is one of eight micronutrients. It is considered as an essential element which has tremendous role in plant growth and development, physiology as well as biochemical composition. There was

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significant effect in the interaction effect of biostimulants and boron on plant height (cm), fresh root weight (g), root dry matter (g), fresh shoot weight (g) and shoot dry matter (g). The interaction effect of biostimulants and boron application was found significant on root length (cm), root girth (mm), root yield per plant (g), There were non-significant effect of biostimulants and Boron on quality parameters viz., carotene content (mg / 100 g).The interaction effect of biostimulants and boron application was found significant on total sugar (%). Climate changes are already affecting plant growth around the world.There are enormous challenges that are compounded by the fact that yields must increase in the coming decades as the planet adds more than 2 billion people.Plant Biostimulants offer a possible solution: a way to maintain yields using fewer resources.Biostimulants continue to raise important questions that require further answers. Much remains to be studied about appropriate application rates, molecular modes of action, not to mention the countless beneficial microbes still unknown to science. But what is clear is that Plant Biostimulants are set to play a key role in building a more sustainable and resilient agriculture .

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