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To standardize the ideal dose of boron and *Azotobacter* for commercial production on growth and yield of cauliflower (*Brassica oleracea* L var. *botrytis*)

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Abstract
The present investigation entitled. "*Micronutrient* and Biofertilizer on the plant growth and yield of cauliflower (*Brassica oleracea* var. *botrytis*)" was carried out during winter season of 2016-17 at Agricultural farm, Department of Agricultural Sciences & Engineering, IFTM University, Lodhipur Rajput, Moradabad (U.P.) in Randomized Block Design with three replications. Different combinations of A_1 (*Azotobacter*@750ml/ha) A_2 (*Azotobacter*@1000ml/ha), B_1 (Boron @10kg/ha) and B_2 (Boron @15kg/ha) and control were used as treatment. Observations were recorded on vegetative and yield parameters. On the basis of observations recorded, it is found that the performance of the A2B2 (Azotobacter@1000ml/ha+Boron@15kg/ha) was better in all plant growth and yield parameters such as plant height (36.21cm), number of leaves (14.33),leaf length **(**30.95cm) and leaf width**(**14.45cm),15, 30 and 45 DAT, curd initiation(77.80), curd diameter**(**17.58cm),**c**urd weight per plant(1039.33g),leaves weight/plant**(**760.00g) and yield (428.00qu/ha.). The values for the plant height(36.21cm), number of leaves (14.33cm), at 15, 30 and 45 DAT, curd weight per plant (1039.33g) and yield (428.00qu/ha.) were recorded nearly similar in a treatment combination of *Micronutrient* and Biofertilizer T_6 A2B2(Azotobacter@1000ml/ha + Boron@ 15kg/ha).
The treatment T_6 A2B2 (Azotobacter@1000ml/ha+Boron@15kg/ha) came out as the best combination for growth and yield characters of cauliflower for commercial production because organically produced vegetable fetch higher price in the market therefore, even if the yield is slightly low with organic inputs, it can be recommended for the commercial production of cauliflower in account of human health, soil health, environmental health and quality product instead of quantity.

Keywords: *Micronutrient* and bio fertilizeron cauliflower, growth and yield

Introduction
In the past, the vegetables were considered to be luxury. Vegetables supplied some of the essential constituents in which the other food minerals are deficient i.e. vitamins and minerals, whose play an important role in human diet. The roles of vegetables in human diet have been recognized all over the word from the ancient times, we get many specific substances from vegetables, needed by human body for growth, reproduction and maintenance of a good health. Among the vegetables, cauliflower (*Brassica oleracea* L var. *botrytis*) is an important member of Crucifer and has probably been rightly described as an aristocrat of Cole crops. The name cauliflower consists of two Latin words namely 'caulis' means cabbage and 'floris' means flower. It is grown throughout the country for its tender curds which are used as vegetable, soup and for pickling. The estimated area under cauliflower is 0.42 million hectares, 8.19 MT productions with 19.8 MT, productivity and 4.9 % production share in Indian vegetable production.
The crop is reported to be a native of Southern Europe in the Mediterranean region and was introduced in India in 1822 from England (Chatterjee, 1986). It is the only vegetable crop which is next to potato. Cauliflower has high protein and peculiar in stability of vitamin C after cooking. It is rich in minerals such as potassium, sodium, iron, phosphorus, calcium, magnesium etc. It also contains vitamin A (Singh, 1997). The popularity of the crop has been constantly increasing and now it occupies more area than other vegetables in certain parts of the world.

