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Effect of Bio-fertilizers and Inorganic Amendments on Mineral Composition and Quality of *Brassica oleracea*

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ABSTRACT: The state of Himachal Pradesh is situated in the Himalayas; which attributes to the wide and diversity in the climatic conditions. Due to seasonal climatic variations, the soil is favorable for the growth of different seasonal as well as off seasonal vegetables; which leads to the deterioration of the fertility of the soil as well as quality of the vegetables thus grown in the field. The current paper deals with such effective and easy methods which attributes to the long term enhancement of the production, fertility and moreover income. We have tried a few combinations of the treatments which have significant and effective results and these can be tried on large scale for the sustainable development of the soil.

Keywords: Fertilizer; organic; biofertilizer; minerals; crops and minerals.

INTRODUCTION: In Himachal Pradesh, there are four distinct agro-climatic zones (low hills, mid hills, high hills and temperate wet and high hills temperate dry). Among different zones, mid hill zone (zone II) is most important (681 to 1800 m above mean sea level). This zone has mild temperate climate with average annual rainfall of about 1500 to 3000 mm (70 % of the rainfall is received during monsoon season and remaining 30 % during winter season). It occupies 1183.2 thousand hectares (21.3 % of total geographical area of the state) and total cropped area of 384.5 thousand hectare (42 % of the total cultivated area of the state). The total area under vegetable crops is more than 25,000 ha, out of which area under important off-season vegetable crops (tomato, capsicum French bean, peas, cabbage & cauliflower) is approximately 2000 hectares (Statistical Outlines, Himachal Pradesh, 2002). The vegetable growing in the state in general and under mid-hills in particular has assumed greater importance owing to favorable agro-climatic conditions for growing seasonal and off-seasonal vegetables, which fetches high premiums in the local market. This zone is also the main producer and exporter of the off- season vegetables particularly tomato, cauliflower, cabbage, capsicum, french bean, peas etc.

The farmers of the mid - hill area generally do intensive vegetable cultivation by harvesting four to five crops in a year. However, due to lack of knowledge, these vegetable growers are indiscriminately using nitrogenous fertilizers in abundance, while the use of phosphate and potassic fertilizers is very limited/disproportionate. Such imbalanced fertilizer use has therefore, led to multi-nutrient deficiencies resulting in yield stagnation and deteriorated soil health. Therefore, to sustain the productivity of different vegetable crops and cropping systems, efficient nutrient management is vital. Thus there is an urgent need to develop more efficient, economically viable and sustainable integrated nutrient management system for vegetable production. The main objectives of the present investigation are to see the effect of organic, bio-fertilizers and inorganic amendments on mineral composition and quality of cauliflower and to see the effect of organic, bio-fertilizers and inorganic amendments on crop productivity vis-à-vis soil fertility.

MATERIALS AND METHODS: In order to achieve the objectives of the present investigation entitled "Studies on the mineral composition of off season cauliflower (*Brassica oleracea* var. Botrytis) under different organic nutrient sources". The details of field experimentation, soil returns in comparison to existing farming practice. Crop and laboratory studies under taken and methodology adopted have been described as under:

Study area and climatic conditions: The field experiment was conducted in one of the farmers' fields in village Hat near the Experimental Farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Hill Agriculture Research and Extension Centre, Bajaura. The

experimental site is situated at 32º 2' N latitude and 72º E longitude at an elevation of 1090 m above mean sea level in mid hill sub humid agro-climatic zone of Himachal Pradesh.

The study area falls in the wet temperate region and is characterized by severe winters and mild summers. Annual temperature ranges from 0.7 to 30 ^{0}C.

Monsoon in general, sets in by the end of June and is very active during July and August. The average annual rainfall is uneven and most of this is received during mid June to mid September. The mean relative humidity in the region varies from 43 to 88 percent.

