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Effect of biostimulants on growth and quality of broccoli (*Brassica oleracea* var. *italica*) cv. Pusa KTS-1

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Abstract
A field experiment was carried out at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, AAU, Anand, Gujarat, India during *Rabi* 2020-21 on broccoli cv. Pusa KTS-1. The experiment was conducted in Randomized Block Design (RBD) with three replications, including 15 treatments. The results revealed that foliar application of Seaweed extract 3 ml/L + Jeevamrut 3% at 30 and 60 DAT recorded higher values of growth attributes *viz.*, plant height, number of leaves, leaf width, leaf length and leaf area at 60 DAT and at harvest time, respectively, more number of branches per plant at lateral curd harvest and stem diameter at harvest stage. Also, significantly higher values of quality parameters *viz.*, highest protein content and ascorbic acid.

Keywords: Broccoli, Pusa KTS-1, biostimulants, growth, quality

Introduction
Broccoli (*Brassica oleracea* var. *italica*) belongs to the family Brassicaceae is an exotic vegetable crop in India. It is also known as Winter broccoli or Heading broccoli in the USA. It is native to the Mediterranean region and cultivated in Italy. Broccoli like other cole crops prefers a cold climatic condition which helps in the developing quality curds. The word broccoli, derived from the Italian word, refers to the flowering top of a cabbage. Broccoli is classified in the Italica cultivar group of the species *Brassica oleracea*. Broccoli has large flower heads, usually green in colour, and some are purple also, arranged in a tree like structure on branches sprouting from a thick, edible stalk. The mass of flower heads is surrounded by leaves. Broccoli mostly resembles cauliflower, which is a different cultivar group of the same species.
The biostimulants are organic products composed of peptides, amino acids, polysaccharides, peptides, humic acids, and phytohormones etc. for immediate uptake and availability within the plant. Their absorption does not depend on the photosynthetic activity as they are directly absorbed by the plant, resulting in lower energy consumption. The aim of these products is not to supply nutrition, but rather to favour and stimulate the metabolism of the plant, decrease plant stress, etc. They are also claimed to enhance crop growth and yield through a series of widely varying mechanisms including activation of soil microbial activity, and promotion or augmentation of the activities of critical soil enzymes or plant growth hormones. (Parrado *et al.*, 2008) [12].

Seaweed extract: It is used for biostimulant production contain cytokinins and auxins or other hormone-like substances (Hamza & Suggars 2001) [7]. They also contain many active mineral and organic compounds, including complex polysaccharides such as laminarin, fucoidan, alginates and plant hormones that contribute to plant growth.

Humic acid (HA): The main fraction of humic substances (HS) and the most active components of soil and compost organic matter. HA can enhance nutrient availability and improve chemical, biological, and physical soil properties. The direct and indirect beneficial effects of HA on plant growth and development are their effect on cell membranes which lead to the enhanced transport of minerals, improved protein synthesis, plant hormone-like activity, promoted photosynthesis, modified enzyme activities, solubility of micro-elements and macro-elements, reduction of active levels of toxic minerals and increased microbial populations. in addition, HA introduced as good accumulators of toxic heavy metals.

Jeevamrut: It promotes immense biological activity in soil and makes the nutrients available to crop. This liquid manures, beneficial organisms survive and are helpful in phosphate

solubilization, nitrogen fixation etc. Application of this organic liquid formulations will enhance the soil microbial activity and population to a larger extent. Jeevamrut is available in two forms: liquid and solid (Ghan-jeevamrut). It is an excellent source of carbon, nitrogen, phosphorous, potassium and other micronutrient which are mainly use as natural manure in organic farming.

Novel organic liquid nutrients

It is an enriched sap of banana pseudo-stem. It is developed and patented by Navsari Agricultural University under NAIP project in the year of 2012. Banana pseudo stem sap is rich in nutrients and having growth promoting substances, its judicious utilization in crop production enhances crop yield with very less input costs.

Materials and Methods: A field experiment entitled "Effect of biostimulants on growth and quality of broccoli (*Brassica oleracea* var. *italica*) cv. Pusa KTS-1". The research experiment was carried out during *Rabi* 2020-21 at Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. The soil of the experimental site was sandy loam, locally known as "*Goradu*". The soil are alluvial by their nature of origin, very deep, well drained and fairly moisture retentive. Soil respond well to manures and irrigations. The water table is more than 10 m in depth. Hence, there is no problem of high-water table in the area. The experiment was conducted in Randomized Block Design (RBD) with three replications, including following 15 treatments and biostimulants applied as foliar spray at 30 and 60 DAT.

