Research Article

Effect of Bio-Fertilizers and Mulching on Growth of Broccoli (*Brassica oleracea* var. *italica* Plenck) Under Protected Condition

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Abstract

In this work, a field study was conducted at the Horticulture Instructional farm, JNKVV, College of Agriculture, Rewa (M.P.) during *Rabi*, 2018-19. The experiment consists of twelve treatment combinations with bio-fertilizers (PSB and *Azotobacter)* and mulch (Rice straw and Black polythene sheet) in Randomized Block Design with replications. The best results showed that application of T_{12} (Black polythene + *Azotobacter* + PSB) proved significantly superior over rest of the treatments concerning plant height (13, 3, 24.5, 43.9 and 56.0 cm) and number of leaves per plant (7.6, 13.7, 21.7, 29.1) at 15, 30, 45 and 60 DAT, leaf area (230.2 cm^2), chlorophyll content in leaves (3.0 mg/g) and taken in primary curd formation (57.8 days).

Keywords: Broccoli, *Brassica oleracea* var. *italica,* Bio-fertilizers**,** Mulching, Growth

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Introduction

Broccoli (*Brassica oleracea*var var. *italica* Plenck), belongs to family Cruciferae, is a member of Cole group. The species originated in the Mediterranean region. The area under cauliflower and broccoli is about 1.38 million hectares in the world with an annual production of about 24.18 million tonnes. In India, cauliflower and broccoli are grown over an area of 0.43 million hectares with annual production of 8.57 million tonnes [1]. In India, it is generally grown in hilly areas of Himachal Pradesh, Jammu and Kashmir, Nilgiri Hills, Uttar Pradesh and Northern plains. It is one of the most nutritious crops and contains vitamin A, vitamin B, vitamin C and minerals like Ca, P and Fe [2]. Its nutritional value consists of energy (34 Kcal), carbohydrate (6.64 g), fat (0.37 g), protein (2.82 g) and water (89.3 g) per 100 g raw broccoli. Nowadays, broccoli attracted more attention due to its multifarious use and great nutritional value. It is also a rich source of sulforaphane compound which is associated with reducing the risk of cancer. The plants often have four petals which can look like crosses. Broccoli possesses abundant fleshy green flower heads arranged in a tree-like fashion on branches sprouting from a thick, edible stalk. The large mass of flower heads is surrounded by leaves. It is beneficial and more nutritious than any other vegetables of the same genus [3]. Bio-fertilizers are important beneficial microorganisms, which can mobilize the nutritionally important elements from non-unstable tostable form through biological processes and are known to increase yield in several vegetables [4]. *Azotobacter* has been well recognized for vegetable crops and several reports showed the role of nitrogen fixation. They can fix 15-20 kg/ha N per year. *Azotobacter* species can also produce antifungal compounds to fight against many plant pathogens. They all increase germination of seeds and vigor in young plants leading to improved crop stands [5]. Phosphate solubilizers bacteria help in the solubilization 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. Phosphate Solubilizing Bacteria (PSB) plays a significant role in solubilizing insoluble phosphate in the soil. Around 95-99 per cent of the total soil, phosphorus is insoluble which is directly not available to plants. The P solubilizers containing bacteria or fungi may convert insoluble form of phosphate to soluble form by producing acid. Mulching is one of the important techniques or practices of covering the soil to make more favorable conditions for plant growth, development and efficient crop production. Different mulch (rice straw, black plastic) reduces the weed population, moderates soil temperature and improves the microbial activity of the soil by improving the environment around the root zone. Mulches can effectively minimize water vapour loss, soil erosion and nutrient loss. Rice straw is weed-free organic mulch that is readily available in the summer and fall after rice crops have been harvested. Previously a waste item, rice straw helps reduce weeds and increase soil moisture when used on its own or as a base layer for mulch. Rice straw is lightweight, so it is best used in a place that will not get heavy winds when used without heavier mulch as a top layer. The nutrients present in the rice straw will get added to the soil as it decomposes. In addition straw mulch will reduce weeds, conserve soil moisture and is also likely to lower the surface soil temperature. The latter might be advantageous especially in the

dry season where high soil temperatures are likely to occur. Black plastic mulch was reported as standard plastic mulch for vegetable production. Mulches were found to act as a barrier to the action of rainfall that compact soil thereby 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 [6]. The most common response to mulch is an increase in total yield. Little information is available concerning the use of mulches in India although its application has been gradually expanding. Most local vegetable farmers use plastic and plant residue mulching. Hence, keeping in view the above facts in mind present investigation is framed to assess the "Effect of bio-fertilizers and mulching on growth of broccoli (*Brassica oleracea* var. *italica* Plenck) under protected condition".

