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Effect of bio-fertilizer and mulching on growth, yield and quality of cauliflower (*Brassica oleracea* var. *botrytis* L.) in central region of Punjab

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Abstract
The field experiment entitled to study the "Effect of bio-fertilizer and mulching on growth, yield and quality of cauliflower (*Brassica oleracea* var. *botrytis* L.)" was carried out at the Experimental Research Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, during Rabi season, 2016-17. The experiment was laid out in randomized block design with three replications comprising of nine treatments viz., T_1 (Control), T_2 (Paddy straw mulching), T_3 (Saw dust mulching), T_4 (PSB@1g per plant), T_5 (PSB@1g per plant + Paddy straw), T_6 (PSB@1g per plant + Saw dust), T_7 (*Azotobacter*@1g per plant), T_8 (*Azotobacter*@1g per plant + Paddy straw) and T_9 (*Azotobacter*@1g per plant + Saw dust). The results revealed that the growth characters like plant height, plant spread and leaf weight and quality parameters like TSS and ascorbic acid were significantly highest with T_8 treatment (*Azotobacter*@1g/plant + Paddy straw). But significantly highest dry matter and quantitative parameters like curd height, average curd weight and average curd yield/ha were recorded with T_5 treatment (PSB@1g/plant + Paddy straw). Maximum net return (₹2,08,054.00) was obtained from T_5 treatment (PSB@1g/plant + Paddy straw) while maximum B:C ratio (3.16:1) was obtained from T_4 treatment (PSB@1g/plant). Whereas, minimum B: C ratio (1.12:1) was recorded under control.

Keywords: bio-inoculants, mulching, growth, yield and quality

Introduction
Cauliflower (*Brassica oleracea* var. *botrytis* L.) belongs to the natural order of Cruciferae and genus Brassica, is a biannual and herbaceous vegetable crop. The word Cauliflower derived from the Latin word 'caulis' meaning stalk and 'floris' meaning flower (Dhaliwal, 2014) [5]. In India cauliflower was introduced in 1822 by Dr. Jemson, a botanist from Kew Gardens, London during the period of East India Company for conducting some horticultural experiments. India is the second largest producer of cauliflower (7,887,000 metric tonnes) in the world after China (9,100,000 metric tonnes) (NHB, 2015-16) [14]. It is specially grown in West Bangal, Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Maharashtra, Madhya Pradesh, Orissa, Uttarakhand and Himachal Pradesh. In India, the total area under cauliflower cultivation is 414,000 ha with productivity 7897 thousand metric tonnes (NHB, 2015-16) [14]. In Punjab, cauliflower grew in an area of 13.23 thousand ha with production of 238.03 thousand metric tonnes (NHB, 2015-16) [14].

Bio-fertilizer are naturally occurring products with living microorganisms which are resulted from the roots or cultivated soil and don't have any ill effect on plant, soil health and environment. Besides their role in fixing atmospheric nitrogen and phosphorous solubilisation; these are also helpful in stimulating the plant growth hormones. Bio-fertilizer viz. *Azotobacter*, PSB and *Azospirillum* fix atmospheric nitrogen and solubilise phosphorous to increase fertility of soil and its biological activities. Bio-fertilizer are the derived product of living microorganism that are capable of fixing atmospheric nitrogen and also convert insoluble phosphorous to soluble phosphorous for uptake of plants (Kumar *et al.* 2015) [11]. Need for use of bio-fertilizer has been raised due to excess use of chemical fertilizer which causes lots of harmful effects both on environment and soil condition such as damage to soil texture. Bacteria, fungi and cynobacteria (blue green alge) are the main sources of bio-fertilizer. Mulching play a significant role in organic farming and are used for many beneficial reason in the agriculture sector such as for soil temperature modification, weed control and for soil conservation but water conservation and erosion control are the most important objectives. Besides this, mulching also add essential plant nutrient into the soil after decomposition which improve the soil physical, chemical and biological properties and leads to increase both the quality as well as quantity of the crop (Bhardwaj, 2013) [4]. Therefore, keeping in view the above facts in mind, an attempt has been made in the present investigation to study the effect

of effect of bio-fertilizer and mulching on growth, yield and quality of cauliflower (*Brassica oleracea* var. *botrytis* L.).