The indiscriminate use of chemical fertilizers has simultaneously resulted in many problem slike degradation of soil productivity, environment pollution, depletion of non-renewable source of energy etc. Hence, the use of chemical fertilizers should be reduced to the minimum and may besubstituted with integrated use of manures, fertilizers, green leaf manure and bio-fertilizers. The approach of integrated plant nutrient system aims at sustaining productivity with minimum deleterious effects of chemical on soil health and environment. In this direction, the applications of bio-fertilizers in vegetable crops have been found very effective. Bio-fertilizers offer an economically attractive and ecologically sound means of reducing external inputs and improving quality and quantity of internal sources. These inputs contain microorganisms which are capable of mobilizing nutritive elements from non-usable form to usable form through different biological process. They are also less expensive, eco-friendly and sustainable; do not require non-renewable source of energy during their production and improve growth and quality of crops by producing plant hormones. Bio-fertilizers also increase the sustainability of the soil and make it more productive. Being bio-control agents, these control many plant pathogens and harmful microorganisms. Various bio-fertilizers which commonly used are *Azotobacter*, *Azospirillum*, Phosphate solubilizing bacteria, *Vesicular Arbuscular mycorrhiza* etc. *Azotobacter* (free living) and *Azospirillum* (Associative symbiotic) are nitrogen fixing bacteria, fixes about 30 kg N/ ha. Apart from the ability to fix atmospheric nitrogen, these are also known for synthesis of biologically active growth promoting substances such as indole acetic acid, gibberellin and Vitamin B in culture media. Phosphate solubilizing bacteria and *Vesicular Arbuscular mycorrhiza* are the important microbes in releasing and making available phosphorous by colonizing the root surface of growing plant root. They also improve theplant growth due to increase in nutrient uptake particularly phosphorus, zinc and other micronutrients, production of growth promoting substances and resistance to plant pathogens.

Materials and Methods

The present study entitled "Effect of micronutrient and biofertilizer on growth and yield of Cauliflower (*Brassica oleracea* L. var. *botrytis*)" was carried out during the winter season in 2016- 17. The details of materials used and research methodology followed during the course of present investigation are described as follows. The experiment was laid out in randomized block design (RBD). All treatments were randomly allocated among the plots and replicated three times and treatment eight [T_0, control; A_1, (*Azotobacter*@750ml/ha); A1B1**,** *(Azotobacter*@750ml/ha+Boron@10kg/ha);A1B2, (*Azotobacter*@750ml/ha+Boron@15kg/ha);A2,(*Azotobacter* @1000ml/ha); A2B1, (*Azotobacter*@1000ml/ha +Boron @10kg/ha); A2B2, (*Azotobacter*@1000ml/ha +Boron @15kg/ha); B1, (Boron @10kg/ha): B2, (Boron @15kg/ha) including standard control.

Results and Discussion

Application of different *Micronutrient* and biofertilizer improved the vegetative growth significantly. Maximum plant height was recorded with treatment A2B2 (21.14cm, 36.21cm) followed by A2 B1 (20.80 cm and 35.53 cm) at 30 and 45 DAT. Maximum leaf length 16.79 cm and 30.95 cm, respectively were recorded at 30 DAT and 45 DAT under the treatment A2B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) followed by treatment A2B1 (Azotobacter @1000ml/ ha + Boron @ 10 Kg/ ha), where 16.58 cm and 30.17 cm leaf length, respectively were recorded at 30 and 45 days after transplanting of seedlings. Maximum leaf width 7.32 cm was recorded at 30 DAT under the treatment A1B1 (Azotobacter@750ml/ ha + Boron @ 10 Kg/ ha) followed by treatment B1 (Boron @ 10 Kg/ ha) where 7.12 cm leaf width was recorded. While maximum leaf width at 45 DAT 14.45 cm was recorded under the treatment A2B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) followed by treatment A2B1 (Azotobacter @1000ml/ ha + Boron @ 10 Kg/ ha), where 14.23 cm leaf width was recorded. Maximum number of leaves also recorded with treatment A2 B2 (9.73 and 14.33)) followed by A2 B1 (9.67, 14.07) at 30 and 45 DAT (Table1).

These results may be attributed to conjoin effects of spray of besal dose and application of *Micronurient* and Biofertilizer. This might have increased the total beneficial microbial population in the *rhizosphere* which improved the growth of the plants by enhancing the availability of nutrients like N, P, K, Zn, Cu, etc. and plant growth hormone as well tomato in onion and Yadegari (2016) [13] in lemon balm. Azotobacter spp. are non – symbiotic heterotrophic bacteria capable of fixing an average 20kgN/ha/year. Bacterization helps to improve plant growth and to increase soil nitrogen through nitrogen fixation by utilizing carbon for its metabolism. Therefore, adequate supply of nitrogen is necessary to achieve high plant height. Boron plays a key role in a diverse range of plant functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes, movement of sugar or energy into growing parts of plants. Adequate boron is also required for effective nitrogen supply. Similar findings were also reported by, Eleiwa *et al.,* (2012) [4], in cabbage and Kashyap *et al.,* (2005) [6] in cabbage and cauliflower.