Materials and Methods

In this work, a field study was conducted at the Horticulture Instructional farm, JNKVV, College of Agriculture, Rewa (M.P.) during *Rabi*, 2018-19. The experiment consists of twelve treatment combinations with bio-fertilizers (PSB and *Azotobacter)* and mulch (Rice straw and Black polythene sheet) in Randomized Block Design with replications. 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. Before the 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 seedlings uniform shape and size were selected and transplanting in well-prepared field. Mulching was done before transplanting of over seedling. The black polythene sheet of 200 gauge thickness was spread beds and rice straw was put into bed. Rice straw and @ 5 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 an appropriate distance in beds. About five weeks old seedlings of sprouting broccoli were transplanted in the field on 15th November, 2018. The distance between row to row and plant to plant was kept 50 cm x 50 cm. Five plants were randomly selected and tagged before flowering from each line to record the data on the following attributes. The observations were recorded for plant height, leaf area, number of leaves per plant, day has taken primary curd formation and Days to maturity. A vegetative observation was recorded at 15, 30, 45 and 60 DAT. The leaf area was measured in the laboratory of Department of Plant Physiology, following electronic Leaf area meter (Liccor 3000). The experiment was laid out in Randomized Block Design with 12 treatments with three replications. The treatments was T_1 - Control, T_2 - *Azotobacter*, T_3 - Phosphate Solubilizing Bacteria (PSB), T_4 - *Azotobacter* + PSB, T_5 - Rice straw, T_6 - Rice straw + *Azotobacter*, T_7 - Rice straw + PSB, T_8 - Rice straw + *Azotobacter* + PSB, T_9 - Black polythene, T_{10} - Black polythene + *Azotobacter*, T_{11} - Black polythene + PSB and T_{12} - Black polythene + *Azotobacter* + PSB. The recorded data were statistically analyzed using analysis of variance as formulated at 5% level of significance [7].

Results and Discussion

The plant height was recorded at 15, 30, 45 and 60 days after transplanting. The plant height of broccoli was influenced significantly due to different treatments at every stage of observations. Bio-fertilizers with mulching, as in treatments T_8 and T_{12} resulted in equally higher plant height and proved significantly superior to all the remaining treatments. The maximum values were noted from T_{12} (Black polythene + *Azotobacter* + PSB). In these two treatments, the plant height at 15 DAT ranged from 12.06 to 13.3 cm, at 30 DAT stage 23.04 to 24.05 cm, at 45 DAT stage 42.02 to 43.09 cm and 60 DAT 55.02 to 56.00 cm. The plant height was lowered down with the decrease in the levels of combined application of mulching and biofertilizer T_6 (Rice straw + *Azotobacter*), T_7 (Rice straw + PSB), T_{10} (Black polythene + *Azotobacter*), T_{11} (Black polythene + *Azotobacter* + PSB). The separately applied bio-fertilizers and mulching (T_2, T_3, T_5 and T_9) recorded the PSB and equally lower values where Black polythene performed the better. The lowest plant height values were 7.5, 13.7 and 33.08, 40.00 cm at 15, 30, 45 and 60 DAT stages, respectively under the control treatment (T_1) data given in **Table 1**. The perusal of data **Table 2** showed that application of bio-fertilizers and mulching treatments significantly increased the number of leaves per plant. This was noted at every stage of observations. The maximum 7.06, 13.07, 21.07 and 29.01 leaves per plant were recorded under the treatment T_{12} (Black polythene + *Azotobacter* + PSB). This was closely followed by 7.3, 12.4, 12.4, 20.6 and 27.3 leaves per plant were recorded under the treatment T_8 (Rice straw + *Azotobacter* + PSB). The formation of leaves was decreased under the combined application of bio-fertilizers with mulching (T_{11}, T_{10}, T_7 and T_6). The separate application of bio-fertilizers (T_2, T_3, T_5 and T_9) further declined the leaves count up to significant extent over T_8 and T_9 treatments. However, their performance was statistically equal but PSB and Black polythene gave the higher leaves count over *Azotobacter* and Rice straw. The control treatment recorded the lowest number of leaves formation

(4.01, 5.06, 8.04 and 15.03 per plant at 15, 30, 45 and 60 DAT) respectively. The leaf area was influenced significantly due to bio-fertilizers and mulching treatments data given in **Table 3**.

