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Effect of mulching and bio-fertilizers on quality characteristics of sprouting Broccoli (*Brassica oleracea var. italica* L.)

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Abstract
The field experiment was conducted at the Horticulture Farm, S.K.N. College of Agriculture, Jobner, Jaipur, Rajasthan during Rabi season 2016-17. The experiment was laid out in Randomized Block Design (RBD) with three replication and experiment comprised of 16 treatment combinations with four levels of each mulching (Control, Mustard straw, Saw dust and Black polythene sheet) and bio-fertilizers (Control, PSB, *Azotobacter* and PSB + *Azotobacter*). The maximum values for all this quality attributes viz. TSS (9.10 %), Vitamin C (81.00 mg/100 g), Nitrogen (0.35 %) and Crude protein (2.21 %) found significantly superior in black polythene mulch treatment. These quality attributes were found at par in mustard straw and minimum in control. The application of PSB + *Azotobacter* resulted in the maximum and significantly more values of quality attributes viz., TSS (9.35 %), Vitamin C (79.55 mg/100 g), Nitrogen (0.37 %) and Crude protein (2.33 %). These quality attributes were found at par in *Azotobacter*, and minimum in control. It is recommended for quality attributes of sprouting broccoli under Semi-arid zone of Rajasthan.

Keywords: Broccoli, *Azotobacter*, Black polythene, Quality, TSS and Crude Protein

1. Introduction
Sprouting broccoli (*Brassica oleracea* var. *italica* L.) is an important cole crop belongs to the family cruciferae. The native place of broccoli is Italy. The United States is the largest producer of sprouting broccoli followed by India. In Italy, it has been used as vegetable from early times but their economic importance becomes appreciable only since the thirties of the century when this vegetable become popular in U.S.A. It is a winter season vegetable and commonly known as *Hari gobhi*, In India morphologically, sprouting broccoli resembles cauliflower except secondary heads which develops in the axils of leaves and may contribute up to 50 per cent of the total yield. There are three types of broccoli, depending on the colour *viz*., green, white and purple. Among the cole crops, the sprouting broccoli is highly nutritious as compared to others. It contains carbohydrates (5.5 %), protein (3.3 %), vitamin-A (3500 IU), vitamin-C (137 mg), vitamin-B_1 (0.05 mg), vitamin-B_2 (0.12 mg), calcium (0.80 mg) and phosphorus (0.79 mg). Broccoli has 4.0, 2.5 and 2.0 times more riboflavin, calcium and ascorbic acid content respectively as compared to cauliflower (Hazra and Som, 1999)[4]. It is also rich source of sulphoraphane. The bioavailability of β-carotene is 22 per cent in combination of fatty foods with carotenoid rich vegetables that enhance the carotenoids uptake. Carotenoids are powerful antioxidants that may reduce the incidence of cancer and coronary heart disease. Broccoli is used as curries, soups, and pickles and also eaten as salad and cooked as sole or mixed vegetable with potato (Thamburaj and Singh, 2001) [17]. Bio-fertilizers include a range of nitrogen fixers, *viz*., *Rhizobium*, *Azotobacter*, *Azospirillium*, Blue Green Algae and *Azolla*. Out of these the importance of *Azotobacter* and *Azospirillium* has been well recognized for vegetable crops and there are several reports that showed the role of nitrogen fixing through *Azotobacter* and *Azospirillium*. In inoculated plants, the fixing of atmospheric nitrogen and its effectiveness increases with the addition of nitrogen at the lower level (Subbiah 1991 and Wange *et al*., 1995) [16, 19]. In addition, there are other bio fertilizers, Phosphate Solubilising Bacteria (PSB), Phosphate Solubilising Fungi and Vasicular Arbuscular Mycorrhizea (VAM). *Azotobacter*s are free living bacteria and fix atmospheric nitrogen in crops and plant without any symbiosis and they do not need a specific host plant. *Azotobacter*s are abundant in well drained, neutral soil. They can fix 15-20 kg/ha N per year. *Azotobacter* species can also produce antifungal compounds to fight against many plant pathogens. They also increase germination of seeds and vigour in young plants leading to improved crop stands. (Siddique *et al*., 2014) [14]. Phosphate solubliser bacteria help in the solublisation of native phosphorus from rock phosphate and other sparingly soluble forms of

