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Response of growth, yield and quality traits in sprouting broccoli (*Brassica oleracea* var. *italica*) to varying fertilizer doses and method of application

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Abstract
A field experiment was conducted on sprouting broccoli (*Brassica oleracea* var. *italica*) to study the growth yield and quality parameters in response to different fertilizer doses, type of fertilizer and method of application under Bengaluru conditions. The results indicated that earliness parameters were not affected significantly due to the varying treatments. The maximum plant height observed was 83.60 cm (T_8) statistically on par with T_9 i.e. 81.79 cm. Maximum number of leaves per plant (18.86) and stalk length (19.66 cm) was seen in T_9. Maximum leaf area (1940.01 cm^2) and Leaf area index (LAI) of 24.55 was observed in T_8. The maximum head weight (254.24 g), plot yield (5.97 kg), yield per hectare (7.62t) and the highest value of TSS (9.56 °Brix) was recorded withT_9. The highest values for all the traits studied were obtained with higher doses of fertilizers applied along with irrigation water. Application through conventional fertilizers and water soluble fertilizers were found to be equally good for yield parameters under same dose treatments.

Keywords: Broccoli, *Brassica oleracea* var. *italica*, fertigation, fertilizer doses, head compactness, TSS

Introduction
Sprouting broccoli (*Brassica oleracea* var. *italica*) is one of the important cool season vegetable crop sbelonging to Brassicacae family. It is a high value exotic vegetable, cultivated for its tender flowering head and the secondary heads i.e. spears. It was introduced in India1986 (Kalia *et al*., 2005) [1] and gained popularity in metropolitan cities, reputed hotels and restaurants (Maurya *et al*., 2008) [2]. Generally, it can be classified into three distinct group *viz*., white, purple and green, out of which green type is highly nutritious (Yoldas *et al*., 2008) [3]. Broccoli is rich source of vitamins, minerals and essential amino acids, also contains the compound glucoraphanin which have anticancerous properties (Swarup, 2012) [4]. It is one of the most nutritious cole crops and contains vitamin A (130 times and 22 times higher than cauliflower and cabbage, respectively), thiamin, riboflavin, niacin, vitamin C and minerals like Ca, P, K and Fe (Sanwal and Yadav, 2005) [5]. It has a very powerful anti-cancer compound, glucosinolate, which provides protection against bowl cancer. It is a native of the coastal areas of Mediterranean Sea from where this crop spread to Europe and other parts of the world. Cultivation of sprouting broccoli started only in the beginning of 19th century (Thamburaj and Singh, 2001) [6]. It is a cool season crop resistant to mild frost. The temperature of 20-25 ^{0}C is optimum for the proper growth, while 15-20 ^{0}C is for head formation. Fertigation technique involves application of fertilizers to the plants through the irrigation system. Fertigation is considered eco-friendly as it avoids the leaching of nutrients and can result in fertilizer savings in the range of 25 to 50 per cent, thereby improving the water and fertilizer use efficiency and in turn, improving the benefit cost ratio in the long term.

Materials and Methods
The experiment was carried out during *Rabi* season 2018-2019 at the Department of Vegetable Science, College of Horticulture, University of Horticultural Sciences, GKVK Campus,

Bengaluru. The experiment was laid out in Randomized Block Design with nine treatments (Table 1) and three replications. Broccoli cv. Palam Samridhi was taken for this experiment. Nitrogen, phosphorous and potassium were applied in the form of Urea, Di-ammonium Phosphate and Muriate of Potash and/or WSF. The crop was raised with a spacing of 60 cm × 45 cm and plot size of 5.4 m x 1.6 m. Data for different traits was recorded on five randomly selected plants in each plot and averaged. Volume of head was recorded by measuring the displaced water which was obtained by dipping the broccoli head in a measuring cylinder. Total chlorophyll content was determined by DMSO method for which 100mg of freshly harvested and clean leaf sample was taken and cut in to small pieces. Leaf samples were transferred to a test tube containing 7 ml DMSO. The test tube was heated at 65ºC for 30-40 minutes in water bath. After incubation the leaf sample was discarded and volume was made to 10 ml with DMSO. Recorded the optical density or absorbance @ 654 and 663 nm, and DMSO was used as blank. Chlorophyll levels in the hexane extracts were calculated using the formula.

