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Effect of bio-inoculants on the performance of cauliflower (*Brassica oleracea* var. *botrytis* L.)

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ABSTRACT

The experiment was laid out in split plot design with three replications. Treatments consisted of five cauliflower varieties allotted in main plot viz, Girija (V_1), White Excel (V_2), Remi (V_3), Pushpa (V_4) and White Marvel (V_5) whereas bio-inoculants treatment (with or without bio-inoculants) as seedling root dipping was taken as sub plot. The pooled results indicated that seedling root dipping in bio-inoculants had significant role on the performance of cauliflower varieties. Curd initiation and curd maturity were advanced in presence of bio-inoculants. The curd weight and total yield per hectare were found superior in presence of bio-inoculants. Variety White Marvel in presence of bio-inoculants emergence best with respect to days to curd initiation (42.75 days) and days to curd maturity (51.84 days), whereas White Excel variety produced significantly highest curd weight (1274.67 g) and yield (29.58 t/ha) in presence of bio-inoculants. However the presence of bio-inoculants showed non-significant differences for the quality attribute like vitamin-A and ascorbic acid content of curd.

Keywords: Bio-inoculants, cauliflower, growth and yield, varieties

Cauliflower (*Brassica oleracea* var. *botrytis* L.) is one of the most widely cultivated cole crop in India occupied an area of 3.69 lakh ha area with a production of 67.45 lakh tones **(**Anon. 2011**).** The edible part contains significant amount of protein, mineral and vitamins along with isothiocyanates and S-methylcysteine sulfoxide which have prominent anti-carcinogenic properties (Hazra *et al*., 2011). Cauliflower varieties are highly sensitive to soil and environmental variation which significantly affect the crop growth and curd yield. Several research suggested that use of bio-fertilizers improved plant nutrients availability and encourages plant growth through synthesis of biologically active growth promoting substances, result in better crop growth and yield.

Application of *Azotobacter* and *Azospirillum* apart from ability to fix atmospheric nitrogen, they are also known for synthesis biologically active growth promoting substances (Asokan *et al.,* 2000). *Azotobacter chroococcum,* a non-symbiotic bacteria is the potential bio-fertilizer and has the capability for contribution nitrogen to a number of non-legumes by tapping atmospheric nitrogen (Singh and Sinsinwar, 2006) and can meet up to 15-20 kg N requirement of crop, besides producing some growth promoting and antifungal substances and vitamins that help in increasing the yield (Das *et al*., 2006). The Phosphorus solubilizing bacteria (*PSB*) in the rhizosphere is known to increase the solubility of insoluble phosphorus through production of aliphatic and aromatic acids, phytase and phospholipase and increase the phosohorus uptake by the plants (Kumar and Ahlawat, 2006; Bera *et al.,* 2013). Kumar *et al*. (2011) reported that the application of PSB along with inorganic fertilizer was proved best for getting higher curd yield in cauliflower.

Biofertilizers increased the efficiency of nitrogen fertilizer, and subsequently increases the yield and quality of cauliflower (Bashyal, 2011). However information on the performance of the cauliflower varieties seedling dipping inoculation with *Azotobactor* and PSB containing bio-inoculants is still meagre for the terai-zone of West Bengal. Keeping this in view, the present experiment was undertaken to study the effect of seedling dipping with bio-inoculants on growth, yield and quality parameter of different cauliflower varieties.

MATERIALS AND METHODS

The experiment was conducted during winter season (November to February) of 2010-11 and 2011-2012 at the experimental farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, situated under terai agro climatic region of West Bengal. The experimental soil was sandy clay loam having pH 5.96, 0.83% organic carbon, 172.79 kg/ha available nitrogen, 22.15 kg/ha available phosphorus and 123.25 kg/ha available potash. The experiment was laid out in split plot design with three replications. Main plot consists of 5 cauliflower varieties and sub plot included bio-inoculants treatment (with or without bio-inoculants). Three Hybrid varieties namely, Girija, White Excel and Remi as well as two improved varieties Pushpa and White Marvel were taken in this experiment. Cauliflower seedlings were

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transplanted in 2.25 × 2.25m plots with both ways spacing of 45 cm on 30th November for both the years. The bio-inoculants- *Azophos* containing *Azotobacter chroococcum* and Phosphate solubilizing bacteria (*Acinetobacter sp*) with standard microbial population (5×10^8) was used in the experiment. The bio-inoculants were applied just before transplanting as seedling root dipping at 250 g/litre of water using rice gruel as adhesive.