soil phosphorus by secreting organic acid. Also there are problems of losses of applied fertilizers and fixation of phosphorus. Mulching has been advocated as an effective means for conserving soil moisture inside the soil. It works as an insulating material against heat or cold and also act as surface barrier to check evaporation to water from soil surface. Mulches can be differentiated in organic and inorganic mulches depending up to the material being used for this purpose Organic mulches include saw dust, mustard straw, pine bark, bark chips, compost, leaf mould, lawn clippings, pea straw, stable straw, spoiled Lucerne, seaweed, mushroom compost, hay, feathers, eucalyptus mulch, manures, waste papers *etc*. However, Inorganic mulches include gravel, scoria, a crushed rock and synthetic plastics of various colors and thickness (Unger, 1975) [18]. Black polyethylene mulch is commonly used because it effectively decreases or eliminates most of the weeds growth by inhibiting photosynthesis. The use of black polyethylene mulch increases yield and earliness of vegetables in the spring season (Dittmar & McRae, 2012) [2]. The color of mulch is an important factor in soil temperature variations due to its effect on the absorbance of short wave radiation. Black and transparent clear plastic mulches provide extremes in the absorbance of short-wave transparent radiation (Shinde, 1997) [13]. Black mulch typically warms the soil 3ºF to 5ºF compared to bare ground (Howell & Hazzard, 2013) [6]. Black polyethylene is popular for vegetable production in cool season because it warms the soil by contact (Hochmuth *et al.*, 2008) [5]. Mulches were found to act as a barrier to the action of rainfall that compacts soil there by reduces soil erosion by water and inhibits weed growth. Black plastic significantly enhanced root growth and facilitated higher nutrient uptake, thereby promoting growth and development of plants (Kumara and Dey, 2011) [7]. The application of organic mulches as a soil cover is effective in improving the quality of soil and increasing crop yield, especially in organic farming. Mulching is an effective method in manipulating crop growing environment to increase yield and improve product quality by controlling weeds, ameliorating soil temperature, conserving soil moisture, reducing soil erosion, improving soil structure and enhancing organic matter content (Opara-Nadi, 1993) [9]. Hence, keeping in view the above facts in mind present investigation is framed to assess the “Effect of Mulching and Bio-fertilizers on quality characteristics of Sprouting Broccoli (*Brassica oleracea var. italica* L.)”.

