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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND QUALITY OF CAULIFLOWER *(BRASSICA OLERACEA* VAR. *BOTRYTIS* L.)

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ABSTRACT

The present experiment was carried out with cauliflower cv. Poosi in a randomized block design with three replications. The experiment comprised of 15 different combinations of five different sources of nutrients including organic, inorganic and bio fertilizers alone and in combinations which were applied following the proper procedures as per treatment. The effect of different treatments were observed and noted that maximum plant height (66.75), plant spread (58.64), curd diameter(16.09), depth of curd (11.76), curd volume (702.00), weight of curd (568.00), yield per hectare (252.48) and ascorbic acid (63.19) was noted by application of ½ N:P:K (recommended dose)+ FYM@5t/ha + poultry manure@2t/ha+ *Azospirillum* (T_{14}). Hence it can be said that the application of ½ recommended dose of NPK along with FYM @5t/ha + poultry manure @2t/ha as well as seedling inoculation with *Azospirillum* was found to be the most effective treatment combination for getting enhanced yield and quality.

INTRODUCTION

Cauliflower (*Brassica oleracea* var. *botrytis* Linn.) is one of the most important vegetable crops belonging to the family *Brassicaceae*. It is being grown round the year for its white and tender curd. It is widely cultivated all over India and abroad for its special nutritive values, high productivity and wider adaptability under different ecological conditions. Like other vegetable crops of the family cauliflower is a heavy feeder of mineral elements, it removes large amount of macronutrients from the soil. Heavy manuring has been recommended for getting good yield of cauliflower by different workers in India (Roy, 1981, Randhawa and Khurana, 1983). Mineral nutrition does play an important role in influencing the quality of crops and it is fact that the soil health deteriorates due to continuous use of chemical fertilizers, Savci (2012). The integrated nutrient management paves the way to overcome these problems, which involves conjunctive use of chemical fertilizers and organic manures to sustain crop production as well as maintenance of soil health (Nanjappa *et al*., 2001). Systematic approach to nutrient management by tapping all possible sources of organic and inorganic in a judicious manner to maintain soil fertility and crop productivity is the essence of integrated nutrient management (INM). In addition, utilization of biofertilizers, which have a ability to enrich the soil with beneficial microorganisms as well as to mobilize the nutritionally important elements from non-usable to usable forms through biological processes resulting in enhanced production of fruits and vegetables offer an alternative (Purkayastha *et al*., 1998).The use of biofertilizers in combination with chemical fertilizers and organic manures offers a great opportunity to increase the production as well as quality of cauliflower. Among the nitrogen fixing bacteria, Azotobacter, not only provides nitrogen, but also synthesizes growth promoting hormones such as IAA and GA. Azospirillum also helps in plant growth and increases the yield of crops by improving root development, mineral uptake etc. The positive role of these biofertilizers has been recorded in many vegetables and spice crops by different scientists. To maintain long term soil health and productivity there is a need for integrated nutrient management through manures and biofertilizers apart from costly chemical fertilizers for better yield of the crop (Mondal *et al.,* 2003) Considering the above facts, the present study was planned and undertaken with the objective to assess the effect of integrated nutrient management on growth, yield and quality of cauliflower cv Poosi.

MATERIALS AND METHODS

The present investigation on effect of integrated nutrient management on growth, yield and quality of cauliflower was carried out in the Rabi season in 2010-11 at vegetable research farm and the laboratory at Bihar Agricultural College, Sabour .The experiment comprised of fifteen treatments (Table 1) and was laid in randomized Block design. Each treatment was replicated thrice. The plants were planted at a spacing of 45 cm each way and the plot size was 3.60 m x 2.25m. Thus the numbers of plants per plot were 40. The seed of cv. "Poosi" was procured for raising of seedlings. The seeds were sown on 9th October' 2010. After sowing, seeds were covered with a thin film of soil mixed with Farm Yard Manure. Thereafter the bed was covered with paddy straws. Water was sprayed