There is increment in no of leaf width (cm) by the application of *Azotobacter*, its stimulate development of foliage, roots, branching etc. which is triggered by fixed nitrogen and plant growth regulator like substances produced. Because negative correlation between leaf width and leaf length. Similar findings were also reported by Eleiwia *et al.,* (2012), Choudhary *et al.,* (2014) in garlic and Singh *et al.,* (2014) [2] in broccoli.

There is increment in no of leaves/ plant by the application of *Azotobacter*, its stimulate development of foliage, roots, branching etc. which is triggered by fixed nitrogen and plant growth regulator like substances produced. Similar result put forwarded by (Sandeep *et al.,* 2011,) [10] Adequate boron is also required for effective nitrogen supply. Similar 32 findings were also reported by Patra *et al.,* (2016) in tomato, Eleiwa *et al.,* (2012) [4] in wheat and Sarhan *et al.,* (2011) in summer squash.

Table 1: Effect of *Micronutrient* and Biofertilizer Growth & Yield of Cauliflower

S. N.	Treatments	Plant height at 15 DAT	Plant height at 30 DAT	Plant height at 45 DAY
1	T_1 (Azotobacter@750ml/ha)	11.923	19.253	33.633
2	T_2 (Azotobacter@750ml/ha+ Boron@10kg/ha	13.633	20.660	34.073
3	T_3 (Azotobacter@750ml/ha+ Boron@15kg/ha)	13.763	20.753	34.327
4	T_4(Azotobacter@1000ml/ha)	13.567	19.467	34.327
5	T_5 (Azotobacter@1000ml/ha+Boron@10kg/ha)	13.893	20.800	35.527
6	T_6 (Azotobacter@1000ml/ha+Boron@15kg/ha)	13.983	21.137	36.213
7	T_7 (Boron@10kg/ha)	13.527	18.813	34.287
8	T_8 (Boron@15kg/ha)	13.617	19.267	34.427
9	T_9 (Control)	11.633	17.100	31.587
SE(m)±		0.553	0.517	0.520
C.D.at 5%		NS	1.563	1.572

The revealed that plant height at 30 DAT and 45 DAT was significantly influenced by the various treatment combinations of boron and Azotobacter, while plant height at 15 DAT was non-significant. Maximum plant height i.e. 21.14 cm and 36.21 cm were recorded at 30 DAT and 45 DAT, respectively under the treatment A2 B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) The significantly maximum incensement in plant height at 30 and 45 DAT under the treatment A2 B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) might be due to combined effect of Azotobacter and boron at higher rates, where Azotobacter utilize atmospheric nitrogen gas for their cell protein synthesis. Similar findings were also reported by 30 Patra *et al.*, (2016) in tomato, Chaudhary *et al.*, (2014) in onion and Yadegari (2016) [13] in lemon balm.

Table 2: Effect of *Micronutrien*t and Biofertilizeron No. of leaves at 15, 30 and 45 days after transplanting.

S. N.	Treatments	No. of plant leaves at 15 DAT	No. of plant leaves at 30 DAT	No. of plant leaves at 45 DAT
1	T_1 (Azotobacter@750ml/ha)	6.000	9.067	13.200
2	T_2 (Azotobacter@750ml/ha+ Boron@10kg/ha)	6.067	9.200	13.667
3	T_3 (Azotobacter@750ml/ha+ Boron@15kg/ha)	6.367	9.333	14.067
4	T_4 (Azotobacter@1000ml/ha)	6.133	9.100	13.333
5	T_5 (Azotobacter@1000ml/ha+Boron@10kg/ha)	6.300	9.667	13.433
6	T_6 (Azotobacter@1000ml/ha+Boron@15kg/ha)	6.333	9.733	14.333
7	T_7 (Boron@10kg/ha)	6.033	8.867	13.333
8	T_8 (Boron@15kg/ha)	6.000	9.033	13.500
9	T_9 (Control)	5.667	8.400	13.000
SE(m)±		0.168	0.203	0.195
C.D.at 5%		NS	0.613	0.591

