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RESEARCH ARTICLE

RESPONSE OF AZOTOBACTER IN CAULIFLOWER (*BRASSICA OLERACEA* L. VAR. *BOTRYTIS*) PRODUCTION AT LAMJUNG, NEPAL

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ABSTRACT

A field experiment was carried out at research field of Lamjung Campus, Nepal during September 2015 to February 2016 to assess the response of cauliflower (*Brassica oleracea* L. var. *botrytis*) to different combination of nitrogenous fertilizer with Azotobacter. 6 treatment with 4 replications were laid out in Randomized Complete Block Design. Phosphorous and potassium was applied full does in all the treatments with chemical fertilizer. It was recorded that the application of recommended doses of nitrogen along with the bio-fertilizer significantly increased morphological characters and yield as compared to other treatments. Besides, the stem diameter was non-significant to the different treatments. It was followed by the full dose of NPK without azotobacter and then 50% nitrogen with azotobacter, which was statistically at par with 25% nitrogen with azotobacter, followed by FYM + Azotobacter. Curd yield along with all the morphological characters were seen lowest in control. Cauliflower curd yield at recommended dose of nitrogen did not significantly differ with the curd yield recorded at half of recommended dose of nitrogen with azotobacter. The finding demonstrated a saving of 50% of nitrogen where it can be substituted with the application of bio-fertilizer to increase the yield and morphological character.

KEYWORDS

biofertilizer, cole crop, inoculation, soil healt

1. INTRODUCTION

Cauliflower (*Brassica oleracea* L. var. *botrytis*), member of family Crucifier is one of the most important vegetable crops grown extensively in sub-temperate climate throughout the world. It is an important commercial vegetable crop grown in Nepal and is one of the highly preferred vegetables in Nepalese kitchen. It is a heavy feeder of mineral elements, it removes large number of macronutrients from the soil. So, it demands constant supply of large amount of nutrients and water for its luxuriant growth. A yield of 50 ton ha^{-1} cauliflower removes approximately 200 kg nitrogen, 85kg phosphorus and 270 kg potassium [1]. Its demand is increasing day by day to meet the requirement of increasing population. But, the productivity of cauliflower in Nepal is still low as compared to other developed countries. The balanced supply of nutrients and scientific management practices has a potential to increase the productivity of cauliflower.

Biofertilizer are a microbial product containing millions of targeted efficient microorganisms for bionutrient delivery to the crop through seed or soil or root inoculation [2]. Biofertilizer means the product containing carrier base (solid/liquid) living microorganisms which are agriculturally useful in terms of nitrogen fixation, phosphorus solubilization or nutrient mobilization to increase the productivity of the soil and or crop [3]. The commonly used artificial multiplied culture of microorganisms for biofertilizer are Rhizobium, Cyanobacteria, Azosipirillum, Azotobacter, Acetobacter, Mycorrhiza, Pseudomonas, Bacillus and Azolla, which can improve soil fertility and crop productivity through augmenting nutrient availability and uptake, stimulating plant growth, controlling and resisting soil borne diseases and improving the soil health and properties [2]. It also imparts better health to plants and soil thereby enhancing crop yields in a moderate way.

It is a natural method without any problem like salinity and alkalinity, soil erosion, soil health, deterioration etc. The microorganisms can be free living or symbiotic with plants and fix atmospheric nitrogen which is plentiful available. Application of biofertilizers help in improving number of biological activities of desired microorganisms in soil and helps to improve plant growth, fruit yield, seed yield and quality. Furthermore, biofertilizers are the non-bulky and cheap sources of nutrients and may prove cost effective and eco-friendly supplementation in vegetable farming and having capacity to increase 2 to 45% yield in vegetable crops [4]. Amongst biofertilizers, Azotobacter has beneficial effects not only to their nitrogen fixing efficiency but also with their ability to produce anti-bacterial and anti-fungal components and growth regulation [5]. Azotobacters are known to increase seed germination rate, root and shoot length, improve nitrogen nutrition, reduce disease incidence, increase grain yield and improve post-harvest seed quality [6].