as per need regularly during morning and evening with the help of rose can to keep the bed moist. Twenty five days old seedlings were used for transplanting in the main field. Different organic manures *viz*. farm yard manure (FYM), vermicompost and poultry manure were applied before transplanting as per the treatment and mixed thoroughly in the soil. Treatment wise different microbial inoculants @ 10g/litre of water were mixed and required quantity of solution was prepared. The roots of uprooted seedlings were dipped in this solution for 20 minutes before transplantation. Half dose of nitrogen as urea with full dose of phosphorus (P_2O_5) as single super phosphate and potash (K_2O) as murate of potash were applied before planting of seedling as basal dressing as per the treatments specification. The desired quantity of fertilizers as per treatments were mixed thoroughly and the mixture was placed and incorporated in the top 6-8 layer of soil on the point marked for transplanting of each seedlings. After placement and incorporation of the fertilizer mixtures, seedlings were transplanted. The remaining half amount of nitrogen was top dressed in two equal split doses at 30 days and 50 days after transplanting. The observations recorded for growth and yield attributing characters viz. plant height (cm), plant spread (cm), stem diameter (cm),number of leaves per plant, number of days taken to curd initiation, number of days taken to curd maturity, diameter of curd (cm), depth of curd (cm), volume of curd(cc), weight of curd (kg), yield (q/ha) and as well as for the quality parameters namely, dry matter content in curd (g), ascorbic acid (mg/100 g). For estimation of ascorbic acid, 2, 6- dichlorophenol-indophenol method (A.O.A.C., 1975) was adopted. Five plants in each treatment combination and in each replication were randomly selected and tagged properly for recording various observations.The observations recorded for the aforesaid five plants were worked out to give means in respect of all the parameters, which were utilized in statistical analysis. The statistical analysis of the data recorded in all observations was carried out by the method of "Analysis of the variance prescribed by Fisher and Yates (1963)". Comparison of the treatments was made with the help of critical differences (C.D.).

RESULTS AND DISCUSSION

The data pertaining to the various observations on growth, yield and quality parameters in cauliflower have been shown in Table 2 and Table 3. The increase in plant height, plant spread, number of leaves, leaf length, width of leaf and leaf size by application of *1/2* NPK along with organics and bio fertilizers (Table 2) might be due to the availability of more nitrogenous compounds to the plant from organic and inorganic sources together, which increases the foliage of the plant and thereby increases the photosynthesis. The adequate supply of the three major nutrients *viz*; NPK is expected to regulate plant physiological functions and morphological responses favourably. It may also be due to the cell elongation by the presence of nitrogenous compounds. The present findings are in conformity with the findings of several workers in different vegetable crops. Marked effect in height of plant was observed due to application of different treatments. Application of ½ N: P: K + FYM@5t/ha + poultry manure@2t/ ha + *Azospirillum* (T_{14}) and T_1 (recommended dose of N: P: K: 120:80:80: kg/ha) produced significantly taller plants *i.e.*66.75cm and 63.48cm respectively. Nitrogen being a constituent of amino acids, nucleotides, nucleic acids, a number of co-enzymes, auxins, cytokinins and alkaloids, induces cell elongation, cell enlargement and cell division. The increase in plant height could be because of certain growth promoting substances secreted by the *Azospirillum*, which in turn, might have led to better root development, better transportation of water, uptake and deposition of nutrients. The results of present investigation in terms of plant height are in concordance with the findings reported earlier by Meena and Paliwal (2003) in cabbage, Patil *et al*. (2003) in knol khol, Bhardwaj *et al*., in broccoli (2007) and Harish (2009) in brinjal.

There was a significant increase in plant spread due to different treatments. Higher plant spread (58.64 and56.75 respectively) was noted with the application of ½ N: P: K + FYM@5t/ha + poultry manure@2t/ha + *Azospirillum* (T_{14}) as well as recommended dose of NPK (T_1) while the minimum plant spread (36.38) was observed in treatment T_1 (recommended dose of N: P: K: 120:80:80: kg/ha).This can be substantiated with the fact that application of NPK along with *Azospirillum* might have increased the photosynthetic capacity and auxin levels in the plant. The effect of *Azospirillum* in enhancing the plant spread of cauliflower might be due to their ability to produce growth promoting substances such as IAA,

Table 1: Treatment details and their symbols

Sl No	Treatment details	Sym.
01	Recommended dose of N:P:K:: 120:80:80: kg/ha	T_1
02	½ N:P:K	T_2
03	½ N:P:K + FYM@10t/ha	T_3
04	½ N:P:K + Vermicompost@4t/ha	T_4
05	½ N:P:K + poultry manure@4t/ha	T_5
06	½ N:P:K + FYM@5t/ha + vermicompost@2t/ha	T_6
07	½ N:P:K + FYM@5t/ha + poultry manure@2t/ha	T_7
08	½ N:P:K + Vermicompost@2t/ha + poultry manure@2t/ha	T_8
09	½ N:P:K + *Azospirillum*	T_9
10	½ N:P:K + FYM@10t/ha + *Azospirillum*	T_{10}
11	½ N:P:K + Vermicompost@4t/ha + *Azospirillum*	T_{11}
12	½ N:P:K + poultry manure@4t/ha + *Azospirillum*	T_{12}
13	½ N:P:K + FYM@5t/ha + vermicompost@2t/ha + *Azospirillum*	T_{13}
14	½ N:P:K + FYM@5t/ha + poultry manure@2t/ha + *Azospirillum*	T_{14}
15	½ N:P:K + VC@2t/ha + poultry manure@2t/ha + *Azospirillum*	T_{15}