Field studies & Experimental details: The field experiment was conducted in rabi season of 2006-2007 in the village Hat near to the Experimental Farm of CSK Himachal Pradesh Krishi Vishvavidayala, Hill Agricultuere Research and Extension Centre, Bajaura, Kullu. The most prevalent farmers existing practice in the study village was cauliflower-cauliflower-cauliflower, however, the cauliflower grown in winter was taken for the present study. The applications of NPK to cauliflower crop were made through urea, single super phosphate and muriate of potash, respectively. The boron was applied through borax. The recommended dose of N:P:K:B was 100:75:55:1 Kg/ha. The bio fertilizers used were PSB and azotobacter. The roots of cauliflower seedlings were inoculated with bio fertilizers before transplanting. The details of the treatments used and experimental design employed are as under:

Treatments:
1. Control (no fertilizers)
2. Organic manure (20 t/ha)
3. Existing Farmers' Practice (FP)
4. 50 % recommended chemical fertilizers + FYM as per farmers' resource + Biofertilizer
5. Recommended Chemical fertilizers + FYM
(The recommended chemical fertilizers refer to major (NPK) and boron)
Total treatments: 5

Design: Randomized Block Design; Replications: The experiment was started in rabi season of 2006-2007 with cauliflower (hybrid-Megha) as the test crop. After completion of layout, each plot was irrigated and brought to field capacity and left for some time so as to ensure optimum moisture for planting seedlings. The transplanting at different farmers' field was done on 11.10.2006; 28.10.2006 and 4.11.2006 with spacing of 60 x 40 cm. The levels of NPK were applied as per the treatment. Half dose of N and full dose of P, K and FYM was applied at the time of sowing. The remaining N was top dressed in two equal splits (45 & 90 days after transplanting). The seedlings of cauliflower were inoculated with bio fertilizers before transplanting. The crop was irrigated as and when required. All the cultural practices as per the recommendation were followed during the entire growth period of cauliflower crop. The experimental plots were kept free of weeds by manual weeding from time to time.

Observations recorded:

Soil studies: Composite soil samples at 0-15 cm depth were collected to determine various soil physico-chemical properties like available major nutrients(N, P, K) and micronutrient (Boron), Organic carbon, and pH using the methods as described in Table 1.

Table 1: Important physico-chemical properties of the soil before initiation of the experiment.

S. No.	Properties	Values	Method adopted
1	PH	6.7	Jackson (1973)
2	Organic carbon	0.78	Rapid Titration Method (Walkley and Black, 1934)
3	Available N	282.3	Alkaline permanganate method (Subbiah and Asija, 1956)
4	Available P	53.3	0.5M NaHCO3, pH 8.5 (Olsen et al., 1954)
5	Available K	215.3	Neutral ammonium acetate method (Merwin and Peech, 1951)
6	Available B	0.37	Berger (1944)

Field observation: When the cauliflower curds attained average marketable size, the harvesting was done periodically and plot wise yield data was recorded.

Soil and plant sampling: Representative soil samples (0-15 cm depth) were collected from each plot before and after harvest of cauliflower. The soil samples were dried in shade, ground in pestle mortar, passed through 2mm sieve and subjected to laboratory analysis. The curd and leaf samples were collected at harvest.

Laboratory studies: Preparation and analysis of soil samples: The soil samples collected before and after the harvest of cauliflower crop, were air dried, ground, passed through 2 mm sieve and finally stored in polythene bags to determine the soil physico-chemical properties as per the standard procedures.

Preparation and analysis of plant samples: The curd and leaf samples collected at the time of the harvest of cauliflower crop during the year 2007 were dried in an oven at 60^{o}C for 3-4 days then ground and stored in polythene bags. The plant samples were wet digested with di-acid mixture) for the estimation of nutrient concentrations. The concentration of major nutrient

(NPK) and boron was determined as per standard procedures.

Quality parameters: The vitamin C content in cauliflower curd was determined using routine titration method.

Statistical analysis: The data obtained during the course of study was analyzed statistically using the technique of analysis of variance as described by Gomez and Gomez (1984).

Economic analysis: The economic analysis of individual treatment was carried out on the prevailing market prices of inputs and output.

RESULTS AND DISCUSSION: Soil chemical properties: The data for soil properties after the harvest of cauliflower has been presented in Table 2. The various treatments had little or no effect on soil pH, as the values after crop harvest remained statistically at par with the initial values (Table 2). The non significant effect of synthetic fertilizers, bio fertilizers and organic manure has also been reported by Parmar et al. (2006). The organic carbon content of soil after the crop harvest improved significantly in all the treatments over the control. However, the highest build up was recorded in organic treatment (treatment 3) but the treatments T2 to T5 remained statistically at par with each other (Table 2). The various treatments increased soil organic carbon from 1.2 to 22.3 percent over control. The highest increase (22.3 %) was recorded in treatment 5. The higher content of organic carbon in soil may be due to addition of organic manure, which contain sufficient amount of organic carbon. Similar findings have also been reported by Parmar et. al (2006).