Farm yard manure was applied to the respective plots at the time of transplanting. The recommended doses of inorganic fertilizers (120 N: 60 P: 60 K kg/ha) were applied in the form of urea (N) single super phosphate (P_2O_5) and muriate of potash (K_2O). Full dose of P and K along with half N were applied as basal and rest N was top dressed after 30 days transplanting. The crop was raised adopting standard package practices. The observation were recorded for plant height, number of leaves/plant, days to curd formation and maturity, curd weight and curd yield. Vitamin-A content of curd was measured in the form of total β-carotene content of curd and then it converted it to vitamin A by dividing with 0.6 (Ranganna, 2001). Ascorbic acid of the curd was determined titrimetrically, using 2, 6 dichlorophenol indophenol dye as per method suggested by Ranganna (1986). Two years data were pooled and statistically analyzed as per method suggested by Panse and Sukhatme (2000).

RESULTS AND DISCUSSION

Effect of bio-inoculants

The results of the present experiment showed that seedling root dipping with biofertilizer-inoculants significantly influenced the growth and yield parameters except quality parameter (Vitamin-A and ascorbic acid) (Table 1 and 2). The pooled data revealed that the application of bio-fertilizer produced significantly highest leaves (16.48plant^{-1}). Seedling root dipping with bio-inoculants significantly reduced the days taken to curd initiation (64.77 days) as well as days taken to marketable curd maturity (71.67 days) as compared to uninoculation. Biofertilizer inoculation showed significant influence on curding percentage (75%), curd weight (709.70 g) as well as curd yield (14.90 t ha^{-1}) as compared to control. This could be due to better availability, solubility, mobility and utilization of plant nutrients resulted in enhanced plant growth and curd prodcution. Use of bio-inoculants might have favoured the growth of soil micro flora and improved the efficacy of the applied manures and fertilizers (Kaushal *et al.,* 2011). Kachari and Korla (2012) established the positive effect bio-fertilizer inoculation on different growth and yield parameters of cauliflower as compared to control. Pandey *et al.,* (2008) also highlighted the positive effects of azotobactor on growth and yield of broccoli.

Effect of varieties

Cauliflower varieties showed significant differences for growth and yield attributes for both the year as well as pooled analysis (Table 1 and 2). Maximum number of leaves (16.37/plant) was recorded by the variety Girija. Days to card initiation and maturity showed significant variation with respect to different varieties. White Marvel recorded the lowest duration (43.17 and 55.33 days, respectively) and the variety Pushpa took highest duration (80.50 and 87 days, respectively) for curd initiation as well as marketable curd maturity. Different varieties have unique genetic characteristic which may be the cause to take different duration for curd initiation as well as marketable curd maturity to the different variety in a same planting date (Kumar *et al.,* 2002). The result of pooled analysis also showed that the curding percentages varied significantly. Remi recorded highest curding percentage (85.82 %) and it was lowest in Pushpa (41.18 %). Different varieties also showed variation for individual curd weight and yield. Among the varieties, White Excel gave the highest individual curd weight and yield (1164.24 g and 26.61 t ha^{-1}) where as White Marvel (345.20 g) gave lowest individual curd weight and Pushpa recorded the lowest curd yield (6.38 t ha^{-1}). Ara *et al*., (2009) and Sharma *et al.* (2006) also found that different variety produced different curd weight and yield which may be due to their genetic characters. Among quality attributes, vitamin A content was found highest in Remi (54.22 IU 100 g of fresh weight^{-1}) followed by White Excel (53.22 IU 100 g of fresh weight^{-1}). The maximum ascorbic acid content was recorded by the variety White Excel (43.57 mg 100 g of fresh weight^{-1}) followed by Remi (43.47 mg 100 g of fresh weight^{-1}). Kumar *et al*. (2010) also recorded the variation in ascorbic acid content in cauliflower varieties.

Interaction between bio-inoculants and varieties

The result indicated a significant interaction between seedling root dipping with bio-inoculants and varieties for the growth and yield attributes of cauliflower for both the year as well as pooled analysis. (Table 2). The highest leaves number was produced by Girija (16.68) when treated with bio-inoculants and it was lowest (14.92) in White Marvel without bio-inoculants. Variety White Marvel recorded lowest days for curd initiation (42.75 days) as well as marketable curd maturity (51.84 days) when treated with bio-inoculants. Earliness in head formation and maturity in presence of bio-inoculants could be attributed to enhanced vegetative growth coupled with adequate reserved food material which facilitated early differentiation of vegetative buds and results in advance curd formation and subsequently early maturity of the curd. The result showed that all the varieties increased the curding percentage when

Table 1: Effect of bio-inoculants and varieties on growth and yield attributes of cauliflower