Materials' and Methods

A field experiment was conducted at the Experimental Research Farm, Mata Gujri College, Shri Fatehgarh Sahib during *Rabi* season of year 2016-2017. The experiment was laid out in randomized block design with three replications comprising of nine treatments viz., T_1 (Control), T_2 (Paddy straw mulching), T_3 (Saw dust mulching), T_4 (PSB@1g per plant), T_5 (PSB@1g per plant + Paddy straw), T_6 (PSB@1g per plant + Saw dust), T_7 (*Azotobacte*r@1g per plant), T_8 (*Azotobacter*@1g per plant + Paddy straw) and T_9 (*Azotobacter*@1g per plant + Saw dust) and the variety was Pusa Giant-26. Two types of mulch such as paddy straw and saw dust were spread over the plots evenly with different treatments to maintain a thickness about 10 cm and 4 cm respectively. The seedlings were transplanted in experimental field on 1st of October. All the cultural practices were followed according to this region. Observations were recorded on randomly selected plants with different characters *i.e*. plant height (cm), plant spread (cm), leaf weight (g), dry matter (%), curd height (cm), average curd weight (g), marketable curd yield (t ha^{-1}), TSS (Total Soluble Solid), ascorbic acid (mg/100g) and cost of cultivation.

Results and Discussions

Effect on Growth characters of Crop

The result of the present study indicated that the growth parameters of plant such as plant height, plant spread, leaf weight and dry matter accumulation of cauliflower crop were significantly influenced by different bio-fertilizers and mulching materials positive correlation with yield.

Among treatments, maximum increase in plant height, plant spread and leaf weight was measured under treatment T_8 (*Azotobacter*@1g/plant + Paddy straw) which was statistically at par with treatment T_9 (*Azotobacter*@1g/plant + Saw dust) and treatment T_7 (*Azotobacter*@1g/plant) while maximum dry matter content was recorded with treatment T_5 (PSB@1g/plant + Paddy straw) which was statistically at par with treatment T_6 (PSB@1/plant + Saw dust) and treatment T_8 (*Azotobacter* @1g/plant + Paddy Straw). The possible reasons for higher growth parameter with *Azotobacter* inoculation may be because of enhanced biological nitrogen fixation which ultimately show positive effect on vegetative growth of plant (Sharma *et al.* 2002) [19]. These findings are similar with Singh *et al.* (2015) [21]. In addition, paddy straw mulching with *Azotobacter* also show positive effect on growth parameters. Mulching help in improving the microclimatic condition of the soil which might have provided a suitable condition for better plant growth. Organic mulching improves physical, chemical and biological properties of soil as it releases nutrients to the soil and ultimately facilitates the crop growth (Kumar *et al.* 1990) [10]. This result correlated with the study of Nkansah *et al.* (2003) [15] and Patra *et al.* (2004) [16]. Beside this, PSB increases the dry matter of curd which is due to the production of some growth promoting substances that are involved in increasing accumulation of food in plant (Singh *et al.* 2013) [20]. The result of Bahadur *et al.* (2006b) [2] strongly confirm the present study who reported significantly higher dry matter in Chinese cabbage from the treatment in which PSB was supplied.