$$\text{Chlorophyll} = 12.7(\text{A633}) - 2.69(\text{A645}) \times \frac{10}{100 \times 0.1 \times 1}$$

The data obtained from the experiment was subjected to statistical analysis of RCBD as described by Panse and Sukhatme (1985) [7].

Table 1: Treatment details

Treatment	Details
T_1	75:45:30 kg NPK ha^{-1} soil application using conventional fertilizer (CF)
T_2	75:45:30 kg NPK ha^{-1} through drip irrigation in six equal splits at weekly intervals using CF
T_3	75:45:30 kg NPK ha^{-1} through drip irrigation in six equal splits at weekly intervals using WSF
T_4	100:60:40 kg NPK ha^{-1} soil application using CF
T_5	100:60:40 kg NPK ha^{-1} through drip irrigation in six equal splits at weekly intervals using CF
T_6	100:60:40 kg NPK ha^{-1} through drip irrigation in six equal splits at weekly intervals using WSF
T_7	125:75:50 kg NPK ha^{-1} soil application using CF
T_8	125:75:50 kg NPK ha^{-1} through drip irrigation in six equal splits at weekly intervals using CF
T_9	125:75:50 kg NPK ha^{-1} through drip irrigation in six equal splits at weekly intervals using WSF

Results and Discussion

The mean plant height of broccoli at harvest time in the experiment varied from 68.00 cm (T1) to maximum 83.60 cm (T8) which was found statistically on par with T9 (81.40 cm). Highest number of leaves (18.66) and stalk length (19.66 cm) was observed in T9. Highest values of leaf area (1940.01 cm^2) and leaf area index (24.55) were found in T8 followed by T9 (1803.97 cm^2 and 22.14, respectively) as evident from Table 2.

Significant differences between different treatments were not observed for earliness parameters *viz*., days taken to first head initiation, 50% head initiation and 50% head maturity, as the values of these traits were found to be statistically on par. Similar observations have been made in cabbage (Nikzad *et al*., 2020) [8].

The average head volume varied from 58.66 cc in T1 to 88.98 cc in T9 and 88.97 cc in T8, T9 and T8 statistically being equal for this trait. Maximum head weight was recorded in T9 (254.24g) which was again found on par with T8 (248.06g). Maximum number of spears/plant were harvested in T9 (36.0), however, no significant differences were seen for weight of spears harvested from different treatments (Table 3). Treatments T8 and T9 were found to highest yielding and statistically on par with each other. Yield per plant, plot yield and yield per hectare was observed as 0.27 kg, 5.48 kg and 6.98 t/ha respectively in T8 and 0.26 kg, 5.94 kg and 7.62 t/ ha, respectively in T9. The TSS varied from 6.27 ^{0}Brix (T1) to 9.56 ^{0}Brix in T9. The results obtained are in consonance with the reports of El-Helaly (2012) [9], Hegazi and AL Sodon (2001) [10], Verma and Yadav (2011) [11], Maurya *et al.* (2008) [2] and Yoldas *et al.* (2008) [3].

The results indicated that for almost all the traits, the values increased with the increasing doses of fertilizers, though no significant differences were observed between the treatments for head compactness and total chlorophyll.

As explained by earlier workers, nitrogen application helps in the translocation of photosynthates in storage organ of head resulting in increased weight of head, plot yield and yield per hectare. The beneficial influence of phosphorus in early stages of growth may be explained by early stimulation of scanty root system through efficient translocation of certain growth stimulating compounds formed on account of protoplasmic activity in phosphorus fed plants, which enhanced absorption of nitrogen and other nutrients and their utilization. The increase in yield attributes and yield due to potassium application may be due to its functional role in higher net photosynthetic activity as it stimulates weight of head, total head yield and biological yield. Adequate nutrient supply causes denser rooting system, which results into improvement in yield attributing characters and yield (Wyatt *et al.*, 1989 and Yang and Guan, 1995) [12, 13].