The integrated use of chemical fertilizers, organic manures and biofertilizers hold great promise to increase the production of cauliflower with less cost. Numbers of vegetables including cauliflower have been found to responding well for better development of growth and yield, particularly increase in curd size and yield of cauliflower to application of biofertilizers along with inorganic fertilizers. Application of chemical fertilizers alone can supply only one or two nutrient elements to the crop. It also deteriorates the soil health as well as pollutes the water bodies and environment in a great extent. On the other hand, supplying only organic inputs can improve soil physical and biological environment but suffers from drawback of low content of plant nutrients. The cost of the chemical fertilizers is in increasing trend, so some day it may reach beyond the reach of marginal farmers in near future. Application of biofertilizer which is environment friendly and a low-cost input along with organic fertilizer play an important role in plant nutrition. The role of the biofertilizer is also perceived as the growth regulators besides its use in nitrogen fixation leading to much higher response on various growth and yield attributing characters [7]. Therefore, there is a need to develop a suitable integrated nutrient management technology which will help in building of soil fertility and productivity of cauliflower. Therefore, the present study was designed to study the integrated use of FYM, biofertilizer, and chemical fertilizers for curd yield, quality of cauliflower and morphologicl characters. This study was conducted to increase the production of cauliflower through the use of Azotobacter.

2. MATERIALS AND METHOD

The research was conducted in horticulture farm of IAAS, Sundarbazar, Lamjung at an altitude of about 650 masl with Longitude of 84° 11'- 84° 38' E and Latitude of 28° 3'- 28° 30' N. The research was designed in a single factor RCBD (Randomized Complete Block Design) with 4 replication and 6 treatments, consisting of different doses of nitrogen and biofertilizer (Azotobacter). The variety of cauliflower (Brassica oleracea var. botrytis L.) var. Snow Mystique was used. The gross area of the plot was 1.8m x 3m (5.4m^2) whereas the net area of plot was 0.9m x 1.8m (1.6m^2). The distance between two plots was maintained 25cm and the spacing within the plot i.e. plant to plant distance was maintained 45cm x 60cm.The accurate doses of FYM i.e. 20 ton ha^{-1} and NPK i.e. 100:60:50 kg NPK ha^{-1} were applied in each plot according to its treatment. Quantitative data were collected before harvesting of the crop. Plant height (cm), Total number of leaves, Leaf length (cm), Leaf breadth (cm), Plant spread (cm), etc. were the parameters of the plants observed before harvesting. Data were analysed by Statistical Package R, Microsoft Excel.

2.1 Inoculum of Azotobacter

A slurry (10%) was prepared for performing inoculation of seedling. Biofertilizer (Azotobacter) @ 2kg per ha was added to the slurry. The seedlings were then uprooted from the nursery bed and required number of seedlings were then dipped into the slurry of inoculation and kept for 30 minutes. 25 days old seedlings were uprooted.

Table 1: Treatments with its doses

Treatments	
T_1	Control
T_2	FYM + Seedling Inoculation (Azotobacter)
T_3	FYM + 100% NPK
T_4	FYM + 100% NPK + Inoculation
T_5	FYM + 50% N + PK + Inoculation
T_6	FYM + 25% N + PK + Inoculation

3. RESULT AND DISCUSSION

3.1 Plant height at 35 DAP

The plant height was significantly influenced by the different treatments. The plant showed maximum height with the application of full doses of NPK along with azotobacter followed by full doses of NPK without azotobacter and then the half dose of nitrogen with azotobacter which was statistically at par with 25% nitrogen with azotobacter. The minimum height was seen in control which was statistically at par with the treatment with FYM + azotobacter. The present data showed that, plants remained dwarf in unfertilized plots (T_1) but plant height was improved with the application of chemical or biofertilizers. The significant difference in plant height must have been attributed owing to certain growth promoting substances secreted by microbial inoculants and increased availability of nitrogen due to the application of the nitrogen fixing azotobacter as they fix the atmospheric nitrogen. The present study finds the support of work reported better growth in onion when those were inoculated with the cultures of Azotobacter and Azospirillum [8,9]. It has been reported that secretion by these bacteria led to better root development which promoted uptake of nutrients, thus, improved the plant height [10].

3.2 Plant height at 60 DAP

The plant height at 60 days after transplanting was significantly influenced by different treatments. Plants with the treatment of full doses of NPK along with azotobacter produced significantly higher plant height as compared to all other treatments. Furthermore, the plant height was not significantly influenced by any of the other treatments. The difference might be attributed due to the secretion of growth regulating substances by the microorganism and the non-significant difference in any other treatment may be due to genetic factors [11].

3.3 Plant height at Harvest

The plant height at harvest was significantly influenced by different treatments. Plants with the treatment of full doses of NPK along with azotobacter produced significantly higher plant height as compared to all other treatments followed by 50% of nitrogen with azotobacter that was statistically at par with full dose of nitrogen without azotobacter and FYM with azotobacter. The lowest plant height was seen in the plot where no any organic or inorganic fertilizer was used, which was at par with 25% nitrogen with azotobacter.

