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Studies on effect of biofertilizers in combination with inorganic nutrients on growth parameters of sprouting broccoli (*Brassica oleracea* var. *italica* L.)

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Abstract
The present investigation was conducted to study the "effect of biofertilizers in combination with inorganic nutrients on growth parameters of sprouting broccoli (*Brassica oleracea* var. *italica* L.)" was conducted during *rabi*, 2017 at College of Horticulture, Venkataramannagudem, West Godavari District, Andhra Pradesh. The experiment was laid out in a randomized block design with three replications comprising fourteen treatments. The results indicated that there was a significant differences among the fourteen treatments and treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) was recorded the maximum plant height (cm), plant spread (cm^2), stalk length (cm), number of leaves and leaf area (cm^2) at all stages of growth. The growth parameters like number of days taken for head initiation and number of days taken for head maturity were minimum in T_4 (100% RDF+ *Azotobacter* + PSB + KSB).

Keywords: Biofertilizers, sprouting broccoli, plant height, plant spread, stalk length, number of leaves, leaf area, number of days taken for head initiation, head maturity

Introduction
Broccoli (*Brassica oleracea* var. *italica* L.) with chromosome number 2n=18 belongs to cruciferous family. The name broccoli has been derived from Italian word 'brocco' means shoot and the word sprouting broccoli refers to development of young flower bud which have been used as vegetable. Broccoli has good organoleptic properties and is a very delicious vegetable. It contains high protein (3.3%), vitamin C (137 mg/100g), vitamin A (3500 IU), vitamin B_2 (0.12 mg/100g), Iron (205 mg/100g) and Calcium (0.80 mg/100g). Cancer Research Centre of USA indicated that broccoli has several anti-cancerogenic properties due to the presence of sulforaphane (Damato *et al*., 1994) [2].

Material and methods
The present investigation entitled "Effect of biofertilizers in combination with inorganic nutrients on growth, yield and quality of sprouting broccoli (*Brassica oleracea* var. *italica* L.)" was conducted during *rabi*, 2017 at College of Horticulture, Venkataramannagudem, West Godavari District, Andhra Pradesh. The soil is of red sandy loam with good drainage and moderate water holding capacity. The physical composition of soil was sand 70%, silt 20% and clay 10% and the chemical composition of soil was soil p^H 6.96, E.C. 0.24 dS m^{-1}, Organic Carbon 0.34%, available nitrogen 136.26 kg/ha, available phosphorus 38.74 kg/ha and available potassium 166.22 kg/ha**.** The experiment was carried out on Pusa KTS-1 of sprouting broccoli. The experiment was laid out in a randomized block design with three replications comprising fourteen treatments. The experimental area was prepared by ploughing once with a mould board plough followed by two harrowing and divided into plots of 3m x 3m. The seedlings of thirty five days old and a height of 15 cm with three to four leaves were transplanted in the experimental field during second week of November, 2017. At the time of final field preparation, farm yard manure @ 20 t/ha was applied to the soil as a basal dose as per the recommendation. Biofertilizers such as *Azotobacter*, PSB (Phosphorous Solubilizing Bacteria) and KSB (Potassium Solubilizing Bacteria) were thoroughly mixed with FYM for rapid multiplication under shade, prior to application in main field. They were applied as basal dressing (5 kg/ha). Both organic and inorganic fertilizers were applied on treatment basis. Irrigation and other intercultural operations were done when necessary. The effect of biofertilizers in combination with inorganic nutrients on growth parameters was observed.

The data was recorded on five randomly selected plants from each treatment and each replication on various growth parameters like plant height, plant spread, stalk length, number of leaves, leaf area, number of days taken for head initiation, number of days taken for head maturity and number of days taken from head initiation to head maturity and subjected to statistical analysis as per the method suggested by Panse and Sukhatame (1967).