During this experiment the source of the nutrients, either conventional fertilizers or water soluble fertilizers (WSF) were not found to affect the values of various traits as evident from statistically on par values of T8 and T9. As future line of work, further higher doses of fertilizers may be studied to observe their effect on earliness and quality parameters.

Table 2: Effect of different fertilizer levels and method of application on growth and earliness traits in sprouting broccoli

Tr. No	Plant height (cm) at harvest	Number of leaves per plant at harvest	Stalk length (cm) at harvest	Leaf area (cm^2)	Leaf area index	First initiation of heads	50% heads initiation	50% heads maturity
T_1	68.00	15.43	15.00	1,557.29	22.78	52.00	58.00	65.00
T_2	72.40	17.13	14.93	1,634.42	22.79	52.66	59.33	63.66
T_3	75.80	17.46	16.20	1,643.92	23.273	51.66	58.33	65.00
T_4	77.00	16.66	15.80	1,563.44	20.11	52.66	58.33	63.33
T_5	81.79	16.00	15.53	1,480.93	18.85	51.33	58.00	62.66
T_6	77.40	17.80	16.60	1,503.22	19.32	51.00	58.66	63.00
T_7	77.40	17.80	16.13	1,717.58	22.72	53.00	59.00	64.33
T_8	83.60	17.93	17.46	1,940.01	24.55	51.33	58.33	64.00
T_9	81.40	18.86	19.66	1,803.97	22.14	51.00	58.66	63.66
Mean	77.19	17.23	16.37	1,649.42	21.83	51.85	58.51	63.85
S.Em±	1.50	0.39	0.29	13.34	0.35	1.23	0.61	0.64
CD at 5%	4.55	1.19	0.90	40.34	1.06	NS	NS	NS
CV	3.37	3.96	3.15	1.40	2.78	4.13	1.80	1.74

Table 3: Effect of different fertilizer levels and method of application on yield parameters and quality traits in sprouting broccoli

Tr. No	Head volume (cc)	Head weight (g)	Number of spears Per plant	Weight of spears (g)	Yield			TSS (°Brix)	Head compactness	Total chlorophyll (mg/g)
					Yield per plant (kg)	Plot yield (kg)	Yield per hectare (t)			
T_1	58.66	217.72	3.20	19.21	0.21	4.14	5.28	6.27	15.4	1.76
T_2	64.70	219.82	3.20	19.67	0.23	4.56	5.81	6.46	14.00	1.95
T_3	65.84	222.47	3.26	19.16	0.22	4.44	5.66	6.72	16.20	2.23
T_4	66.40	226.69	3.40	19.22	0.22	5.22	6.66	6.88	20.46	1.95
T_5	70.89	237.37	3.26	19.25	0.25	5.19	6.62	6.98	17.86	2.16
T_6	78.88	221.16	3.33	19.42	0.23	4.98	6.35	7.20	17.40	2.06
T_7	82.78	212.21	3.13	19.18	0.23	4.63	5.90	7.42	17.53	2.00
T_8	88.97	248.06	3.20	22.33	0.27	5.48	6.98	8.69	20.46	2.02
T_9	88.98	254.24	3.60	21.27	0.26	5.97	7.62	9.56	19.06	2.12
Mean	74.01	228.86	3.28	19.86	0.24	4.96	6.32	7.35	17.60	2.03
S.Em±	1.07	5.31	0.03	1.17	0.01	0.26	0.33	0.13	1.67	0.13
CD at 5%	3.24	16.06	0.11	NS	0.02	0.79	1.01	0.39	NS	NS
CV	2.51	4.02	1.99	10.23	6.83	9.17	9.18	3.09	16.49	11.21

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