There was a significant effect of different treatments on the availability of nutrients after the cauliflower harvest (Table 2). The available nitrogen was highest in treatment 5 and other treatments also had higher available N in comparison to control where no fertilizers were added. The percent increase in treatment 5 over the control was 32.6 percent and the range of increase in different varied from 5.8 to 32.6 percent. The same trend in availability of P, K and B was also observed. The increase in available P in treatment 5 was 53.8 percent over control, whereas, such increase in available K and boron in treatment 5 was 17.8 percent and 85.7 percent in comparison to control respectively. Highest improvement in soil P and K was recorded in treatment 5 (balanced inputs use) and lowest in treatment 1 (no fertilizer application). The significant build up of soil available N due to fertilizer application and FYM could be attributed to increased activity of N fixing bacteria and build up in organic N fraction of the soil due to biochemical degradation and mineralization, thereby, resulting in higher accumulation of N in soil (Miller et al., 1987). Higher soil P status may be due to lower utilization of P by the crop from applied sources which resulted in building up of higher soil P status (Prasad, 1994).

Microbial soil properties: Improved soil K status was as a result of direct K addition in available K pool of soil and quantity of K being added by FYM (Tandon and Sekhon, 1988). Apparently, synergistic effect of synthetic and bio-fertilizers and farmyard manure could have brought significant improvement in soil available micronutrients (Tisdale et. al., 1995).

The data revealed that the total population of bacteria, fungi and actinomycetes in soil after the crop harvest were highest in plots supplied with farmyard manure followed by 50 % NPK fertilizers and FYM applied along with bio fertilizers. The carbon bio mass was highest in organic treatment and minimum in the plots where no FYM was applied. The farmers practice had also carbon bio mass as was recorded in organic plot. The same trend was also observed in case of enzyme activity, as the higher concentrations of dehydrogenase and acid phosphatase enzymes was recorded in organic treatment and farmers practice. The availability of more humus in FYM treated plots might have favored higher microbial population and enzyme activities.

Table 2: Effect of treatments on soil properties after crop harvest.

Treatment	Soil Properties					
	pH	OC (%)	N (Kg/ha)	P_2O_5 (Kg/ha)	K_2O (Kg/ha)	B (mg/kg)
T1	6.6	0.67	258.4	48.5	200.8	0.28
T2	6.7	0.81	294.6	60.5	214.6	0.33
T3	6.6	0.87	307.2	64.9	219.5	0.38
T4	6.7	0.82	323.9	69.4	223.6	0.40
T5	6.7	0.82	342.7	74.6	236.7	0.52
CD (5%)	NS	0.11	7.2	5.6	8.1	0.04
Av. initial values	6.7	0.78	282.3	53.3	215.3	0.37

Table 3: Effect of treatments on nutrient uptake.

Tr.	Nutrient Uptake (Kg/ha)											
	Nitrogen			Phosphorus			Potassium			Boron (mg/kg)		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
T1	18.4	19.1	19.5	22	18.8	18.8	93.5	70.5	82.6	0.149	0.152	0.141
T2	22.9	23.4	25.3	27.9	23.7	23.4	105.5	85.6	87.9	0.176	0.186	0.159
T3	30	32.8	31.9	34.4	28.9	29.6	122.5	106.1	99.5	0.248	0.207	0.172
T4	38.4	43.1	42.9	44.3	38.9	38.3	152.9	131.2	116.5	0.346	0.294	0.222
T5	54.2	67.4	67	53.9	56.7	51.2	191.2	199.2	183.7	0.462	0.468	0.406
CD (5%)	4.8	7.1	4.7	2.2	3.7	3.2	16.1	12.8	10.1	0.05	0.04	0.02

Table4: Effect of treatments on whole system productivity, quality and economics.

Tr.	Productivity (Q/ha)	Vit. C (mg/100g)			Net Returns (Rs/ha)	B:C Ratio
		F1	F2	F3		
T1	239.6	43.8	55.1	48.9	-119870	-0.19233
T2	272.7	45.6	58.1	51.2	-49660	-0.07968
T3	335.0	46.9	59.6	52.4	47738	0.072643
T4	414.9	49.3	61.6	54.3	218900	0.335063
T5	745.5	53.4	64.4	57.4	899852	1.348723
CD (5%)	56.3	2.1	1.3	1.1	-	-

Mineral Composition: The various treatments had considerable effect on the minerals composition of cauliflower (fig 1 to 12). In general, the highest concentration of mineral nitrogen, phosphorus, potassium and boron was recorded with the combined use of organic, inorganic and bio fertilizers, except in few cases where the concentration of these minerals was higher in control plots. However, concentration in treatment 1 to 3 was almost equal in all the cases. The N, P, K and B concentration varied from 0.80 to 1.14 %, 0.20 to 0.30 %, and 0.67 to 1.20 % and 0.0016 to 0.0021 %, respectively.