Treatment	Treatments details
T_1	Control (water spray)
T_2	Seaweed extract 3ml/L
T_3	Humic acid 5 ml/L
T_4	Jeevamrut 3%
T_5	Novel biostimulant 10 ml/L
T_6	Seaweed extract 3ml/L + Humic acid 5 ml/L
T_7	Seaweed extract 3 ml/L + Jeevamrut 3%
T_8	Seaweed extract 3 ml/L + Novel biostimulant 10 ml/L
T_9	Humic acid 5 ml/L + Jeevamrut 3%
T_{10}	Humic acid 5 ml/L + Novel biostimulant 10 ml/L
T_{11}	Jeevamrut 3% + Novel biostimulant 10 ml/L
T_{12}	Seaweed extract 3 ml/L + Humic acid 5 ml/L + Jeevamrut 3%
T_{13}	Seaweed extract 3 ml/L + Jeevamrut 3% + Novel biostimulant 10 ml/L
T_{14}	Humic acid 5 ml/L + Jeevamrut 3% + Novel biostimulant 10 ml/L
T_{15}	Seaweed extract 3ml/L + Humic acid 5 ml/L + Jeevamrut 3% + Novel biostimulant 10 ml/L

Observations recorded for different parameters. Plant height was measured in centimetre from ground level to the tip of main leaf with the help of measuring scale, number of leaves, leaf width (cm) and leaf length (cm) with the help of measuring scale, leaf area (cm^2) was measured with the help of leaf area meter at 30, 60 DAT and at harvest time, number of branches per plant at main curd and lateral curd harvest and stem diameter (mm) with the help of vernier callipers at harvest time for each treatment and mean values were worked out. The protein content was estimated as per the procedure outlined by Johan Kjeldahl (Piper, 1943) [13] and ascorbic acid content in the juice was determined titrametrically using 2, 6-dichlorophenol indophenol dye described by Ranganna (1986) [14].

Result and Discussion

Growth attributes: Growth attributes *viz.*, plant height (cm), number of leaves, leaf width (cm), leaf length (cm) and leaf area (cm^2) at 60 DAT and at harvest time, number of branches per plant at lateral curd harvest and stem diameter (mm) were significantly influenced by foliar application of biostimulants. Whereas plant height, number of leaves, leaf width, leaf length and leaf area at 30 DAT and number of branches per plant at main curd harvest were found non-significant.

Foliar application of Seaweed extract 3 ml/L + Jeevamrut 3% recorded maximum plant height (72.95 and 74.24 cm), maximum number of leaves per plant (20.73 and 21.01), maximum leaf width (23.92 and 24.24 cm), leaf length (30.00 and 30.24 cm), leaf area (674.61 and 692.68 cm^2) at 60 DAT and at harvest time respectively, more number of branches per plant at lateral curd harvest (9.80) and maximum stem diameter (47.38 mm) at harvest stage.

Table 1: Effect of biostimulants on growth attributes of broccoli cv. Pusa KTS-1

Treatments	Plant height (cm)			Number of leaves			Number of branches		Stem diameter (mm)
	30 DAT	60 DAT	At harvest time	30 DAT	60 DAT	At harvest time	At main curd harvest	At lateral curd harvest	
T_1	24.07	63.59	64.64	7.80	17.60	17.80	3.15	8.20	33.54
T_2	25.53	69.34	71.19	8.20	19.66	19.86	3.14	8.73	42.70
T_3	26.28	70.00	71.80	8.26	19.80	20.06	3.13	8.60	43.98
T_4	24.70	72.51	73.06	8.26	20.40	20.45	2.97	9.33	46.06
T_5	27.60	70.38	72.07	8.40	19.86	20.19	2.95	9.06	43.98
T_6	24.50	66.87	68.00	7.80	18.60	19.33	2.94	8.46	38.62
T_7	27.93	72.95	74.24	8.20	20.73	21.01	2.98	9.80	47.38
T_8	26.80	65.93	67.46	7.73	18.53	19.26	2.96	8.93	36.58

T_9	28.11	66.17	67.95	7.93	18.60	19.26	3.01	8.60	37.07
T_{10}	25.93	64.89	65.89	8.46	18.46	19.00	2.97	8.86	35.16
T_{11}	26.53	70.95	72.80	8.06	20.13	20.33	3.14	9.40	45.58
T_{12}	25.05	67.86	69.27	7.93	18.93	19.52	2.95	8.66	40.68
T_{13}	25.93	68.53	70.46	8.13	19.06	19.59	3.13	8.73	41.37
T_{14}	26.00	67.29	68.08	8.26	18.66	19.46	3.15	8.66	39.77
T_{15}	24.50	64.24	65.31	7.73	17.73	18.54	2.92	8.26	34.24
S.Em.±	1.27	1.60	1.62	0.36	0.54	0.47	0.08	0.21	1.16
C.D. at 5%	NS	4.63	4.70	NS	1.57	1.37	NS	0.62	3.35
C.V.%	8.44	4.06	4.05	7.74	4.91	4.18	4.31	4.20	4.95