Results and discussion

The results obtained from the present investigation are presented in the Table 1. The treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) was recorded the maximum plant height 19.00 cm, 40.01 cm and 58.03 cm at 30 DAP, 60 DAP and final harvest respectively. The increase in the plant height in treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) is due to the combined effect of inorganic fertilizers with biofertilizers which lead to the decomposition of organic matter by microbial inoculants and thus releasing the available nutrients to the plants from the soil and additionally, the application of inorganic fertilizers resulted in ultimate increase in height of the plant. It may also be due to the cell elongation by the presence of nitrogenous compounds. Nitrogen being a constituent of amino acids, nucleotides, nucleic acids, a number of co-enzymes, auxins, cytokinins and alkaloids induces cell elongation, cell enlargement and cell division. These findings are in accordance with work done by Srichandan *et al.* (2015) [11], Singh *et al.* (2016) [10], Goutam and Biradar (2017) [3], Kumar *et al.* (2017) [6] in broccoli and Kumar *et al.* (2018) [5] in knol-khol. The treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) recorded maximum plant spread 2630.42 cm^2, 3139.24 cm^2 and 3529.79 cm^2 at 30 DAP, 60 DAP and final harvest respectively. The accelerated plant spread in treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) is due to combined effect of biofertilizers, which made the unavailable form of nutrients to available form at critical stages of plant growth, along with the application of inorganic fertilizers resulted in luxuriant growth of the plant. The integration of organic manures or bio-inoculants might have supplemented the cause with their ability to increase the photosynthetic capacity and secretion of beneficial growth promoting substances like IAA, GA, kinetin, riboflavin and thiamine, which can result in better plant growth. These findings are in line with Bhagavantagoudra and Rokhade (2001) [1] in cabbage, Yadav *et al.* (2012) [13], Kumar *et al.* (2013) [7], Tekasangla *et al.* (2015) [12] in cauliflower and Singh *et al* (2016) [10], Goutam and Biradar (2017) [3] in broccoli. The treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) was recorded the maximum stalk length (10.00 cm) at final harvest. It might be due to the cell elongation by the presence of nitrogenous compounds. Nitrogen being a constituent of amino acids, nucleotides, nucleic acids, a number of co-enzymes, auxins, cytokinins and alkaloids induces cell elongation, cell enlargement and cell division. These findings are in line with Kumar *et al.* (2013) [7] and Tekasangla *et al.* (2015) [12] in cauliflower and Goutam and Biradar (2017) [3] in broccoli. The treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) recorded maximum no. of leaves per plant 11.06, 16.21 and 23.01 at 30 DAP, 60 DAP and final harvest respectively. The increase in number of leaves might be due to the combined effect of biofertilizers and inorganic fertilizers which resulted in higher absorption of nutrients enhanced the cell division, cell elongation and thus concomitant increase in metabolic activity (Torrey, 1950). These findings are in line with Mohapatra *et al.* (2013) [8], Hanaa *et al.* (2016) [4], Singh *et al.* (2016) [10], Goutam and Biradar (2017) [3], Kumar *et al.* (2017) [6] in broccoli who found accelerated increase in leaf area with application of combination of bioinoculants and inorganic fertilizers. The treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) recorded maximum leaf area 381.97 cm^2, 446.33 cm^2 and 478.52 cm^2 at 30 DAP, 60 DAP and final harvest respectively. The increase in leaf area might be due to increase in leaf length and leaf width with the beneficial effect of biofertilizers and inorganic fertilizers as they accelerated rate of photosynthesis thereby enhancing the vegetative growth. These findings are in line with Mohapatra *et al.* (2013) [8], Srichandan *et al.* (2015) [11] and Singh *et al.* (2016) [10] in broccoli. The treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) took minimum days (58.03 days and 70.05 days) for head initiation and head maturity respectively. This could be due to better availability, solubility, mobility and utilization of plant nutrients resulted in enhanced plant growth and head prodcution. These findings are in line with Singh *et al* (2016) [10], Goutam and Biradar (2017) [3] in broccoli and Kumar (2018) [5] in knol-khol.

Table 1: Effect of biofertilizers in combination with inorganic nutrients on growth parameters in sprouting broccoli (*Brassica oleracea* var. *italica* L.)