That maximum leaf length 16.79 cm and 30.95 cm, respectively were recorded at 30 DAT and 45 DAT under the treatment A2B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) The significantly maximum leaf length at 30 and 45 DAT under the treatment A2B2(Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha), due to combined effect of Azotobacter and boron at higher rates, where Azotobacter spp. are non – symbiotic heterotrophic bacteria capable of fixing an average 20kgN/ha/year (Kizilkaya, R. 2009). Bacterization helps to improve plant growth and to increase soil nitrogen through nitrogen fixation by utilizing carbon for its metabolism (Monib *et al.*, 1979a). Findings were also reported by Patra *et al.*, (2016) in tomato, Eleiwa *et al.*, (2012) [4] in wheat and Sarhan *et al.*, (2011) in summer Squash, Azotobacter spp. are non – symbiotic heterotrophic bacteria capable of fixing an average 20kgN/ha/year (Sandeep *et al.*, 2011) [10] its stimulate development of foliage, roots, branching etc.

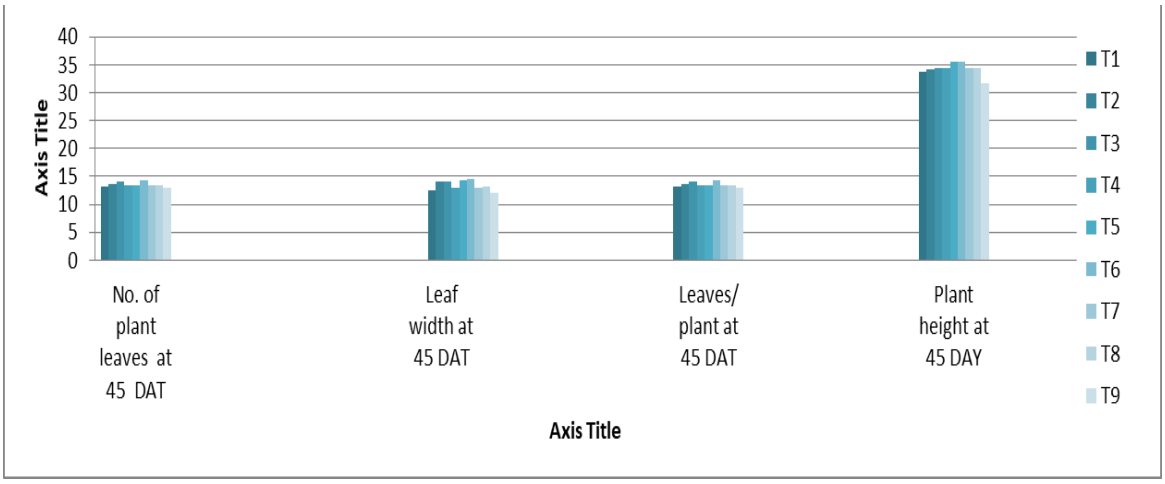

Fig 1: Vegetative growth of cauliflower

Table 3: Effect of boronand *Azototobacter* on leaf width (cm) at 15, 30 and 45 DAT

S. N.	Treatments	Leaf width 15 DAT	Leaf width at 30 DAT	Leaf width at 45 DAT
1	A_1 (Azotobacter@750ml/ha)	3.74	6.49	12.56
2	A_1B_1 (Azotobacter@750ml/ha+Boron@10kg/ha)	3.96	7.32	14.11
3	A_1B_2 (Azotobacter@750ml/ha+Boron@15kg/ha)	3.85	7.05	14.11
4	A_2(Azotobacter@1000ml/ha)	3.76	6.65	12.88
5	A_2B_1(Azotobacter@1000ml/ha+Boron@10kg/ha)	4.18	6.44	14.23
6	A_2B_2(Azotobacter@1000ml/ha+Boron@15kg/a)	4.25	7.02	14.45
7	B_1 (Boron@10kg/ha)	4.15	7.12	12.99
8	B_2 (Boron@15kg/ha)	4.06	6.65	13.21
9	A_0B_0(Control)	3.86	6.13	12.03
SE(m)±		0.334	0.233	0.379
C.D.at 5%		NS	0.703	1.145