Table 2: Effect of biostimulants on growth attributes of broccoli cv. Pusa KTS-1

Treatments	Leaf width (cm)			Leaf length (cm)			Leaf area (cm^2)		
	30 DAT	60 DAT	At harvest time	30 DAT	60 DAT	At harvest time	30 DAT	60 DAT	At harvest time
T_1	12.23	19.63	20.21	14.18	25.72	25.78	116.89	471.49	541.87
T_2	13.01	21.16	21.98	14.31	28.47	28.56	130.94	608.91	625.74
T_3	12.64	21.31	22.08	14.53	28.66	28.58	127.94	616.90	630.72
T_4	12.90	22.71	23.46	15.66	29.03	29.38	130.68	653.27	665.06
T_5	13.22	21.74	22.34	16.35	28.80	28.77	143.38	629.48	641.24
T_6	13.47	20.62	21.23	14.98	27.10	27.36	128.42	580.24	620.89
T_7	13.19	22.76	23.54	16.20	30.00	30.24	139.59	674.61	692.68
T_8	13.11	20.16	21.03	15.51	26.69	27.04	126.59	571.88	599.43
T_9	12.69	20.45	21.06	15.68	26.70	27.08	130.14	578.22	616.69
T_{10}	12.96	20.10	20.68	15.12	26.34	26.66	125.74	556.22	598.17
T_{11}	12.68	22.38	22.93	14.39	28.84	29.02	129.08	641.36	650.86
T_{12}	13.04	21.05	21.70	15.68	27.82	28.06	125.89	601.04	621.71
T_{13}	13.35	21.08	21.70	14.79	28.10	28.39	125.51	603.75	624.99
T_{14}	13.57	21.00	21.58	15.24	27.77	27.69	130.05	584.21	621.19
T_{15}	12.87	19.74	20.32	14.40	26.06	26.40	128.16	552.03	586.15
S.Em.±	0.33	0.56	0.56	0.50	0.65	0.70	4.56	24.05	21.61
C.D. at 5%	NS	1.60	1.59	NS	1.89	2.03	NS	69.67	62.59
C.V.%	4.40	4.55	4.40	5.75	4.07	4.34	6.11	7.00	6.01

Increase in plant height, number of leaves, leaf area and number of branches by the application of seaweed extract might be due to seaweed extract improved root system could be influenced by endogenous auxins as well as other compounds in the extracts and it also improves nutrient uptake by roots resulting in root systems with improved water and nutrient efficiency and stimulate the division of cells and their extension, and their role in the balance of biological processes within the plant tissues, thereby causing enhanced plant height and vigour. Wajahatullah *et al.* (2009) [16]. Similar, results were also reported by Crouch *et al*., (1992) [4], Al Bermani (2017) [1], Manea *et al.* (2018) [10] in broccoli.

The beneficial effects of Jeevamrut were attributed to higher microbial load and growth hormones which might have enhanced the soil biomass thereby sustaining the availability and uptake of applied as well as native soil nutrients which ultimately resulted in better growth of crops. Similar results were found by Palekar (2006) [11], Vasanthkumar (2006) [15] and Devakumar *et al*. (2008) [6].

Quality parameters

Seaweed extract 3 ml/L + Jeevamrut 3% recorded highest protein content (4094.68 mg/100g) and ascorbic acid (41.49 mg/100g).

The increase in the protein content by the foliar application of seaweed extract might be due to promotive effects on root proliferation and higher uptake of N, P and sulphur needed for protein synthesis. Similar results reported by Anantharaj and Venkatesalu (2001) [2] in *Vigna catajung*. Also, protein content is increase with application of jeevamrut due to higher nitrogen content in plant (Desai *et al*., 2014) [5].

A foliar application of seaweed extract and jeevamrut increase in ascorbic acid might be due to presence of microelements and plant growth regulators especially cytokinin present in seaweed extract. it helps to increase the enzymatic activity of plants due to application of seaweed extract and jeevamrut. Similar results reported by Khemnar and Chaugule (2000) [9] in *Trigonella foenum-graecum* and Beckett (1994) [3] in beans.

Table 3: Effect of biostimulants on protein content and ascorbic acid of broccoli cv. Pusa KTS^{-1}

Treatments	Protein content (mg/100 g)	Ascorbic acid (mg/100 g)
T_1	2932.22	31.12
T_2	3764.89	36.19
T_3	3584.33	32.69
T_4	3925.78	39.14
T_5	3873.55	38.21
T_6	3467.18	31.51
T_7	4094.68	41.49
T_8	3825.62	37.54
T_9	3623.20	32.89
T_{10}	3795.87	36.55
T_{11}	3984.80	39.73
T_{12}	3675.07	34.22
T_{13}	3714.80	34.46
T_{14}	3636.09	33.50
T_{15}	3042.93	31.45
S.Em.±	86.22	1.01
C.D. at 5%	249.73	2.93
C.V.%	4.08	4.96

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