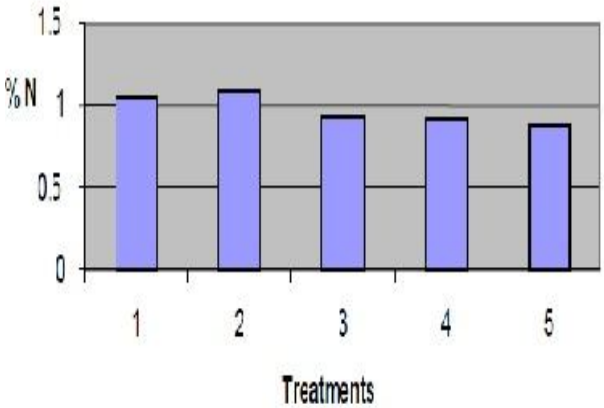

Figure 1: Percentage nitrogen in cauliflower (Farmer I).

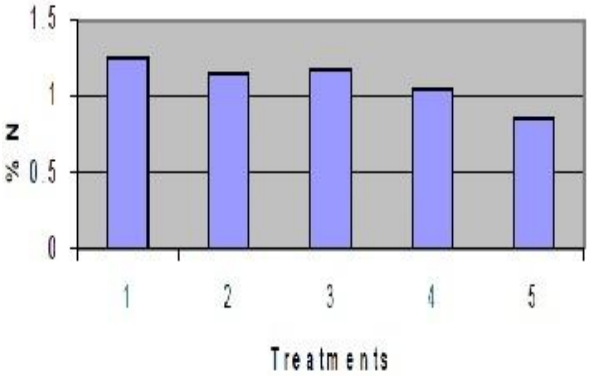

Figure 2: Percentage nitrogen in cauliflower (Farmer II).

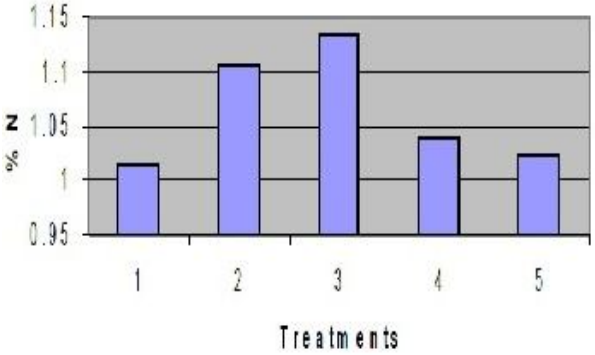

Figure 3: Percentage nitrogen in cauliflower (Farmer III).

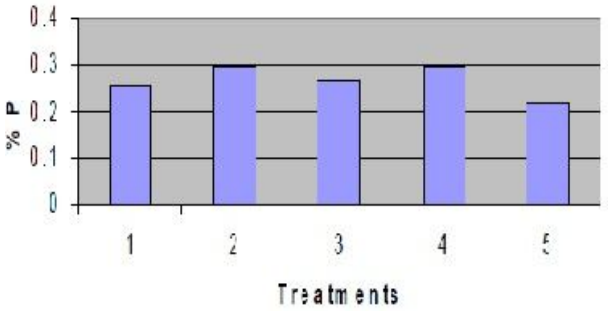

Figure 4: Percentage phosphorus in cauliflower (Farmer I).

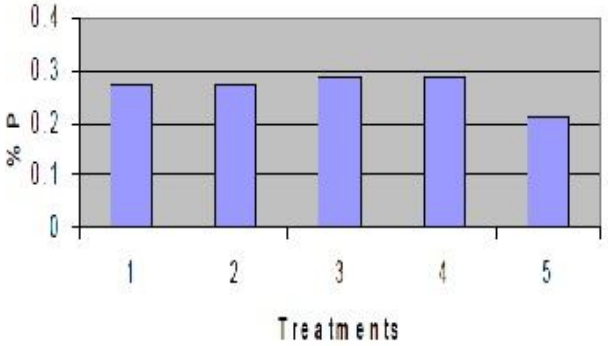

Figure 5: Percentage phosphorus in cauliflower (Farmer II).