Table 4: Effect of boronand *Azotobacter* on number of leaves per plant at 15, 30 and 45 DAT

S. N.	Treatments	Leaves/ plant at 15 DAT	Leaves/ plant at 30 DAT	Leaves/ plant at 45 DAT
1	A_1 (Azotobacter@750ml/ha)	6.00	9.07	13.20
2	A_1B_1 (Azotobacter@750ml/ha+ Boron@10kg/ha)	6.07	9.20	13.67
3	A_1B_2 (Azotobacter@750ml/ha+Boron@15kg/ha)	6.37	9.33	14.07
4	A_2 (Azotobacter@1000ml/ha)	6.13	9.10	13.33
5	A_2B_1(Azotobacter@1000ml/ha+Boron@10kg/ha)	6.30	9.67	13.43
6	A_2B_2(Azotobacter@1000ml/ha+Boron@15kg/ha)	6.33	9.73	14.33
7	B_1 (Boron@10kg/ha)	6.03	8.87	13.33
8	B_2 (Boron@15kg/ha)	6.00	9.03	13.50
9	A_0B_0(Control)	5.67	8.40	13.00
SE(m)±		0.168	0.203	0.195
C.D.at 5%		NS	0.613	0.591

The revealed that number of leaves per plant significantly influenced by the different treatments at 30 and 45 DAT, while at 15 DAT, showed the non – significant effect. Maximum no. of leaves / plant (9.73 and 14.33) were recorded at 30 DAT and 45 DAT, respectively under the treatment combination A2 B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) Significantly maximum no. of leaves/ plant at 30 and 45 DAT under the treatment A2B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha), due to combined effect of Azotobacter and boron at higher rates, where Azotobacter spp. are non – symbiotic heterotrophic bacteria capable of fixing an average 20kgN/ha/year (Kizilkaya, R. 2009). Adequate boron is also required for effective nitrogen supply. Similar 32 findings were also reported by Patra *et al.*, (2016) in tomato, Eleiwa *et al.*, (2012) [4] in wheat and Sarhan *et al.*, (2011) in summer squash

Table 5: Effect of boronand *Azotobacter* on days to curd initiation, curd diameter (cm), Curd weight/plant (g), Leaves weight/plant (g) and Curd yield (Q/ha).

S. N.	Treatments	Days to curd initiation	Curd diameter (cm)	Curd weight/plant (g)	Leaves weight/plant (g)	Curd yield (Q/ha)
1	A_1 (Azotobacter@750ml/ha)	83.93	15.43	861.33	666.00	318.33
2	A_1B_1 (Azotobacter@750ml/ha+ Boron@10kg/ha)	80.33	16.47	948.67	673.33	370.33
3	A_1B_2 (Azotobacter@750ml/ha+Boron@15kg/ha)	80.33	16.55	967.33	731.00	388.00
4	A_2 (Azotobacter@1000ml/ha)	83.13	15.62	880.00	734.67	336.00
5	A_2B_1(Azotobacter@1000ml/ha+Boron@10kg/ha)	79.27	16.64	966.67	760.00	411.00
6	A_2B_2(Azotobacter@1000ml/ha+Boron@15kg/ha)	77.80	17.58	1039.33	708.00	428.00
7	B_1 (Boron@10kg/ha)	81.85	15.50	896.67	719.33	341.67
8	B_2 (Boron@15kg/ha)	80.23	15.58	913.33	672.00	353.00
9	A_0B_0(Control)	84.27	15.33	842.67	610.33	301.00
SE(m)±		1.001	1.001	0.878	19.696	12.616
C.D.at 5%		3.028	3.028	2.656	59.558	38.148