Table 1 Plant height of broccoli at different growth stages as influenced by bio-fertilizers and mulching

Treatments	Treatments Details	Plant height (cm)			
		15	30	45	60 DAT
T_1	Control	7.5	13.7	33.8	40.0
T_2	*Azotobacter*	9.6	17.7	34.2	45.5
T_3	Phosphate Solubilizing Bacteria (PSB)	10.9	18.9	35.4	47.0
T_4	*Azotobacte*r + PSB	10.6	20.0	37.8	49.2
T_5	Rice straw	10.1	19.9	36.0	48.9
T_6	Rice straw +*Azotobacter*	10.6	20.5	38.1	51.9
T_7	Rice straw + PSB	10.7	21.1	39.7	52.6
T_8	Rice straw + *Azotobacter*+ PSB	12.6	23.4	42.2	55.2
T_9	Black polythene	10.1	20.2	36.7	50.0
T_{10}	Black polythene + *Azotobacte*r	11.2	21.9	41.6	53.5
T_{11}	Black polythene + PSB	12.1	22.7	41.8	54.5
T_{12}	Black polythene + *Azotobacte*r + PSB	13.3	24.5	43.9	56.0
	S.Em±	0.42	0.55	0.86	1.51
	C.D. (P=0.05)	2.53	2.37	3.07	3.60

*DAT – Days after Transplanting

Table 2 Number of leaves per plant at different growth stages as influenced by bio-fertilizers and mulching

Treatments	Treatments Details	Number of leaves per plant			
		15	30	45	60 DAT
T_1	Control	4.1	5.6	8.4	15.3
T_2	*Azotobacter*	4.6	7.9	12.4	18.0
T_3	Phosphate Solubilizing Bacteria (PSB)	5.0	8.3	12.9	18.7
T_4	*Azotobacte*r + PSB	6.0	9.3	15.2	21.5
T_5	Rice straw	5.2	9.1	13.8	19.6
T_6	Rice straw +*Azotobacter*	6.5	9.9	16.2	22.9
T_7	Rice straw + PSB	6.7	10.3	17.6	24.0
T_8	Rice straw + *Azotobacter*+ PSB	7.3	12.4	20.6	27.3
T_9	Black polythene	5.5	8.7	14.3	20.7
T_{10}	Black polythene + *Azotobacte*r	6.8	10.9	18.9	25.0
T_{11}	Black polythene + PSB	7.0	11.7	19.8	26.7
T_{12}	Black polythene + *Azotobacte*r + PSB	7.6	13.7	21.7	29.1
	S.Em±	0.42	0.55	0.86	1.51
	C.D. (P=0.05)	1.23	1.58	2.48	4.36

*DAT – Days after Transplanting

The maximum leaf area (230.2 cm^2) was recorded from T_{12} (Black polythene + *Azotobacter* + PSB). This was significantly superior to all the remaining treatments. However, the second best treatment was T_8 (Rice straw + *Azotobacter* + PSB) where the leaf area was 227.4 cm^2. The third best treatment was T_{11} (Black polythene + PSB), the value being 225.6 cm^2. The formations of leaves were decreased under the combined application of bio-fertilizers with mulching (T_{11}, T_{10}, T_7 and T_6). The performance of the separate effect of bio-fertilizers and mulching was at par to each other (215.0 to 219.07 cm^2). The minimum leaf area (197.1 cm^2) was noted from the control treatment. Data given in **Table 3 showed** that maximum chlorophyll content (3.00 mg/g) was recorded in treatment T_{12} (Black polythene + *Azotobacter* + PSB), which was significantly superior over rest of the treatments except treatment T_8 (Rice straw + *Azotobacter* + PSB) which was remained at par. The treatment T_{12} (Black polythene + *Azotobacter* + PSB), as well as T_8, T_{11} and T_{10} having other combination bio-fertilizers with mulching, brought about equally longer period in the first curd initiation (57.08 to 59.03 days). The formation of leaves was decreased under the combined application of bio-fertilizers with mulching. Similarly, amongst the separate application of bio-fertilizers and mulching brought primary curd initiation in 67.01, 65.01, 64.08, 63.07 days (T_2, T_3, T_5 and T_9) as compared to control

treatment also showed the same range of period taken to primary curd initiation (66.05 days). Amongst the treatments, T_8 and T_{12} having bio-fertilizers with mulching resulted in equally minimum period taken for curd maturity (91.02 and 91.00 days). This was followed by T_4, T_6, T_7, T_{10} and T_{11} having combined application bio-fertilizers and mulching (95.09, 95.01, 94.00, 93.01 to 92.04 days) the values being statistical identical. The similar trend was noticed in T_2, T_3, T_5, and T_9 treatments having separately applied bio-fertilizers and mulching. Under each set of treatments, PSB and Black polythene performed decreased maturity period followed by *Azotobacter* and Rice straw. The control treatment also recorded the maximum period of curd maturity (104.00 days) data given in **Table 4.** The observations recorded in the chapter of experimental results reflect the significant effect of bio-fertilizers on plant growth attributes. Maximum plant height (cm), number of leaves per plant, leaf area (cm^2), chlorophyll content in leaves (mg/g), days taken in primary curd formation and Days to maturity recorded in combination of PSB + *Azotobacter*.