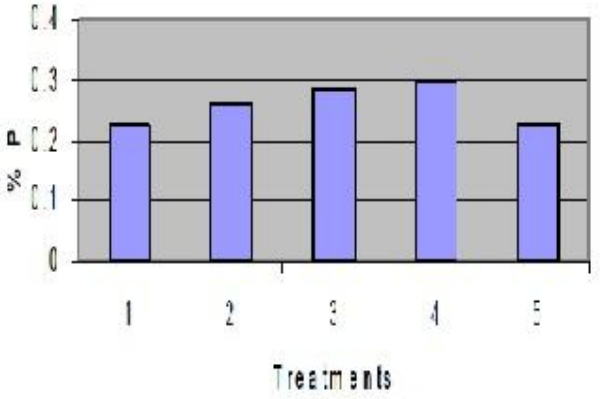

Figure 6: Percentage phosphorus in cauliflower (Farmer III).

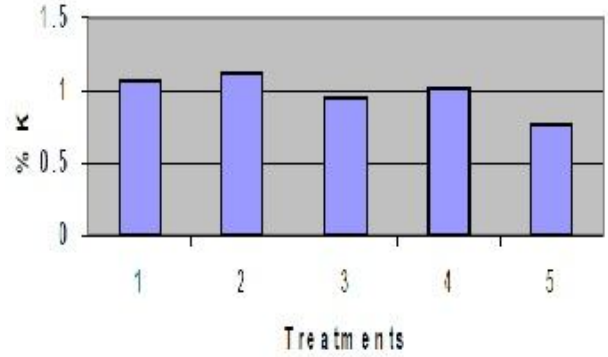

Figure 7: Percentage potassium in cauliflower (Farmer I).

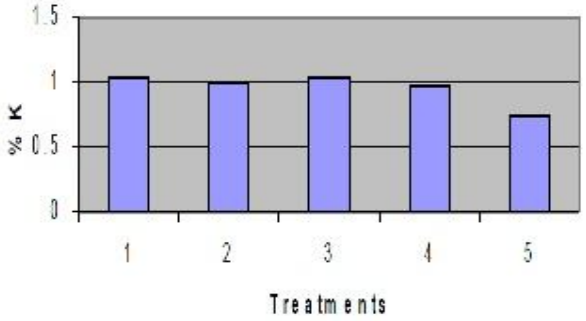

Figure 8: Percentage potassium in cauliflower (Farmer II).

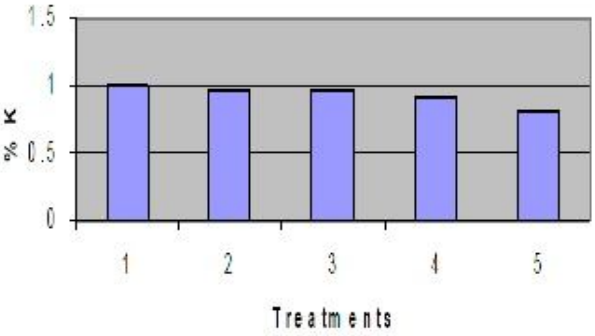

Figure 9: Percentage potassium in cauliflower (Farmer III).

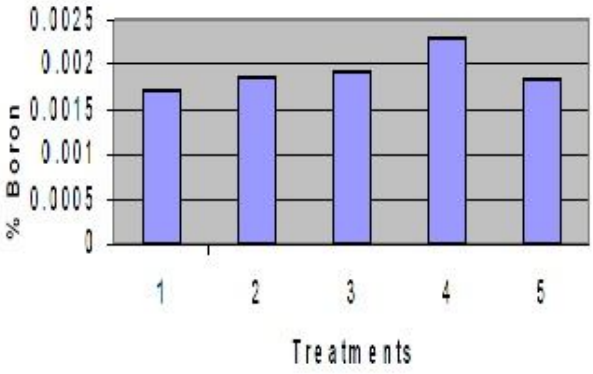

Figure 10: Percentage boron in cauliflower (Farmer I).