3.4 Number of leaves at 35 DAP

The data presented above showed significant differences for number of leaves in cauliflower with different treatments. It was noticed that maximum number of leaves in cauliflower was obtained in plots where Azotobacter along with recommended dose of nitrogen was applied which was at par with 50% nitrogen with aztobacter followed by 25% nitrogen with azotobacter, which was at par with full dose of nitrogen without azotobacter and FYM + azotobacter. The lowest number of leaves was recorded in plots where no fertilizer i.e. either organic or inorganic was applied. The increase in leaf number could be because of certain growth promoting substances secreted by microbial inoculants and increased the availability of nitrogen. More numbers of leaves cause more photosynthesis which may lead to increase in curd yield in cauliflower. During present investigation, it was observed that in plots where biofertilizers was applied produced a greater number of leaves and these results are in accordance with the findings [9,12].

3.5 Number of leaves at 60 DAP

The data presented above showed significant differences for number of leaves in cauliflower at 60 DAP with different treatments. It was noticed that maximum number of leaves in cauliflower was obtained in the plots where Azotobacter along with recommended dose of nitrogen was applied which was at par with 50% nitrogen with aztobacter, 25% nitrogen with azotobacter, FYM + azotobacter and Full dose of nitrogen without azotobacter. The lowest number of leaves was recorded in the plots where no fertilizer i.e. either organic or inorganic was applied. These less difference in leaf numbers might be attributed due to the reasons that these parameters are under strong genetic influence and did not show significant effect.

3.6 Plant Spread

The data shown above revealed that maximum plant spread was found in plots where azotobacter was applied with full dose of nitrogen, followed by the treatment with azotobacter + 50% nitrogen which was statistically at par with 25% nitrogen with azotobacter, FYM + azotobacter and full dose of nitrogen without azotobacter. Minimum plant spread was recorded in treatment where neither organic nor inorganic fertilizer was applied. The more the plant spread, the more will be the exposed part to the sunlight, which may lead to increase in photosynthesis and apart from this, the more canopy coverage causes more shading effect which helps in moisture retention.

Table 2: Effect of Azotobacter on plant height, leaf no., plant spread, leaf area and yield of cauliflower in Lamjung 2015/16

Treatments	Plant height (cm) at 35 DAP	Plant height (cm) at 60 DAP	Plant height at Harvest	No. Of leaves at 35DAP	No. Of leaves at 60DAP	Plant Spread (cm)
contrl	4.589^{e}	12.96^{b}	16.59^{b}	5.33^{c}	10.33^{b}	58.1^{b}
FYM+ino	5.300^{de}	14.22^{b}	17.22^{ab}	5.67^{bc}	11.33^{ab}	64.8^{ab}
FYM+100%N	7.489^{b}	16.72^{b}	17.28^{ab}	6.67^{bc}	12.33^{ab}	71.6^{ab}
FYM+100%N+ino	9.011^{a}	22.74^{a}	20.89^{a}	9.00^{a}	13.33^{a}	76.3^{a}
FYM+50%N +ino	6.522^{c}	16.73^{b}	17.97^{ab}	7.33^{ab}	12.00^{ab}	72.3^{ab}
FYM+25%N +ino	6.000^{cd}	16.30^{b}	16.78^{b}	5.67^{bc}	11.33^{ab}	65.3^{ab}
Significance	**	**	*	**	*	*

Means within the column followed by the same letter(s) do not differ significantly at 0.05%

* = Significance, ** = highly significance, ino = inoculation

3.7 Leaf area at 35 DAP

The data below showed smallest leaf area (length and breadth) was found in the plots where neither inorganic nor biofertilizers was applied. Further data showed, maximum leaf area from the treatment where azotobacter was applied along with recommended dose of nitrogen, followed by the treatment where a full dose of recommended NPK without azotobacter was applied. It was statistically at par with the treatment with FYM + azotobacter, 50% nitrogen with azotobacter and 25% nitrogen with azotobacter. Biofertilizers significantly influenced the parameters like leaf length which caused more photosynthesis that may lead to more yield. Plant on exposure to the action of growth promoting substances like auxin and gibberellins synthesized by inoculated microorganisms and leaf breadth which tends to increase the leaf area index resulting in more chlorophyll content by inoculated microorganisms [13]. Similar results were also reported found that inorganic as well as biofertilizers greatly influenced the growth of plants and thereby various physiological parameters [14,15].

3.8 Leaf area at 60 DAP

The data above showed smallest leaf area in the plots where neither inorganic nor biofertilizers was applied. Further data showed, maximum leaf area from the treatment where azotobacter was applied along with recommended dose of nitrogen followed by the treatment with 50% nitrogen with azotobacter and 25% nitrogen with azotobacter which was statistically at par with full dose of nitrogen without azotobacter that is at par with FYM + azotobacter.