Table 3 Leaf area and Chlorophyll content (mg/g) a of broccoli as influenced by bio-fertilizers and mulching

Treatments	Treatments Details	Leaf area (cm^2)	Chlorophyll content (mg/g)
T_1	Control	197.1	1.27
T_2	*Azotobacter*	215.0	1.34
T_3	Phosphate Solubilizing Bacteria (PSB)	216.0	1.38
T_4	*Azotobacter*+PSB	220.2	1.66
T_5	Rice straw	217.6	1.44
T_6	Rice straw +*Azotobacter*	222.2	1.90
T_7	Rice straw +PSB	223.3	2.02
T_8	Rice straw+*Azotobacte*r+ PSB	227.4	2.73
T_9	Black polythene	219.7	1.64
T_{10}	Black polythene +*Azotobacter*	224.9	2.20
T_{11}	Black polythene +PSB	225.6	2.33
T_{12}	Black polythene +*Azotobacter* + PSB	230.2	3.00
	S.Em±	6.33	0.07
	C.D. (P=0.05)	18.19	0.22

Table 4 Days taken in primary curd formation and Days to maturity of broccoli as influenced by bio-fertilizers and mulching

Treatments	Treatments details	Days to primary curd formation	Days to maturity
T_1	Control	66.5	104.0
T_2	*Azotobacter*	67.1	99.2
T_3	Phosphate Solubilizing Bacteria (PSB)	65.1	97.6
T_4	*Azotobacte*r+PSB	62.4	95.9
T_5	Rice straw	64.8	97.2
T_6	Rice straw +*Azotobacter*	61.8	95.1
T_7	Rice straw +PSB	60.3	94.0
T_8	Rice straw+ *Azotobacter*+ PSB	58.2	91.2
T_9	Black polythene	63.7	96.3
T_{10}	Black polythene + *Azotobacter*	59.3	93.1
T_{11}	Black polythene +PSB	58.3	92.4
T_{12}	Black polythene +*Azotobacter* + PSB	57.8	91.0
	S.Em±	5.65	2.78
	C.D. (P=0.05)	1.96	8.00

*Average of 3 replications

The results of present are in agreement with those archived by [8] reported as a same trend of bio-fertilizers attribute to production of different phytohormones like IAA, GA, Cytokinin which could have led to better root development, better uptake and translocation of nutrients that ultimately resulted in increased growth attributes of the

plant. [9] reported of different application of *Azotobacter* improves nitrogen status of the soil because this is a free nitrogen fixer. Application of efficient and healthy strain of *Azotobacter*in rhizosphere has resulted in greater fixation of atmospheric nitrogen for use by the plant resulting in vigorous growth of plant. Inoculation with PSB transforms unavailable phosphorus in soil into plant utilizable form. The use of bio-fertilizers However, the improvement in these characters were limited where these bio-fertilizers were used alone, but the additive effect was noticed when N_2 fixers and PSB were used together. Such an additive influence of bio-fertilizers is attributable to mutually beneficial role played by each of the two groups of bio-fertilizers used in the study. [6] studied on the effect of black polythene created etiolated conditions to the rhizosphere that resulted in enhanced root growth and facilitated higher nutrient uptake, thereby promoting plant growth and development of sprouting broccoli plants. Mulches were also found to act as a barrier for weed growth and ultimately controlled the competition for nutrients between the broccoli plants and weeds. [10] studied on the of white plastic mulch compared to the reason soil moisture retained by rice straw mulch might be due to that fact white plastic mulch allowed less amount of water into the soil received through precipitation. However, rice straw allowed more water thus being able to retain more water in the soil.

Conclusion

Based on the present investigation, it is concluded that the broccoli cultivar "Green Magic" responded that application of mulch and bio-fertilizers enhanced the growth of broccoli as a comparison to control. Application of black polythene with *Azotobacter* + PSB may be considered as best treatment in terms of growth in broccoli curd.

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