Table 2: Effect of integrated nutrient management on plant height (cm), plant spread (cm), diameter (cm), number of leaves/plant, number of days taken to curd initiation, number of days taken to curd maturity of cauliflower

Tr. Sym.	Treatment details	Plant height (cm)	Plant spread (cm)	Stem diameter (cm)	No.of leaves/plant	No. of days taken to curd initiation	No. of days taken to curd maturity
T_1	Recommended dose of N:P:K :: 120:80:80: kg/ha	63.48	56.75	3.21	21.16	103.00	119.00
T_2	½ N:P:K	42.70	36.38	2.42	13.88	88.00	101.00
T_3	½ N:P:K + FYM@10t/ha	56.59	54.92	2.88	11.56	91.00	103.00
T_4	½ N:P:K + vermicompost@4t/ha	49.57	42.41	2.59	12.96	88.00	105.00
T_5	½ N:P:K + poultry manure@4t/ha	51.16	44.38	2.68	14.26	89.00	10.00
T_6	½ N:P:K + FYM@5t/ha + vermicompost@2t/ha	54.82	50.63	2.83	17.90	93.00	104.00
T_7	½ N:P:K + FYM@5t/ha + poultry manure@2t/ha	55.12	52.74	2.86	18.76	94.00	106.00
T_8	½ N:P:K + vermicompost@2t/ha + poultry manure@2t/ha	50.75	45.68	2.70	15.80	87.00	96.00
T_9	½ N:P:K + *Azospirillum*	46.72	40.32	2.49	19.74	88.00	97.00
T_{10}	½ N:P:K + FYM@10t/ha + *Azospirillum*	58.71	53.68	2.98	19.23	93.00	107.00
T_{11}	½ N:P:K + vermicompost@4t/ha + *Azospirillum*	51.68	47.22	2.74	16.97	91.00	103.00
T_{12}	½ N:P:K + poultry manure@4t/ha + *Azospirillum*	52.76	49.18	2.78	15.89	90.00	115.00
T_{13}	½ N:P:K + FYM@5t/ha + vermicompost@2t/ha + *Azospirillum*	64.56	57.36	3.06	20.84	96.00	118.00
T_{14}	½ N:P:K + FYM@5t/ha + poultry manure@2t/ha+ *Azospirillum*	66.75	58.64	3.18	19.86	99.00	116.00
T_{15}	½ N:P:K + vermicompost@2t/ha + poultry manure@2t/ha + *Azospirillum*	53.62	50.32	2.80	17.28	93.00	109.00
C.D.(5%)		6.07	4.88	0.25	1.77	NS	12.71
C.V. (%)		6.66	5.91	5.34	6.21	6.61	7.12

Table 3: Effect of integrated nutrient management on yield and quality characters of cauliflower

Tr. Sym.	Treatment details	Diameter of curd (cm)	Depth of curd (cm)	Volume of curd (cc)	Weight of curd (g)	Yield (q/ha)	Dry matter in curd(%)	Ascorbic acid (mg/100g of juice)
T_1	Recommended dose of N:P:K :: 120:80:80: kg/ha	14.13	11.03	680.00	532.00	235.71	10.52	38.75
T_2	½ N:P:K	9.03	6.11	472.00	330.00	146.95	13.24	34.19
T_3	½ N:P:K + FYM@10t/ha	11.74	9.41	602.00	462.00	206.13	11.02	36.38
T_4	½ N:P:K + vermicompost@4t/ha	9.96	6.95	496.00	346.00	153.85	13.00	44.15
T_5	½ N:P:K + poultry manure@4t/ha	9.35	7.20	488.00	352.00	156.82	12.96	53.90
T_6	½ N:P:K + FYM@5t/ha + vermicompost@2t/ha	11.16	9.10	576.00	435.00	193.80	11.35	47.28
T_7	½ N:P:K + FYM@5t/ha + poultry manure@2t/ha	11.55	9.26	598.00	458.00	204.16	11.12	46.12
T_8	½ N:P:K + vermicompost@2t/ha + poultry manure@2t/ha	10.50	7.59	425.00	382.00	170.63	12.85	52.65
T_9	½ N:P:K + *Azospirillum*	9.26	6.47	452.00	335.00	149.42	13.18	54.56
T_{10}	½ N:P:K + FYM@10t/ha + *Azospirillum*	11.84	9.54	617.00	492.00	218.95	10.04	41.18
T_{11}	½ N:P:K + vermicompost@4t/ha + *Azospirillum*	10.63	8.52	538.00	408.00	181.47	12.65	51.98
T_{12}	½ N:P:K + poultry manure@4t/ha + *Azospirillum*	10.80	8.74	527.00	415.00	184.93	12.28	51.57
T_{13}	½ N:P:K + FYM@5t/ha + vermicompost@2t/ha + *Azospirillum*	14.82	11.30	682.00	552.00	245.58	10.35	61.66
T_{14}	½ N:P:K + FYM@5t/ha + poultry manure@2t/ha+ *Azospirillum*	16.09	11.76	702.00	568.00	252.48	10.18	63.12
T_{15}	½ N:P:K + vermicompost@2t/ha + poultry manure@2t/ha + *Azospirillum*	11.94	8.88	532.00	426.00	189.36	11.96	50.38
C.D.(5%)		1.17	0.81	56.16	53.32	20.39	1.23	4.17
C.V. (%)		6.08	5.49	6.01	7.37	6.32	6.27	5.26

