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Response of bio-fertilizers on growth and yield of cauliflower (*Brassica oleracea Var.botrytis* L.) under irrigated conditions of Punjab

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Abstract

*Response of bio-fertilizers on growth and yield of cauliflower (*Brassica oleracea Var.botrytis *L.) under irrigated conditions of Punjab was conducted during* rabi *season of 2020-21 at the Campus for Agricultural Research and Advanced Studies Dhablan of the G.S.S.D.G.S. Khalsa College Patiala, Punjab. The field experiment was laid out in randomized block design with 11 different treatments with 3 replications. bio-fertilizers significantly influenced the growth and yield of cauliflower. All the growth parameters like plant height (cm), number of leaves plant^{-1}, Leaf length (cm) Leaf width (cm) and yield (258.53 q ha^{-1}) was significantly higher in treatment T10 : Azotobacter + PSB + Azospirillum (seedling inoculation.*

Keywords: cauliflower, bio-fertilizers, PSB and *Azotobacter*

Introduction

Cauliflower (*Brassica oleracea* var. *botrytis*) is one of the most important cool season crop grown in the world. The word Cauliflower is derived from Latin word Caulis means Stalk and flower means floris. It belongs to family Cruciferae and is originated from Mediterranean region. Its chromosome number (2n) is 18. It is widely grown for its edible part i.e. Curd. It is cultivated in India from Mughal period. Cauliflower was introduced in India in 1822 by a botanist Dr. Jenson. Presently, India is the second largest producer of vegetables in the world next to China. Among all the cole crops (cauliflower, cabbage, knol-khol, broccoli etc.) India occupies first position in the production of cauliflower. It is widely used as an essential component of food in medicinal forms and also as an immediate source of family's income. It grows well in deep loamy soil having pH of 5.5-6.5. Cauliflower is a crosspollinated crop which requires an isolation distance of 1000m is kept between the different varieties of the same species to produce true to type seed. The recommended spacing for early season varieties is 45cm X 45cm. And for late season recommended spacing is 45cm X 60cm. Closer spacing causes small curds Kachari (2009). Vegetables play an important role in the maintenance of human health. Cauliflower is cooked as a vegetable and also used as an ingredient in other dishes like salads, soups and many other edible products. In India, the area under Cauliflower is about 458 thousand hectares. Total production of Cauliflower in India is about 8840 tonnes (NHB, 2016). In Punjab, the area under Cauliflower is 17.06 thousand hectares and total production of cauliflower in Punjab is 279.67 thousand tonnes.

Materials and Methods

The field experiment was laid out in randomized block design with 11 different treatments with 3 replications. The soil of experimental field was clay, soil pH 7.3, medium in organic carbon (0.73%), low in available nitrogen (260.7 kg ha^{-1}), medium in available phosphorus (21.5 kg ha^{-1}) and potassium (130.3 kg ha^{-1}).All the nutrients were applied in basal dose at one day before sowing. The plant material comprised of Cauliflower var. Girija as per treatment was transplanted on 8 November, 2020. The crop was planted maintaining a distance of 60 cm and 20 cm between the row and plants respectively. Five representative sample plants were

randomly selected from each of the plots plant height was recorded in cm. The number of leaves per plant were counted from the five randomly selected sample plants and the values of these were summed up and averaged. To study the Leaf length (cm) Leaf width (cm) of five plants were collected from the sampling rows of each plot at 30 days interval from sowing till harvest of the crop. The plant samples were then weighted to record the average fresh weight of knob. The produce was separated into grades of knob and weight and number of knob were recorded separately for each grade. The knob of each plot the border and sampling row was weighed in kilogram.

Results and Discussion

Plant height (cm)

The response of different treatments on plant height at 30 DAT, 45 DAT and at harvest of cauliflower was significant whereas at 15 DAT the results were non- significant (Table 1 & Fig. 1). It was observed that plant height at 15 DAT shows non-significant results because the bacteria applied during seedling and soil inoculation takes 15 days to establish itself, so shows no variation between the treatments. Whereas the maximum plant height was recorded with treatment T_{10} (*Azotobacter* + PSB + *Azospirillum* seedling inoculation) at 30 DAT (40.07 cm) which was at par with T_4 (Seedling inoculation of PSB), T_6 (*Azotobacter* + PSB seedling inoculation) and T_8 (Seedling inoculation of *Azospirillum*) i.e. 37.27 cm, 39.13 cm and 37.70 cm and the minimum plant height at 30 DAT was observed in T_1 (Control) i.e. (27.99 cm). Simultaneously, the maximum plant height at 45 DAT (51.43 cm) and at harvest (66.40 cm) was recorded in T_{10} (*Azotobacter* + PSB + *Azospirillum*) which was at par with T_6 at 45 DAT (50.23 cm) and followed by T_6 at harvest (62.26 cm) and the minimum plant height at 45 DAT (40.67 cm) and at harvest (50.03 cm) was recorded in T_1 (Control).