Treatment	No. of leave plant $^{-1}$			Days to curd initiation			Days to curd maturity			Curding percentage (%)		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
Bio-inoculants												
B_0	15.21	15.60	15.41	68.00	69.33	68.67	75.47	78.13	76.80	70.64	71.55	71.10
B_1	16.41	16.55	16.48	64.73	64.80	64.77	71.60	71.73	71.67	74.87	75.12	75.00
SEm(±)	**0.02**	**0.15**	**0.07**	**0.37**	**0.21**	**0.21**	**0.26**	**0.28**	**0.19**	**0.96**	**0.89**	**0.65**
LSD (0.05)	**0.11**	**0.90**	**0.29**	**2.24**	**1.25**	**0.81**	**1.60**	**1.72**	**0.75**	**5.84**	**5.40**	**2.57**
Variety												
V_1	16.44	16.30	16.37	72.5	73.50	73.00	78.33	80.67	79.50	79.56	82.46	81.01
V_2	15.96	16.58	16.27	72.17	74.33	73.25	78.50	78.83	78.67	82.50	85.68	84.09
V_3	15.40	16.18	15.79	63.00	64.33	63.67	71.33	72.83	72.08	86.57	85.07	85.82
V_4	15.47	15.81	15.64	80.67	80.33	80.50	87.50	87.00	87.25	41.18	41.17	41.18
V_5	15.77	15.53	15.65	43.50	42.83	43.17	52.00	55.33	53.67	73.96	72.30	73.13
SEm(±)	**0.31**	**0.28**	**0.21**	**0.45**	**0.46**	**0.32**	**0.44**	**0.35**	**0.28**	**0.99**	**1.12**	**0.75**
LSD (0.05)	**0.92**	**0.83**	**0.60**	**1.34**	**1.37**	**0.91**	**1.33**	**1.06**	**0.82**	**2.97**	**3.37**	**2.16**
Interaction												
B_0V_1	15.82	15.64	15.73	74.00	74.33	74.25	79.33	82.00	80.67	77.99	81.19	79.59
B_0V_2	15.24	16.12	15.68	74.67	77.00	76.42	82.00	84.00	83.00	80.20	84.83	82.52
B_0V_3	14.73	15.86	15.30	64.00	67.33	66.50	73.67	76.67	75.17	85.20	84.39	84.80
B_0V_4	15.16	15.61	15.39	82.33	85.33	84.58	89.00	91.00	90.00	38.14	37.61	37.88
B_0V_5	15.10	14.73	14.92	45.00	42.67	43.25	53.33	57.00	55.17	71.73	69.72	70.73
B_1V_1	17.06	16.30	16.68	71.00	72.67	72.25	77.33	79.73	78.53	81.13	83.75	82.44
B_1V_2	16.69	16.58	16.64	69.66	71.67	71.17	75.00	73.67	74.34	84.81	86.53	85.67
B_1V_3	16.09	16.17	16.13	62.00	61.33	61.50	69.00	69.00	69.00	87.97	85.71	86.84
B_1V_4	15.78	15.80	15.79	79.00	75.33	76.25	86.00	83.00	84.50	44.22	44.75	44.49
B_1V_5	16.44	15.52	15.98	42.00	43.00	42.75	50.00	53.67	51.84	76.19	74.89	75.54
SEm(±)	**0.44**	**0.39**	**0.29**	**0.63**	**0.65**	**0.45**	**0.63**	**0.50**	**0.40**	**1.40**	**1.59**	**1.06**
LSD (0.05)	**1.31**	**1.17**	**0.84**	**1.89**	**1.94**	**1.30**	**2.20**	**1.50**	**1.15**	**4.19**	**4.76**	**3.05**

Note : Y_1:2011-12; Y_2:2012-13; B_0: No Bio-inoculants, B_1: With Bio-inoculants (Azotobacter chroococcum and Acinetobacter sp), V_1: Girija, V_2: White Excell, V_3: Remi, V_4:Pushpa and V_5:White Marvel.

Table 2: Effect of bio-inoculants and varieties on yield and quality attributes of cauliflower