T. No	Treatments	Plant height (cm) at			Plant spread (cm^2) at			Stalk length (cm) at Final harvest	No. of leaves at			Leaf area at (cm^2)			No. of days taken for head initiation	No. of days taken for head maturity	Days for head initiation to head maturity
		30 DAP	60 DAP	Final harvest	30 DAP	60 DAP	Final harvest		30 DAP	60 DAP	Final harvest	30 DAP	60 DAP	Final harvest			
T_1	100% RDF + *Azotobacter*	17.64	36.33	55.05	2,511.64	2,988.65	3,422.57	9.10	10.64	15.80	22.47	365.81	429.87	455.16	59.86	71.67	11.81
T_2	100% RDF + PSB	17.96	36.94	55.41	2,478.47	2,890.32	3,383.41	9.40	9.96	15.27	21.85	347.87	406.94	429.62	60.25	72.01	11.76
T_3	100%RDF + KSB	17.29	35.26	54.27	2,420.12	2,810.49	3,336.97	8.80	9.50	15.06	21.29	324.39	384.98	407.15	60.48	72.49	12.01
T_4	100% RDF + *Azotobacter* + PSB + KSB	19.00	40.01	58.03	2,630.42	3,139.24	3,529.79	10.00	11.06	16.21	23.01	381.97	446.33	478.52	58.03	70.05	12.02
T_5	75% RDF + *Azotobacter*	16.21	32.74	51.12	2,289.85	2,601.09	3,123.08	7.60	8.49	14.52	20.42	284.62	347.63	377.13	61.85	73.56	11.71
T_6	75% RDF + PSB	16.42	33.83	52.07	2,271.25	2,572.92	3,073.67	7.80	8.29	14.37	19.84	273.88	339.10	366.43	61.41	74.89	13.48
T_7	75% RDF + KSB	15.76	32.31	50.09	2,107.09	2,514.39	3,010.71	7.50	7.86	13.70	19.47	264.37	320.46	351.17	62.34	74.21	11.87
T_8	75% RDF + *Azotobacter* + PSB + KSB	18.00	38.00	56.47	2,593.17	3,009.10	3,488.65	9.60	10.87	15.96	22.93	372.23	436.48	467.65	59.26	71.12	11.86
T_9	50% RDF + *Azotobacter*	14.53	31.29	46.13	2,084.19	2,492.61	2,941.29	7.20	7.65	13.39	19.23	244.79	305.13	336.88	62.71	74.55	11.84
T_{10}	50% RDF + PSB	15.42	31.65	48.47	1,931.71	2,421.77	2,874.93	7.40	7.27	13.13	18.79	219.01	281.71	303.37	63.16	75.22	12.06
T_{11}	50% RDF + KSB	14.47	30.01	45.33	1,865.87	2,378.22	2,795.77	7.10	7.04	12.97	18.12	209.37	267.90	289.12	63.81	76.41	12.60
T_{12}	50% RDF + *Azotobacter* + PSB + KSB	16.40	34.21	52.72	2,306.91	2,667.93	3,193.64	7.90	8.65	14.65	20.62	293.86	353.01	385.14	61.03	73.19	12.16
T_{13}	*Azotobacter* + PSB + KRB	13.21	29.00	42.24	1,721.06	2,265.17	2,660.17	6.90	6.97	12.48	17.59	182.54	246.72	277.83	64.63	77.89	13.26
T_{14}	100% RDF (100:60:40 NPK kg ha^{-1})	16.88	34.85	53.25	2,346.45	2,785.75	3,280.40	8.30	8.72	14.86	20.79	305.84	364.64	397.19	60.96	72.93	11.97
	S Em ±	0.588	1.046	1.714	35.925	37.734	43.987	0.243	0.355	0.507	0.638	13.604	17.507	23.180	0.911	0.966	1.242
	CD at 5%	1.719	3.058	5.011	105.01	110.298	128.577	0.710	1.039	1.483	1.864	39.764	51.175	67.756	2.663	2.822	NS

Conclusion

From the above study, it was concluded that, among the different treatment combinations, treatment T_4 (100% RDF+ *Azotobacter* + PSB + KSB) was superior in growth parameters like plant height, plant spread, stalk length, number of leaves, leaf area, number of days taken for head initiation and number of days taken for head maturity is due to the combined effect of biofertilizers and inorganic fertilizers.

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