The plant height was increased due to the seedling inoculation of (*Azotobacter*+ PSB + *Azospirillum*) as *Azotobacter* is a free-living bacteria and can fix atmospheric nitrogen in the soil which enhance the soil fertility and improve the soil texture, PSB solubilize the phosphorus in available form so that plants can easily uptake the nutrients and *Azospirillum* is associative symbiotic and makes association with the root hairs of the host plant which enhance the root growth and close contact of root hairs with the host plant. Bio-fertilizers also produce phytohormones such as auxins, gibberllins and vitamins which helps in cell elongation and cell enlargement hence, increased the metabolic activity which ultimately increase the plant height of the plant.

In a parallel study, Nkansah *et al. (*2003) who witnessed that quick release of nutrients to soil through bio-fertilizers, quick uptake by plants results in increased vegetative growth. The recent observations are in close conformity with, Singh

Table 1: Response of bio-fertilizers on plant height (cm) at 15, 30, 45 DAT and at harvest of cauliflower

Treatments	Plant height (cm)			
	15DAT	30DAT	45DAT	At harvest
T_1: Control	11.53	27.99	40.67	50.03
T_2: Seedling inoculation of *Azotobacter*	12.27	36.73	46.10	57.93
T_3: Soil inoculation of *Azotobacter*	11.67	35.23	44.07	54.23
T_4: Seedling inoculation of PSB	12.77	37.27	46.60	58.13
T_5: Soil inoculation of PSB	12.14	36.30	44.73	55.00
T_6 : *Azotobacter* +PSB (seedling inoculation)	13.48	39.13	50.23	62.26
T_7: *Azotobacter*+PSB (soil inoculation)	12.76	36.93	46.90	58.90
T_8: Seedling inoculation of *Azospirillum*	13.00	37.70	47.00	59.00
T_9: Soil inoculation of *Azospirillum*	12.63	36.63	45.13	55.27
T_{10}: *Azotobacter* + PSB+*Azospirillum* (seedling inoculation)	13.57	40.07	51.43	66.40
T_{11}: *Azotobacter* + PSB + *Azospirillum* (soil inoculation)	12.90	38.07	48.40	60.39
SE (d)	NS	1.51	0.63	0.69
CD (0.50)	NS	3.16	1.31	1.43

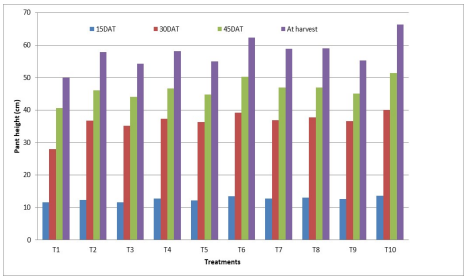

Fig. 1. Response of bio-fertilizers on plant height (cm) at 15, 30, 45 DAT and at harvest of cauliflower

(2015) and Kachari (2009) in cauliflower who observed accelerated growth of plants by the use of bio-fertilizers.

Number of leaves plant^{-1}

The effect of different treatments on number of leaves plant^{-1} at 30 DAT,45 DAT and at harvest of cauliflower was significant whereas at 15 DAT the results were non-significant because bio-fertilizers have some micro-organisms which convert elements to available nutrient for plant roots but in this short duration of 15 days micro-organisms were unable to convert the elemental nutrients (Table 2 & Fig. 2). The maximum number of leaves plant^{-1} were recorded in treatment T_{10} (*Azotobacter* + PSB + *Azospirillum* seedling inoculation) at 30 DAT (14.50) which was at par with T_6 (*Azotobacter* + PSB seedling inoculation) at 30 DAT (13.6), also T_{10}gave increased number of leaves plant^{-1}at 45 DAT (20.67) and at harvest (22.43) which was closely tracked with T_6 (*Azotobacter* + PSB seedling inoculation) at 45 DAT (19.30) and at harvest (20.13). The minimum number of leaves plant^{-1} were observed inT_1 (Control) at 30DAT (10.40), at 45 DAT (15.00) and at harvest (15.33).