3.9 Curd Height

The curd height was significantly increased with application of biofertilizers along with chemical fertilizers compared to recommended dose of fertilizers. Application of azotobacter with full dose of nitrogen recorded the highest curd height which was at par with full dose of nitrogen without azotobacter, 50% nitrogen with azotobacter followed by 25% nitrogen with azotobacter which was at par with FYM + azotobacter. The lowest curd height was recorded in the plots where neither inorganic nor biofertilizers was applied. It directly influences the yield.

3.10 Curd Diameter

The highest curd diameter was recorded in the plot where full dose of recommended nitrogen along with azotobacter was applied which was at par with the other treatments beside control that recorded the lowest curd diameter. It directly influences the curd weight and yield of cauliflower. The larger diameter of the curd might be attributed by the secretion of growth regulating substances by the microorganisms.

3.11 Stem Diameter

The data presented above showed non-significant differences for diameter of stem in cauliflower. The non-significant result in stem diameter might be attributed due to the reasons that these parameters are under strong genetic influence and did not show significant effect.

3.12 Curd Weight

The data revealed that the lowest curd/head weight in cauliflower was found in plots, which was not fertilized at all (control). From further investigation of data, it was found that in cauliflower, maximum curd weight was obtained in plots where azotobacter was applied with full dose of nitrogen. It was significantly higher than treatment control, FYM + azotobacter, FYM + recommended dose of nitrogen, Azotobacter + 50% nitrogen, azotobacter + 25% nitrogen. Improvement in yield with azotobacter along with the recommended dose of nitrogen might be due to better fixation of atmospheric nitrogen, increased supply of nitrogen which may accelerate synthesis of chlorophyll, amino acids, enzymes and carbohydrate use and better uptake of soluble N by the plants. The abilities of Azotobacter (biofertilizer) have been postulated to be partially due to production of phytohormones, including gibberellins, cytokines like substances and auxins from tryptophan, ethylene and vitamins and partially due to nitrogen fixation.

3.13 Yield

Investigation of the data presented above revealed that yield of cauliflower was lowest in plots where neither chemical nor biofertilizers was applied. It was found that maximum yield was obtained in the plots where Azotobacter was applied with full dose of nitrogen followed by full dose of nitrogen without azotobacter which was at par with the treatment with Azotobacter + 50% nitrogen and azotobacter + 25% nitrogen. It was significantly higher than the control and FYM + Full dose of NPK. Use of biofertilizers in combination with chemical fertilizers was efficient in yield increase over the exclusive application of chemical fertilizers and can be attributed to increase in uptake of nutrients resulting in faster synthesis and translocation of photosynthates from source (leaves) to sink (curd).

Table 3: Effect of Azotobacter on plant height, leaf no., plant spread, leaf area and yield of cauliflower in Lamjung 2015/16

Treatments	Leaf area (cm^2) at 35 DAP	Leaf area (cm^2) at 60 DAP	Curd height (cm)	Curd diameter (cm)	Stem diameter (cm)	Curd weight (kg)	Yield (ton ha^{-1})
contrl	102.8^{c}	602^{c}	8.77^{c}	12.10^{b}	2.533	0.357^{c}	12.93^{d}
FYM+ino	115.5^{bc}	743^{bc}	9.83^{bc}	13.97^{ab}	3.100	0.687^{b}	24.43^{c}
FYM+100%N	176.1^{b}	857^{b}	11.63^{ab}	16.70^{ab}	3.200	0.847^{b}	33.33^{ab}
FYM+100%NPK+ino	250.3^{a}	1035^{a}	12.83^{a}	17.53^{a}	3.300	1.133^{a}	41.53^{a}
FYM+50%N+ino	135.2^{bc}	835^{b}	11.13^{ab}	16.63^{ab}	3.167	0.807^{b}	29.80^{bc}
FYM+25%N+ino	117.5^{bc}	782^{b}	10.50^{abc}	14.37^{ab}	2.867	0.693^{b}	27.53^{bc}
Significant	**	**	*	*	N.S.	**	**

Means within the column followed by the same letter(s) do not differ significantly at 0.05%

*Significance **, highly significance ino = inoculation

4. CONCLUSION

The present study concludes that leaf size i.e. leaf length and width of cauliflower was significantly influenced with azotobacter when applied along with full dose of nitrogen. The findings recorded maximum curd weight of cauliflower when seedlings of those were treated with azotobacter along with recommended level of nitrogen. The yield was also found maximum with the application of azotobacter along with full dose of nitrogen followed by azotobacter along with half dose of nitrogen which was statistically at par with the full dose of nitrogen without azotobacter. Thus, it was concluded that a saving of 50% of nitrogen can be obtained when the seedlings are treated with azotobacte i.e. 50% nitrogen can be substituted with the application of bio-fertilizer to increase the yield and morphological character.

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