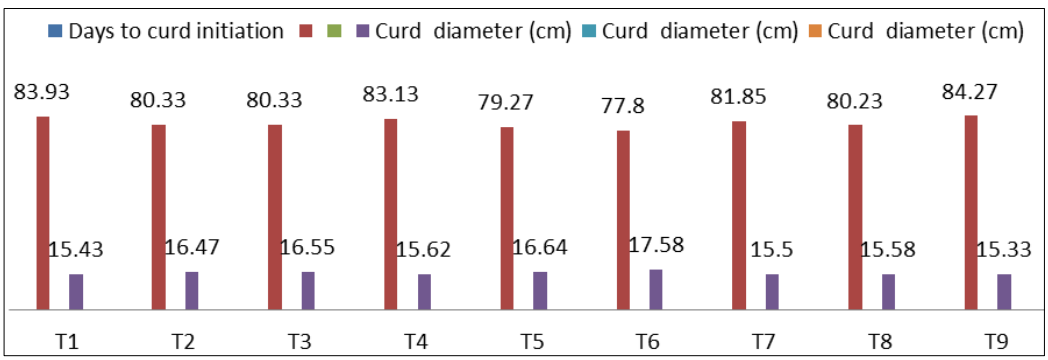

Fig 2: Days to curd initiation and curd diameter (cm)

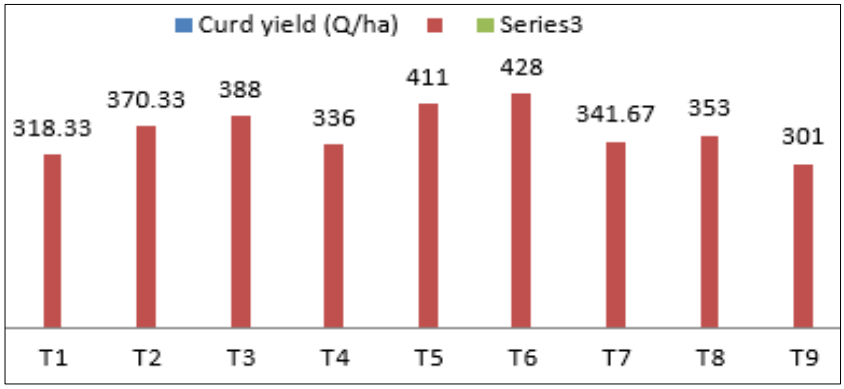

Fig 3: Curd yield (Q/ha)

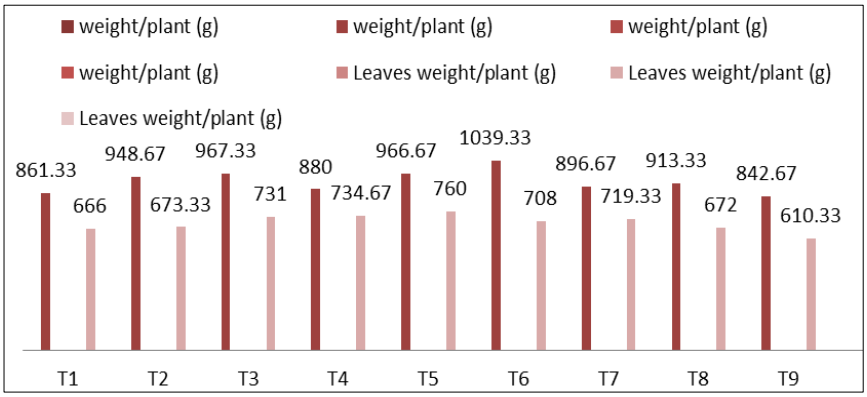

Fig 4: Weight/plant (g) and leaves weight/plant (g)

The data revealed that days to curd initiation significantly influenced by the treatment combinations. It is evident from table that minimum days recorded (77.80) for curd initiation under the treatment A2B2 (Azotobacter @1000 ml/ ha + Boron @ 15 Kg/ ha) Early curds initiation was recorded in this experiment under the under the treatment A2B2 (Azotobacter @1000 ml/ ha + Boron @ 15 Kg/ ha) due to the combined effect of Azotobacter and boron at higher rates. Azotobacter in balanced nutrient condition results in 3.5% increment in leaf area index at rosette stage of canola crop and additional application of Azotobacter shot up the yield by 21.17% over the control (chemical fertilizer) Yasari *et al.*, (2007) flowering sites and in developing fruits. Our findings are close conformity with the findings of Moniruzzaman *et al.*, (2007) [7], Chander *et al.*, (2010) [1], Rakesh *et al.*, (2010) and Das *et al.*, 2015) [3] in garden pea.