gibberellins like substances, vitamin B_{12}, thiamine, riboflavin (B_2) etc. These results in respect of this character are in complete agreement with the findings of Bhagavantagoudra and Rokhade (2002) in cabbage, Sharma and Chandra (2002) in cabbage and cauliflower and Choudhary and Choudhary (2005) in cabbage.

It was observed that the diameter of stem was markedly influenced by different treatments. The plants getting the full recommended dose of NPK registered the highest stem diameter (3.12) which showed parity with ½ N: P: K + FYM@5t/ ha + poultry manure @ 2t/ha + *Azospirillum* (T_{14}) and ½ N: P: K + FYM @ 5t/ha + vermicompost @2t/ha + *Azospirillum* (T_{13}). The results summarized above in respect of stem diameter are closely in consonance with findings reported earlier by Meena and Paliwal (2003) in cabbage and Singh *et al*. (2004) in cauliflower.

The number of leaves per plant was highest with application of full recommended dose of NPK and showed parity with the ½ N: P: K + FYM @ 5t/ha + poultry manure@2t/ha + *Azospirillum* (T_{14}). This is probably due to the facts that nitrogen might have contributed towards an increase in leaf buds and finally increased leaf number.

The number of days taken to curd initiation and curd maturity was significantly affected due to application of different treatments as shown in Table 2. The plots getting the ½ N: P: K + Vermicompost@2t/ha + poultry manure@2t/ha (T_8) reached first to curd initiation (87) and curd maturity(96) while treatments T_1(Recommended dose of N:P:K: :120:80:80 kg/ ha) significantly delayed to curd initiation and curd maturity. Similar results have also been reported by Westerveld *et al*. (2003) in cabbage. It was also observed by Chaubey *et al*. (2006) in his study on cabbage that higher fertility level favoured the maturity time whereas the process of growth and development was slower at lower fertility level.

The maximum diameter (16.04), depth (11.76) and volume (5.68) of curd were obtained with application of ½ N: P: K + FYM@5t/ha + poultry manure@2t/ha + *Azospirillum* (T_{14}) which was at par with ½ N: P: K + FYM@5t/ha + vermicompsot@2t/ha + *Azospirillum* (T_{13}). This may be due to increased vegetative growth as induced by integrated nutrient management which might account for increased carbohydrates accumulation as a result of increased photosynthesis. However the minimum diameter, depth and volume of curd were was produced by the treatment T_2 (½ N: P: K)

A cursory glance over the table-3 indicates that the weight of curd was markedly influenced by the application of different treatments. The heaviest curd (568.00 g) developed in the plants grown under the influence of treatment T_{14} (½ N: P: K + FYM@5t/ha + poultry manure @2t/ha + *Azospirillum*) which was at par with treatments T_{13} (½ N:P:K + FYM@5t/ha + vermicompost@2t/ha + *Azospirillum*) . The increase in curd weight might be due to the more photosynthesis from a larger area of the leaves and the translocation of photosynthates to the sink which is ultimately the curd. The increase in the curd weight at this level might also be due to the increase in the length and width of the leaves, plant spread, curd diameter and curd depth. Kumar *et al* (2013), Pandey *et al*. (2008), Sharma and Singh (2003) and (Singh *et al*., 2005) also noted the similar findings in various cole crops. The lowest curd weight (330.00 g) was recorded in the treatment T_2 (½ N:P:K) which was statistically similar to T_9 (½ N: P: K + *Azospirillum*), T_4 (½ N:P:K + Vermicompost@4t/ha), T_5 (½ N: P: K + poultry manure@4t/ha) and T_8 (½ N:P:K + Vermicompost @ 2t/ha + poultry manure@2t/ha).