Materials and methods

The present investigation entitled “Effect of Mulching and Bio-fertilizers on quality characteristics of Sprouting Broccoli (*Brassica oleracea var. italica* L.)” was carried out at the Horticulture Farm, S.K.N. College of Agriculture, Jobner. Jaipur, Rajasthan during Rabi season 2016-17. The experiment was laid out in Randomized Block Design (RBD) with three replication and experiment comprised of 16 treatment combinations with four levels of each mulching (Control, Mustard straw, Saw dust and Black polythene sheet) and bio-fertilizers (Control, PSB, *Azotobacter* and PSB + *Azotobacter*). Before sowing the seed were treated with PSB and *Azotobacter* culture alone as well as in combination of both as per treatment plan, using standard methods. Suspension of half kilogram bio-fertilizer in seven liters of water was prepared for treatment of seedlings. Prior to required quantity of culture was mixed in cold jiggery water and the seedling of sprouting broccoli were dipped in solution for 10 minutes before transplanting. These healthy seedling uniform shape and size were selected and transplanting in well prepared field. Mulching was done prior to transplanting of over seedling. The black polythene sheet of 200 gauge thickness was spread beds and mustard straw and saw dust were put into bed size 1.8 x 1.8 m and the holes of 1 x 1 inch were made on polythene sheets as per the plant and row to row distance similarly. Mustard straw and saw dust @ 5 t/ha & 10 t/ha were spread of above 1 cm thickness as mulch on top soil of the beds and thereafter, transplanting of the seedling was done at appropriate distance in beds. About six weeks old seedlings of sprouting broccoli were transplanted in the field on 21st October, 2016 and the average height of the seedlings was about 8-10 cm. The distance between row to row and plant to plant was kept 45 cm x 45 cm. Thus, 16 plants were accommodated in each plot. Five plants were randomly selected and tagged before flowering from each line to record the data on the following attributes. The observations were recorded on Nitrogen content in curd of wet digestion of head sample with H_2SO_4 and H_2O_2 carried out and then colorimetric determination was performed on spectronic-20 after development of yellow colour with Nesseler’s reagent in digestion-I, crude protein content in the head was analyzed separately for nitrogen (%) content by colorimetric method. Nitrogen content was multiplied with 6.25 factors to calculate crude protein content in curd, total soluble solids (^{0}Brix) was measured with the help of an Erma hand refractometer and were corrected using standard reference table and express in terms of (^{0}Brix) at 200, ascorbic acid (mg/100g) Ascorbic acid content was determined by diluting the known volume of juice with 3% meta-phosphoric acid and titrating with 2,6-dichlorophenol-indo-phenol solution till the faint pink colour was obtained (AOAC, 1960) [1]. All the parameters were collected from five randomly selected plants of each treatment. Least significant difference at 5% level was used for finding the significant differences among the treatment means. The data obtained from selected plants were subjected to analysis of variance Panse and Sukhamate (1961) [10].

Results and discussion

Effect of mulching on quality parameters

The data presented in the experimental results clearly indicate the significant effect of mulching on quality attributes of curd. Maximum nitrogen crude protein (%), total soluble solid (%) and vitamin C (mg/100 g) content in curd of sprouting broccoli. The maximum values for all this quality attributes were found significantly superior in black polythene mulch treatment. These quality attributes were found at par in mustard straw and minimum in control. The perusal of data Table 1 showed that application of mulching treatments significantly increased the TSS content. Treatment M_3 (black polythene) recorded significantly maximum TSS (9.10%) which was 60.49 per cent higher over M_0 (control). The interaction effect of mulching and bio-fertilizer treatments was found non- significant. The maximum vitamin C content in curd (81.00 mg/100 g) was recorded in treatment M_3 (black polythene), which was significantly superior over rest of the treatments except treatment M_1 (mustard straw) which was remained at par. The increase in vitamin C content in curd was registered 23.36 per cent in treatment M_3 more over M_0 (control).

The maximum nitrogen content 0.35% was recorded in treatment M_3 (black polythene), which was significantly superior over rest of the treatments except treatment M_2 (saw dust) which was remained at par. The increase in nitrogen content was registered 40.00 per cent in treatment M_3 more over M_0 (control). The maximum crude protein content in curd 2.21% was recorded in treatment M_3 (black polythene), which was significantly superior over rest of the treatments except treatment M_2 (saw dust) which was remained at par. The increase in crude protein content in curd was registered 38.99 per cent in treatment M_3 more over M_0 (control). Similar findings on quality attributes was also by Gupta and Acharya (1993) [3] in strawberry. The strawberry plants mulched with black polythene film gave fruits with high TSS, and high sugar content as well as acid sugar ratio in fruits. Srivastava and Agarwal (1964) [15] also reported in their findings that black poly mulch resulted in more than 57 per cent increase in ascorbic acid content in strawberry fruit as compared to control. Generally the crop in field without covering the top soil by any means has to face rather stress conditions, there by resulting in poor quality of the produce but the use of black polyethylene and mustard straw mulch created favorable environment rhizosphere, thereby better plant growth and ultimately better quality of sprouting broccoli curds was obtained in the present study.