Treatment	Curd weight plant $^{-1}$ (g)			Yield (t ha^{-1})			Vitamin A (IU 100 fresh weight^{-1})			Ascorbic acid (mg 100 fresh weight^{-1})		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
Bio-inoculants												
B_0	579.01	610.27	594.64	11.25	12.21	11.73	51.51	52.55	52.03	42.49	42.76	42.63
B_1	700.20	719.20	709.70	14.64	15.16	14.90	51.75	52.49	52.12	42.60	42.74	42.67
SEm(±)	**16.05**	**28.66**	**16.42**	**0.48**	**0.65**	**0.40**	**0.09**	**0.08**	**0.06**	**0.06**	**0.03**	**0.03**
LSD (0.05)	**97.69**	**174.40**	**64.49**	**2.90**	**3.96**	**1.58**	**0.54**	**0.48**	**0.23**	**0.35**	**0.18**	**0.13**
Variety												
V_1	690.35	705.69	698.02	14.96	15.73	15.35	50.58	51.36	50.97	43.22	42.48	42.85
V_2	1147.33	1181.15	1164.24	25.79	27.42	26.61	52.64	53.79	53.22	44.09	43.04	43.57
V_3	452.90	519.43	486.17	10.67	12.05	11.36	52.94	55.49	54.22	42.59	44.35	43.47
V_4	561.73	573.03	567.38	6.32	6.43	6.38	51.73	51.43	51.58	40.75	42.69	41.72
V_5	346.017	344.38	345.20	6.98	6.81	6.90	50.24	50.55	50.40	42.10	41.19	41.65
SEm(±)	**21.12**	**21.18**	**14.95**	**0.39**	**0.41**	**0.28**	**0.94**	**0.61**	**0.56**	**0.40**	**0.49**	**0.32**
LSD (0.05)	**63.31**	**63.50**	**43.08**	**1.17**	**1.22**	**0.81**	**2.82**	**1.82**	**1.61**	**1.21**	**1.47**	**0.92**
Interaction												
B_0V_1	615.37	655.04	635.21	13.05	14.42	13.74	49.92	51.47	50.70	43.21	42.44	42.83
B_0V_2	1039.73	1067.30	1053.52	22.65	24.60	23.63	52.74	53.92	53.33	43.93	43.08	43.51
B_0V_3	382.80	467.53	425.17	8.85	10.67	9.76	52.84	55.61	54.23	42.53	44.33	43.43
B_0V_4	549.47	565.06	557.27	5.72	5.78	5.75	51.55	51.34	51.45	40.61	42.78	41.70
B_0V_5	307.70	296.43	302.07	6.00	5.61	5.81	50.49	50.42	50.46	42.18	41.15	41.67
B_1V_1	765.33	756.33	760.83	16.89	17.03	16.96	51.25	51.25	51.25	43.23	42.51	42.87
B_1V_2	1254.33	1295	1274.67	28.92	30.24	29.58	52.54	53.67	53.11	44.26	43.00	43.63
B_1V_3	523	571.33	547.17	12.51	13.43	12.97	53.04	55.37	54.21	42.65	44.38	43.52
B_1V_4	574	581	577.50	6.92	7.08	7.00	51.92	51.52	51.72	40.88	42.60	41.74
B_1V_5	384.33	392.33	388.33	7.96	8	7.98	50.24	50.55	50.40	42.00	41.24	41.62
SEm(±)	**29.87**	**29.95**	**21.15**	**0.55**	**0.58**	**0.40**	**0.94**	**0.86**	**0.79**	**0.57**	**0.69**	**0.45**
LSD (0.05)	**89.54**	**89.80**	**60.92**	**1.65**	**1.73**	**1.15**	**3.98**	**2.57**	**2.28**	**1.71**	**2.08**	**1.29**

Note: Y_1:2011-12; Y_2:2012-13; B_0: No Bio-inoculants, B_1- With Bio-inoculants, V_1: Girija, V_2 : White Excell, V_3:Remi, V_4:Pushpa and V_5:White Marvel.

seedling was dipped in bio-inoculants. Significantly highest curd weight (1274.67 g) as well as curd yield (29.58 t. ha^{-1}) was recorded in White Excel when treated with bio-inoculants. Variety White Marvel without bio-inoculants recorded the significantly lowest curd weight (302.07 g). Terai zone soil is characterized by low in available nitrogen and phosphorus due to the acidic nature of the soil. The iron and alluminium of the soil reacted with the applied inorganic phosphorus and get fixed as ferric phosphate or alluminium phosphate in the soil.

The initial growth and root development of the seedlings get affected due to poor availability of phosphorus. Seedling root dipping with *Azotobacter* and phosphate solubilizing bacteria might have enhanced the availability and solubility of the soil nitrogen and phosphorus which lead to increased vigour and curd yield. Bashyal (2011) pointed that biofertilizer inoculation enhances phytohormone production, nitrogen fixation, phosphate solubilization and specific activities of enzymes involved in the metabolic pathway might be the reason behind growth and yield improvement in cauliflower. Sharma and Sharma (2010) also reported significant improvement in plant height, number of leaves per plant, curd diameter, curd depth, gross weight/plant and marketable curd yield when cauliflower was treated with inorganic fertilizers in presence of biofertilizers. The results on quality attributes indicated that vitamin A as well as ascorbic acid content of curd for all the cauliflower varieties were increased in presence of biofertilizer however the differences were statistically non significant.

The experimental findings showed that seedling root dipping with bio-inoculants offers great potential as organic amendment for cauliflower cultivation. Growth and yield attributes were significantly influenced by interactions of bio-inoculation and varieties. Seedling root dipping with *Azotobacter chroococcum* and Phosphate solubilizing bacteria (*Acinetobacter sp*) containing bio-inoculants proved its superiority in enhancing the growth, yield and quality attributes of cauliflower. The practice will help to achieve desired yield, augment nutrient efficiency and will sustain the fertility and productivity of soil under terai zone of West Bengal. in long run.

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