Effect on yield characters of crop

The various treatments were influenced significantly on yield attributing characters. Among the various treatments, the maximum curd height, average curd weight and marketable curd yield was measured under treatment T_5 (PSB@1g/plant + Paddy straw) which was statistically at par with T_6 (PSB@1g/plant + Saw dust). The minimum yield attributes were recorded in T_1 (control treatment). Increased effect on yield attributes were measured with the application of PSB because it not only increase the uptake of phosphorus but also mediated solubilization of insoluble phosphates through release of organic acid, metabolites which control soil born phytopathogens and release of pathogen suppressing metabolites mainly siderphores, phytohormones and lytic enzyme (Vassilev *et al.* 2006) [23]. Similar result was observed by Kachari and korla (2009) [8]. Additionally, mulching also show positive effect on yield attributes which may be due to the efficient use of available soil moisture, inhibition of weed growth, protection of surface soil erosion, reduction in nutrient loss from soil by crop (Belel, 2012) [3]. These results are in line with the findings of Jamil *et al.* (2005) [6] and Kabir *et al.* (2016) [7].

Effect on quality characters of crop

The result of the present experiment showed significant effect on ascorbic acid while non significant on TSS. Among various treatments, highest ascorbic acid and TSS was recorded with treatment T_8 (*Azotobacter*@1g/plant + Paddy straw) which was statistically at par with treatment T_9 (*Azotobacter*@1g/plant + Saw dust) and treatment T_7 (*Azotobacter*@1g/plant) while minimum was observed under T_1 (control). Increased ascorbic acid due to the application of *Azotobacter* because it has positive effect on the enzyme reaction and formation of metabolites for carbohydrates and proteins synthesis which lead to increases ascorbic acid content (Bahadur *et al.* 2003) [1]. Similar, results were found by Narayanamma *et al.* (2005) [13] and Sable and Bhamare (2007) [17] who reported that *Azotobacter* helps in increasing the ascorbic acid content. Beside this, Paddy straw mulching also show increase in ascorbic acid content and give best result than other treatments when applied in combination with PSB. The results of present study are in agreement with the observations of Najafabadi *et al.* (2012) [12] in garlic and Kamal and El-Shazly (2013) [9] in tomato. On the other hand, improvement in TSS with the application of biofertilizers over control, may be due to high nutrient uptake and increase photosynthesis rate besides, physiological and biochemical activities were also affected (Thilakavathy and Ramaswamy, 1999) [22].

Effect on economics of crop cultivation

Data on economics of various treatments were presented in Table 4 revealed that the plot treated with T_5 (PSB@1g/plant + Paddy straw) treatment gave maximum net returns of Rs 208054 ha^{-1}. Maximum benefit: cost ratio (3.16:1) was observed in treatment T_4 (PSB@1g/plant) while minimum benefit: cost ratio (1.12:1) was recorded under control. The reason behind maximum net return was higher yield while maximum B: C ratio due to only use of PSB in treatment T_4 which reduce the cost of mulching. Beside this give good yield which help increase the B: C ratio. Similar result was found by Sharma *et al* (2009) [18].

Conclusion

On the basis of above study, it can be concluded that the use of bio-fertilizer and mulching in cauliflower gave higher yield and performed better with respect to growth and quality

characters. Increase effect on growth characters (plant height, plant spread and leaf weight) was found with treatment T_8 (*Azotobacter* @ 1g/plant + Paddy straw) while maximum dry matter was observed with treatment T_5 (PSB @ 1g/plant + Paddy straw). Increased effect on yield and yield contributing characters (curd height, average curd weight and marketable yield per hectare) was observed with the application of T_5 (PSB @ 1g/plant + Paddy straw). On the other hand, quality characters (ascorbic acid, total soluble solids) performed better under treatment T_8 (*Azotobacter* @ 1g/plant + Paddy straw). Beside this, treatment T_5 (PSB @ 1g/plant + Paddy straw) gave maximum gross income and net returns among all the treatments. Hence, application of treatment T_5 (PSB @ 1g/plant + Paddy straw) be suggested for commercial cultivation of cauliflower for getting higher yield with maximum net returns per unit area.