Effect of bio-fertilizers on quality parameters

The data presented in the experimental results clearly indicate the significant effect of bio-fertilizer on quality attributes of curd. Maximum nitrogen crude protein (%), total soluble solid (%) and vitamin C (mg/100 g) content in curd of sprouting broccoli. The maximum values for all this quality attributes were found significantly superior in PSB + *Azotobacter* treatment. These quality attributes were found at par in *Azotobacter*, and minimum in control. Data given in table 1 showed that application of bio-fertilizers significantly increased the TSS content. Treatment B_3 (PSB + *Azotobacter*) recorded significantly maximum TSS (9.35%) which was 64.51 per cent higher over B_0 (control). The Maximum vitamin C content in curd (79.55 mg/100 g) was recorded in treatment B_3 (PSB + *Azotobacter*) that was significantly superior over rest of the treatments except B_1 (PSB), which was statistically at par. The increase in vitamin C content in curd in treatment B_3 was registered 13.94 per cent over B_0 (control). The maximum nitrogen content 0.37 % was recorded in treatment B_3 (PSB + *Azotobacter*) which was significantly superior over rest of the treatments except treatment B_2 (*Azotobacter*) which was remained at par. The increase in nitrogen content was registered 94.74 per cent under treatment B_3 over B_0 (control). The maximum crude protein content in curd 2.33% was recorded in treatment B_3 (PSB + *Azotobacter*) which was significantly superior over rest of the treatments except treatment B_2 (*Azotobacter*) which was remained at par. The increase in crude protein content in curd was registered 97.46 per cent under treatment B_3 over B_0 (control). The increase in vitamin-C content in broccoli might be due to increase in microbial activity of soil which might have added growth regulators, vitamins and hormones to the soil and ultimately to the plants. Similar findings have also been observed by Mohapatra *et al*. (2013) [8]. The increase in protein content might be due to better availability of desired and required quantity of N in root zone of the crop resulting from its solubilization caused by organic acid produced from the decaying of the organic matter. Since protein content is a function of N content in seeds. The increased uptake of nutrients by broccoli roots may also be due to the increased availability of nitrogen resulting from the integration of inorganic sources of N with organic source and atmospheric N-fixation by bio-fertilizers. (Ranjeet and Ravi, 2004) [11]. Bio-fertilizers enhance the availability of the nitrogen and phosphorus to plants and give rise better utilization of the nutrients by the plant which might have in turn promoted more root growth and development by higher nitrogen fixation in the soil. The increased uptake of nitrogen with bio-fertilizers helped in increasing photosynthetic area, chlorophyll content coupled with increased net photosynthetic rate and in turn increased supply of carbohydrates to the plants. The present findings are in close agreement with the earlier work done by Sable and Bhamare (2007) [12] in cauliflower.

Table 1: Effect of mulching and bio-fertilizers on quality parameters of broccoli.

Treatment	TSS (%)	Vitamin C (mg/100 g^{-1})	Nitrogen (%)	Crude protein (%)
Mulching				
M_0 - Control	5.67	65.66	0.25	1.59
M_1 - Mustard straw	7.83	79.76	0.30	1.89
M_2 - Saw dust	7.32	72.87	0.33	2.09
M_3 - Black polythene	9.10	81.00	0.35	2.21
SEm$\pm$	0.19	1.93	0.01	0.06
CD (P = 0.05)	0.55	5.58	0.03	0.16
Bio-fertilizers				
B_0 - Control	5.68	69.82	0.19	1.18
B_1 - PSB	7.51	77.75	0.34	2.10
B_2 - *Azotobacter*	7.37	72.18	0.35	2.17
B_3 - PSB+ *Azotobacter*	9.35	79.55	0.37	2.33
SEm$\pm$	0.19	1.93	0.01	0.06
CD (P = 0.05)	0.55	5.58	0.03	0.16

Conclusion

On the basis of the results obtained in the present investigation, it may be concluded that application of mulching and different bio-fertilizers enhanced the quality of sprouting broccoli as comparison to control. Application of black polythene along with PSB + *Azotobacter* may be considered as best treatment in terms of quality in broccoli curd.

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