The amplification in number of leaves plant^{-1} might be due to biological nitrogen fixation because nitrogen is the major nutrient which play vital role in growth and development of plants. As growth regulating substances are produced by bio-fertilizers, results in more nucleo- protein synthesis which is highly responsible for leaf beginning as advised by Singh (2015). Increased number of leaves plant^{-1} can also be due to development of better nutritional environment in the root zone by the application of bio-fertilizers. PSB results in early encouragement of root system, translocation of growth compounds which plays an important role in vegetative growth of plants.

Similar results in growth characters were observed by Nkansah *et al*. (2003), Sable *et al.* (2007) and Kachari (2009) in broccoli who found accelerated growth in plant.

Leaf length (cm)

The data revealed that (Table 3 & Fig. 3)

Table 2: Response of bio-fertilizers on number of leaves plant^{-1} at 15, 30, 45 DAT and at harvest of cauliflower

Treatments	Number of leaves plant^{-1}			
	15DAT	30DAT	45DAT	At harvest
T_1: Control	5.17	10.40	15.00	15.33
T_2: Seedling inoculation of *Azotobacter*	6.13	12.60	17.70	18.03
T_3: Soil inoculation of *Azotobacter*	5.27	11.70	16.27	16.47
T_4: Seedling inoculation of PSB	6.37	12.80	17.97	18.31
T_5: Soil inoculation of PSB	5.30	11.91	16.90	17.27
T_6 : *Azotobacter* +PSB (seedling inoculation)	6.83	13.64	19.30	20.13
T_7: *Azotobacter*+PSB (soil inoculation)	6.38	12.27	17.63	18.00
T_8: Seedling inoculation of *Azospirillum*	6.57	12.86	17.90	18.23
T_9: Soil inoculation of *Azospirillum*	5.40	12.07	16.93	17.27
T_{10}:*Azotobacter* + PSB + *Azospirillum* (seedling inoculation)	6.93	14.50	20.67	22.43
T_{11}:*Azotobacter* + PSB + *Azospirillum* (soil inoculation)	6.70	12.90	17.97	18.66
SE (d)	NS	0.42	0.56	0.75
CD (0.50)	NS	0.87	1.17	1.55

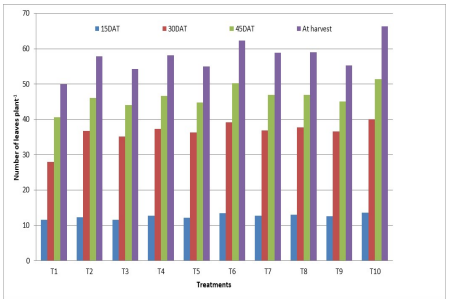

Fig. 2. Response of bio-fertilizers on number of leaves plant^{-1} at 15, 30, 45 DAT and at harvest of cauliflower

The increase in leaf length in T_{10} - *Azotobacter* + PSB + *Azospirillum* (seedling inoculation) was due to beneficial effect of bio-fertilizers as they accelerate photosynthesis rate which boost vegetative growth of the plant. Rodriguez and Fraga (1999) also reported the vital role of phosphorus in vegetative growth promotion of the plant as PSB solubilizes the insoluble phosphate into soluble form and hence making phosphorus nutrient available to the plants.

The results are in line with Singh *et al.*(2013), Kumar *et al.* (2015), Bhagavantagoudra and Singh (2015) in cauliflower and Nkansah *et al.*(2003), *Sharma et al.* (2009) in cabbage.