The highest curd yield in quintal per hectare (252.48) was obtained with application of ½ N: P: K + FYM@5t/ha + poultry manure@2t/ha + *Azospirillum* (T_{14}) which was at par with ½ N: P: K + FYM@5t/ha + vermicompost @ 2t/ha + *Azospirillum* (T_{13}). The increase in yield and yield components due to the application of biofertilizers can be attributed to the release of bioactive substances having similar effect as that of growth regulators besides enhancement of nutrient absorption. 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). The lower yield with inorganic fertilizers alone could be due to reduction in adequate supply of mineral nutrients because of fixation. Kumar (2013) have reported that integration of organic and inorganic fertilizers application significantly increased the yield in broccoli over inorganic fertilizers alone and also over control. Sharma and Singh (2003) in pea and (Singh *et al.,* 2005) in cowpea also reported similar findings. Khan and Pariari (2012), in their study on chilli have also reported that the inoculation with Azospirillum + 75% N along with P and K produced maximum fruit yield in chilli. The increase in the yield is also due to the supply of additional nutrient through organics as well as inorganics resulting in an improvement in the physical and biological properties of soil as reported by (Sharma *et al.,* 2005) in broccoli. The increase also might be due to the fact that these nutrients are important constituents of nucleotides, proteins, chlorophyll and enzymes, which are involved in various metabolic process which have direct impact on vegetative and reproductive phase of the plants. These results are in accordance with the findings of Singh (2002) in cabbage, Manivanan and Singh (2004) in broccoli and Krezel and Koota (2004) in Chinese cabbage

The lowest curd yield (146.95 q/ha) was noticed in treatment T_2 (½ N: P: K), however, was just at par with T_4 (½ N: P: K + Vermicompost@4t/ha) and T_5 (½ N: P: K + poultry manure @4t/ha) having curd yield of 153.85 q/ha and 156.82 q/ha, respectively.

The maximum dry matter content in curd (13.24 %) was noted in treatment T_2 (½ N: P: K). It might be due to the release of sufficient quantity of nutrient by the process of mineralization at a constant level that in turn gave higher dry matter. The lowest dry matter (10.04%) was obtained in treatment T_{10} (½ N: P: K + FYM@10t/ha + *Azospirillum*). Similar results were also noted by Kumar *et al.,* 2013 in broccoli.

The study regarding vitamin C content indicated that the ascorbic acid content in curd (Table 3) decreased significantly with application of higher nutrients. The highest ascorbic acid content (63.12) in curd was obtained with the treatment T_{14} (½ N: P: K + FYM@5t/ha + poultry manure @2t/ha + *Azospirillum*) followed by T_{13} (½ N: P: K + FYM@5t/ha + vermicompost@2t/ha + *Azospirillum*) producing (54.76) milligram of ascorbic acid per 100g of juice. The lowest (34.19)

ascorbic acid was recorded with the treatment ½ N: P: K (T_2). These findings are in close agreement with those earlier reported by Singh (2004) in cauliflower, Guo *et al*. (2004) in cabbage, Sable and Bhamare (2007) in cauliflower and Dutta Ray *et al*. (2014) in Pomogranate. Reduction in vitamin C at higher nutrient level is due to the more vegetative growth which provide larger area for the photosynthesis and transpiration resulting thereby in upward movement of water from root zones to the upper part of the plants and decrease in the vitamin C content. It might be also due to the fact that the chemical fertilizers reduce the content compared to the organics by dilution effects. There is a general observation that organically managed crop have usually higher vitamin C than the conventional fertilized crop because when a plant is exposed with more nitrogen, it increases protein production and reduces carbohydrates synthesis. Since vitamin C is synthesized from carbohydrates, its levels are also reduced. In case of organically managed soil, plants are generally exposed with comparatively lower amount of nitrogen and several plant nutrients are released slowly over time. Therefore, organic crop would be expected to maintain higher vitamin 'C' and carbohydrates and less protein as reported by Bahadur *et al*. (2003) in broccoli. Furthermore, soil micro-organism affects soil dynamics and plant metabolisms and ultimately results in differences in plant composition and nutritional quality as reported by Worthington (2001) and Bahadur *et al*. (2003).

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