Table 1: Effect of biofertilizer and mulching on plant growth characteristics of cauliflower cv. Pusa Giant-26

Treatments	Plant height (cm)	Plant spread (cm)	Leaf weight (g)	Dry matter of curd (%)
T_1: Control	40.76	45.11	332.16	6.50
T_2: Paddy Straw mulching (10cm)	44.60	50.75	380.65	6.68
T_3: Sawdust (4cm)	43.29	48.08	362.71	6.62
T_4: PSB @ 1g/plant	50.94	53.32	453.29	8.90
T_5: PSB @ 1g/plant + Paddy Straw (10cm)	54.30	54.93	477.25	9.75
T_6: PSB @ 1g/plant + Sawdust (4cm)	52.39	52.87	459.88	9.33
T_7: *Azotobacter* @ 1g/plant	55.57	57.58	520.83	8.52
T_8: *Azotobacter* @ 1g/plant + Paddy Straw (10cm)	58.77	59.79	552.36	9.12
T_9: *Azotobacter* @ 1g/plant + Sawdust (4cm)	56.35	58.42	534.18	8.63
SE(m) ±	1.37	0.77	11.52	0.26
CD 0.05	4.10	2.30	34.53	0.78

Table 2: Effect of biofertilizer and mulching on yield characteristics of cauliflower cv. Pusa Giant-26

Treatments	Curd height (cm)	Average curd weight (g)	Curd yield per ha (tonne)
T_1: Control	8.89	302.71	12.61
T_2: Paddy Straw mulching (10cm)	10.70	425.23	19.22
T_3: Sawdust (4cm)	10.20	370.72	16.69
T_4: PSB @ 1g/plant	12.34	552.27	24.87
T_5: PSB @ 1g/plant + Paddy Straw (10cm)	14.11	640.81	28.77
T_6: PSB @ 1g/plant + Sawdust (4cm)	14.02	629.93	26.15
T_7: *Azotobacter* @ 1g/plant	12.03	560.58	24.45
T_8: *Azotobacter* @ 1g/plant + Paddy Straw (10cm)	13.01	590.13	25.45
T_9: *Azotobacter* @ 1g/plant + Sawdust (4cm)	12.91	578.39	25.07
SE(m) ±	0.33	12.94	1.23
CD 0.05	0.98	38.80	3.68

Table 3: Effect of biofertilizer and mulching on quality characteristics of cauliflower cv. Pusa Giant-26

Treatments	TSS (° Brix)	Ascorbic acid (mg 100 g^{-1})
T_1: Control	3.70	57.54
T_2: Paddy Straw mulching (10cm)	4.03	60.22
T_3: Sawdust (4cm)	3.87	59.36
T_4: PSB @ 1g/plant	4.67	64.33
T_5: PSB @ 1g/plant + Paddy Straw (10cm)	4.93	66.88
T_6: PSB @ 1g/plant + Sawdust (4cm)	4.37	65.91
T_7: *Azotobacter* @ 1g/plant	4.77	68.77
T_8: *Azotobacter* @ 1g/plant + Paddy Straw (10cm)	5.03	70.21
T_9: *Azotobacter* @ 1g/plant + Sawdust (4cm)	4.95	69.58
SE(m) ±	0.57	0.49
CD 0.05	NS	1.47

Table 4: Economics of various treatments in Cauliflower cv. Pusa Giant-26

Treatments	Gross income (ha^{-1})	Total cost of cultivation (ha^{-1})	Net return (ha^{-1})	B:C ratio
T_1: Control	126100	59371	66729	1.12:1
T_2: Paddy Straw mulching (10cm)	192200	79371	112829	1.42:1
T_3: Sawdust (4cm)	166900	65371	101529	1.55:1
T_4: PSB @ 1g/plant	248700	59646	189054	3.16:1
T_5: PSB @ 1g/plant + Paddy Straw (10cm)	287700	79646	208054	2.61:1
T_6: PSB @ 1g/plant + Sawdust (4cm)	261500	65646	195854	2.98:1
T_7: *Azotobacter* @ 1g/plant	244500	59646	184854	3.09:1
T_8: *Azotobacter* @ 1g/plant + Paddy Straw (10cm)	254500	79646	174854	2.19:1
T_9: *Azotobacter* @ 1g/plant + Sawdust (4cm)	250700	65646	185054	2.81:1

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