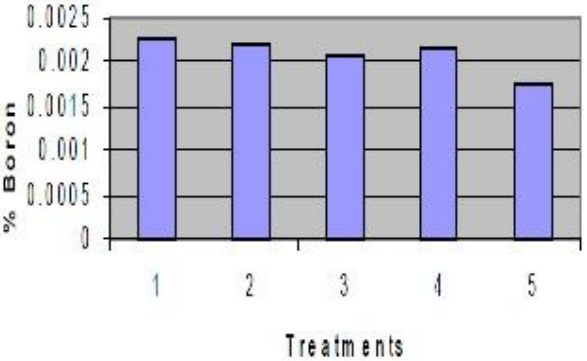

Figure 11: Percentage boron in cauliflower (Farmer II).

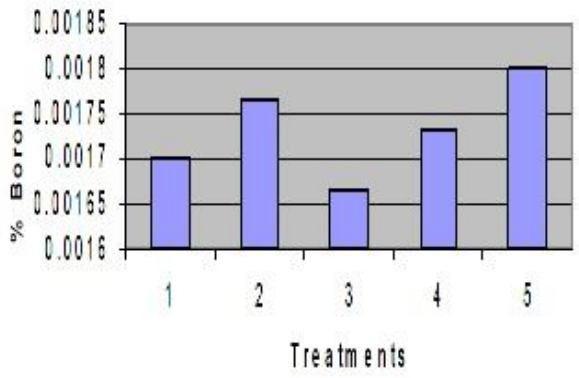

Figure 12: Percentage boron in cauliflower (Farmer III).

Nutrient uptake: The effect of various treatments on the nutrient uptake was significant and highest nutrient absorption was recorded with balanced fertilizer doses when applied with bio fertilizers and organic manure (T5). In general, the treatments T1 and T2 were statistically at par but inferior to farmers' practice Table 3). The uptake of N in three farmers' field varied from 41.1 to 252.9 percent, likewise, P uptake varied from 21.6 to 201.6 percent and that of K uptake varied from 25.0 to 182.5 percent. The boron uptake in all the farmers in a village varied from a minimum of 33.5 percent to the highest of 210 percent.

The well-developed root system, additional nutrients supplied by FYM, significant improvement in soil physical properties (Mishra and Kapoor, 1992), better absorption of nutrient by the plant due to higher microbial and metabolic activity and higher photosynthesis rate, enhanced the uptake of major and micronutrients with the adoption of integrated nutrient management (Singh, 1987).The current findings are also in consonance with the observations of Datt et al. (2003).

Productivity: The productivity of cauliflower in individual farmer field as well as whole system productivity increased with the integrated use of fertilizers and organic manure (Table 4). The highest marketable curd yield of cauliflower was recorded in T5 and minimum in control plot. Treatment 1 and 2 were statistically at par with each other. The increase in the whole system productivity was 211.1 percent as compare to control.

The increased cauliflower yield with the application of chemical fertilizers in conjugation with organic manure and bio-fertilizers may be attributed to improved vegetative growth, better availability of nutrients, greater synthesis of carbohydrates and their translocation (Singh, 1987), additional nutrients supplied by farmyard manure, enhanced photosynthetic activity and improvement in soil physical properties which led to better soil physical health (Sharma, 1986). The higher net returns obtained in treatment 5 (Table 4) was due to increased productivity of cauliflower with applied synthetic and bio-fertilizers and organic manure over treatment 1. The results are in conformity with the findings of Sharma et al. (2005), who reported highest net returns with integrated nutrient management in broccoli.

Quality: The application of recommended NPK fertilizers, bio fertilizers and FYM (treatment 5) recorded significantly higher value of vitamin C. The percent increase in vitamin C content in cauliflower crop of three farmers varied from 4.5 to 21.9 percent. Kumar et al. (2004) have also reported beneficial effects of integrated nutrient management in increasing vitamin C content in tomato.

Net returns: On the basis of economics of various treatments, the plots receiving no fertilizer application and organic manure could not give handsome returns. However, the net returns in the farmers' existing practice slightly increased in comparison to control and organic treatment. The highest profit was recorded with integrated use of fertilizers (chemical & bio fertilizers) and organic manure (T5). The net profit of the system varied from -49,660 to 8,99,852 rupees/ha with a benefit cost ratio of -0.07 to 1.35.

CONCLUSION: It is concluded from the present study that integrated use of all the plant nutrient sources including farmyard manure, bio fertilizers and synthetic fertilizers had significant effect on increasing yield and profitability besides, improvement in quality of cauliflower and soil health. The conformity of the experimental findings needs further investigation for second year to arrive at valid conclusion.

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