Yield (qha^{-1})

Table 3: Response of bio-fertilizers on leaf length (cm) at 15, 30, 45 DAT and at harvest of cauliflower

Treatments	Leaf length (cm)			
	15DAT	30DAT	45DAT	At harvest
T_1: Control	5.90	11.70	20.17	22.82
T_2: Seedling inoculation of *Azotobacter*	6.55	13.50	23.67	27.33
T_3: Soil inoculation of *Azotobacter*	6.98	12.63	21.43	25.93
T_4: Seedling inoculation of PSB	7.16	13.80	23.87	27.60
T_5: Soil inoculation of PSB	7.10	12.80	21.70	26.17
T_6 : *Azotobacter* +PSB (seedling inoculation)	7.74	16.40	25.00	29.07
T_7: *Azotobacter*+PSB (soil inoculation)	7.20	13.93	22.30	27.67
T_8: Seedling inoculation of *Azospirillum*	7.33	14.33	24.06	27.73
T_9: Soil inoculation of *Azospirillum*	7.37	12.97	21.97	26.27
T10 *Azotobacter* + PSB + *Azospirillum* (seedling inoculation)	7.93	17.07	26.75	30.81
T_{11} : *Azotobacter* + PSB + *Azospirillum* (soil inoculation)	7.02	14.50	24.21	27.83
SE (d)	NS	0.51	0.62	0.58
CD (0.50)	NS	1.06	1.29	1.21

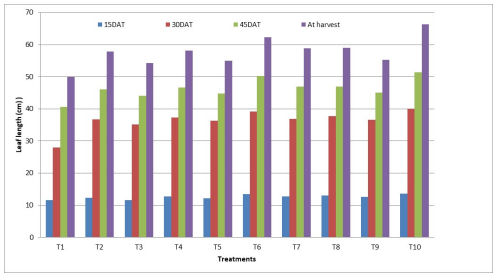

Fig. 3 : Response of bio-fertilizers on leaf length (cm) at 15, 30, 45 DAT and at harvest of cauliflower

leaf length of plant significantly amplified under different bio-fertilizers at 30, 45 DAT, at harvest and shows non-significant results at 15 DAT as in early stages it might have less stabilization on microbial population. The treatment T_{10} (*Azotobacter* + PSB + *Azospirillum* seedling inoculation) gave maximum leaf length at 30 DAT (17.07 cm), at 45 DAT (26.75 cm) and at harvest (30.81 cm) which was at par with T_6 (*Azotobacter* + PSB seedling inoculation) at 30 DAT (16.40 cm), at 45 DAT (25.00 cm) and at harvest (29.07cm).While minimum leaf length at 30 DAT(11.70cm),at 45DAT (20.17cm) and at harvest (22.82 cm) was observed in T_1 (Control).

Table 4: Response of bio-fertilizers yield (q ha^{-1}) of cauliflower

Treatments	Yield (q ha^{-1})
T_1: Control	136.90
T_2: Seedling inoculation of *Azotobacter*	206.67
T_3: Soil inoculation of *Azotobacter*	204.27
T_4: Seedling inoculation of PSB	207.32
T_5: Soil inoculation of PSB	205.10
T_6 : *Azotobacter* +PSB (seedling inoculation)	215.15
T_7: *Azotobacter*+PSB (soil inoculation)	207.43
T_8: Seedling inoculation of *Azospirillum*	208.04
T_9: Soil inoculation of *Azospirillum*	205.40
T_{10}:*Azotobacter* + PSB + *Azospirillum* (seedling inoculation)	258.53
T_{11}: *Azotobacter* + PSB + *Azospirillum* (soil inoculation)	208.13
SE (d)	1.46
CD (0.50)	3.04

The results revealed that (Table 4) maximum curd yield (258.53 q ha^{-1}) was obtained from treatment T_{10} - *Azotobacter* + PSB + *Azospirillum* (seedling inoculation) which remained close with T_6- *Azotobacter* + PSB (seedling inoculation) 215.15 q ha^{-1}. While the minimum curd yield (136.90q ha^{-1}) was found in the control treatment.

According to results the highest curd yield was due to enhancement of nitrogen fixation, phosphate solubilization, increase in enzymatic activity and growth promoting hormones such as auxins, cytokinins. Increase in uptake of nutrients results in faster synthesis and deviation of photosynthates i.e. glucose and oxygen from leaves (source) to curd (sink). Also bio-fertilizers help the host plant to thrive in adverse soil conditions by increasing the soil surface which helps in increasing the productivity of cauliflower.

The present results are in line with Singh *et al.* (2014), Dashrath bhai (2005) who reported effect of bio-fertilizers and nitrogen significantly increase the yield of cabbage. Singh *et al.* (2015) in cabbage and cauliflower, *Sharma et al.* (2009) in cauliflower also witnessed similar outcomes.

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