That curd diameter of cauliflower significantly influenced by the applications of boron and Azotobacter individually and in all possible combinations. That maximum curd diameter i.e. 17.58 cm was recorded under the treatment A2B2 (Azotobacter @1000 ml/ ha + Boron @ 15 Kg/ ha) Significantly maximum curd diameter was recorded under the treatment A2B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) in all treatments in this experiment due to the combined effect of Azotobacter and boron. Azotobacter in balanced nutrient condition results in 3.5% increment in 33 leaf area index at rosette stage of canola crop and additional application of Azotobacter shot up the yield by 21.17% over the control (chemical fertilizer) Yasari *et al.*, (2007). Similar findings were also reported by Moniruzzaman *et al.*, (2007) [7], Chander *et al.*, (2010) [1], Rakesh *et al.*, (2010) and Das *et al.*, 2015) [3] in garden pea.

The revealed that curd weight per plant significantly influenced by the different treatment of Azotobacter and boron. Maximum curd weight/ plant (1039 g) was recorded under the treatment A2B2 (Azotobacter @1000 ml/ ha + Boron @ 15 Kg/ ha) Significantly maximum curd weight/plant was recorded under the treatment A2B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) as well as curd diameter in all treatments in this experiment. Curd diameter and curd weight/ plant in cauliflower are correlated to each other. Similar results were also reported by Moniruzzaman *et al.*, (2007) [7], Chander *et al.*, (2010) [1], Rakesh *et al.*, (2010) and Das *et al.*, 2015 [3] in garden pea.

The leaves weight/plant (g) significantly influenced by the application of Azotobacter and boron. The maximum leaves weight/plant

(g) i.e. 760.00g was recorded under the treatment A2B1 (Azotobacter @1000 ml/ ha + Boron @ 10 Kg/ ha) followed by treatment A2 (Azotobacter @1000 ml/ ha) Significantly maximum leaves weight/ plant was recorded under the treatment A2B1 (Azotobacter @1000 ml/ ha + Boron @ 10 Kg/ ha) followed by treatment A2 (Azotobacter @1000ml/ ha). It's might be due to the effect of Azotobacter, where Azotobacter spp. are non – symbioticheterotrophic bacteria capable of fixing an average 20kgN/ha/year (Kizilkaya, R. 2009). Similar result put forwarded by Sandeep *et al.*, 2011 [10], which revealed that there is better growth response of Azotobacter inoculated plants as compared to non – inoculated control plants. Similar findings were also reported by Patra *et al.*, (2016) in tomato, Eleiwa *et al.*, (2012) [4] in wheat and Sarhan *et al.*, (2011) in summer squas Curd yield significantly influenced by the different treatment combinations.

Maximum curds yield(428.00 q/ha) was recorded under the treatment A2 B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) Maximum curds yield was recorded under the treatment A2 B2 (Azotobacter @1000ml/ ha + Boron @ 15 Kg/ ha) at *par* with A2B1 (Azotobacter @1000ml/ ha + Boron @ 10 Kg/ ha) might be due to the combined effect of

Azotobacter and boron at higher levels. Azotobacter in balanced nutrient condition results in 3.5% increment in leaf area index at rosette stage of canola crop and additional application of Azotobacter shot up the yield by 21.17% over the control (chemical fertilizer) Yasari *et al.,* (2007). The rate of increase in the leaf area determines the photosynthetic capacity of plant, which leads to better assimilation of produce and towards yield while boron increases the rate of transport of sugars (which are produced by photosynthesis in mature plant leaves) to actively growing regions, flowering sites and in developing fruits. Our findings are close conformity with the findings of Moniruzzaman *et al.,* (2007) [7], Chander *et al.,* (2010) [1], Rakesh *et al.,* (2010) and Das *et al.,* 2015) [3] in garden pea.

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