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Influenced of organic and biofertilizers on yield and quality of cabbage (*Brassica oleracea* var. *capitata*)

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Abstract
A field experiment entitled "Effect of organic manures and biofertilizers on growth, yield and quality of cabbage (*Brassica oleracea* var. *capitata*)". The experiment consisted of sixteen treatment combinations with four levels of organic manures (Control, FYM 25 t ha^{-1}, vermicompost @ 8.5 t ha^{-1} and FYM @ 16.5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1}) and four levels of biofertilizers (Control, *Azotobacter*, PSB and *Azotobacter* + PSB) in Randomized Block Design with three replications. Results indicated that application of vermicompost @ 8.5 t ha^{-1} and inoculation with *Azotobactor* + PSB significantly superior over rest of the treatments in respect to Average volume of head, head yield per plot, total head yield, ascorbic acid, protein content and nitrogen content except treatment M_3 (FYM 16.5 t/ha + VC 2.8 t/ha), being statistically at par with each other.

Keywords: biofertilizer, cabbage yield and quality, farmyard manure, vermicompost, PSB

Introduction
Cabbage *(Brassica oleracea* var. *capitata* L.) is by far the most important member of the genus Brassica grown in the world. It is a biennial crop of temperate region. However, it's cultivation is equally successful in the tropical and sub- tropical regions. The major cabbage growing states are Orissa, West Bengal, U.P., Bihar, Karnataka, Maharashtra, Gujrat, Punjab and Himachal Pradesh (Fageria *et al.*, 2003) [3]. Cabbage is rich in minerals and vitamins. It contains, vitamin-A (2000 IU), thiamine (0.06 mg), riboflavin (0.03 mg) and vitamin-C (124 mg) per 100 g edible part. It also contains minerals like potassium (114 mg), phosphorus (44 mg), calcium (39 mg), sodium (14.1 mg) and iron (0.8 mg) per 100 g of edible part (Fageria *et al*., 2003) [3]. Cabbage is used as salad, boiled, cooked, cured, pickling and dehydration purposes. It neutralizes acidity and improves digestion and appetite (Katyal and Chadha, 1985) [5].

FYM being rich in organic matter is required for supplementing the nutrients provided through other manure. The organic manure not only provides nutrients to plants but also improves the soil texture by binding effect to soil aggregates. Organic manure increases CEC, water holding capacity and phosphate availability of the soil, besides improving the fertilizer use efficiency and microbial population of soil; it reduces nitrogen loss due to slow release of nutrients. Vermicompost is a slow releasing & organic manure which have most of the macro as well as micro nutrients in chelated form and fulfill the nutrients requirement of plant for longer period.

Vermicompost helps in reducing C:N ratio, increasing humic acid content, cation exchange capacity and water soluble carbohydrates. It also contains biologically active substances such as plant growth regulators. Bio-fertilizers are agriculturally beneficial microorganisms, which have the ability to mobilize the nutritionally important elements from non- usable form to usable form through biological processes. They are known to increase yield in several vegetables besides resulting in considerable saving of inorganic fertilizers (Kumar *et al*., 2001) [7].

Azotobacter and PSB are the biofertilizers which nourish the crops and soil by liberating the growth promoting substances and vitamins. Azotobacter fixes atmospheric nitrogen in the root zone of the plants. It is a free living aerobic nitrogen fixing bacteria, can substitute for part of inorganic fertilizer. Azotobacter inoculation saves nitrogenous fertilizers by 10 to 20 percent (Mohandas, 1999).

Phosphorus Solubilizing Bacteria (PSB) solubilises unsoluble fixed phosphates present in the soils, when it inoculated, secret acetic substances and solubilizes the otherwise unavailable insoluble soil phosphorus. The inoculation with PSB bio-fertilizer increase the yield of crops by 10 to 30 percent (Tilak and Annapurna, 1993) [11].

These bio-fertilizers are organic and thus are absolutely safe and provide mechanical support, vigour and health to the seedlings. These biofertilizers suppress the incidence of pathogens and act as biological control agents and provide tolerance to the plants against drought and stresses. They are eco-friendly (pollution free) and are based on renewable energy sources and provide sustainability to the farming system.

Materials and Methods

A field experiment was conducted during *rabi* season of 2014-15 at Department of Horticulture, College of Agriculture, Jobner, in a randomized block design with three replications. The soil was loamy sand in texture, alkaline in reaction (pH 8.1), low in organic carbon (0.16 %), low available nitrogen (130 kg/ha), medium available phosphorus (15.1 kg P2O5/ ha) and medium in potassium (140 kg K2O/ha) content. The experiment consisted three treatment of organic manures (Control, VC 5t/ha, FYM 15 t/ha) three treatment of biofertilizers (Control, Azotobacter, PBS, Azotobacter +PSB) there by, making sixteen treatment combinations. Seedlings root were inoculated with *Azotobacter* and PSB culture both as per treatment, using standard method. Bio-fertilizer i.e. PSB and *Azotobacter* were applied @ 247g per hectare seedlings. The culture was dissolved in water and dips the seedlings of cabbage in solution for 30 minutes before sowing. The Cabbage cv. 'Pride of India' was transplanted on 18th October 2014 with Beds size 2.7 m x 1.8 m, when average height of seedlings was about 10-12 cm. The distance between row to row and plant to plant was kept as 45 × 45 cm. Thus 24 plants were accommodated in each plot. The transplanting was done in the evening hours followed by light irrigation. The 6-10 days interval irrigations were applied during growing season. Intercultural operations *viz.*, thinning, gap filling hoeing and weeding were followed after 20 days of sowing to maintain recommended spacing and weed control. Two hand weeding during growing period and observations on tagged plants were recorded.

Results and discussion

Organic Manures

Results indicated that application of vermicompost @ 8.5 t/ha significantly higher in diameter of head, average weight of head, average volume of head, head yield per plot and total head yield (q ha^{-1}) were significantly over control (Table 1) with M_3 and found statistically at par with each other. Vermicompost, might have increased the efficiency of added chemical fertilizers in the soil, activities of nitrogen fixing bacteria and increased rate of humification which enhances the availability of both native and added nutrients in soil resulting in increase yield attributes and yield of Cabbage. The increase in yield attributes and yield with application of FYM and vermicompost might be due to higher availability and uptake of plant nutrients, growth substances throughout the crop period and favourable C:N ratio coupled with more available nutrients (Marimuthu *et al.*, 2002) [8] and may also be due to the better utilization of nitrogen for reproductive growth rather than vegetative growth (Gowda *et al.*, 1979) [4].

Quality Attributes and Quality

The maximum ascorbic acid content, N content and crude protein content in cabbage head were recorded significantly higher with the treatment M_2 (vermicompost @ 8.5 t ha^{-1}**)**. The maximum ascorbic acid content, crude protein content and N content in cabbage head were recorded with treatment B_3 (*Azotobacter* + PSB) and found significantly superior over rest of the treatments. The increase in protein content might be due to better availability of desired and required quantity of N in root zone of the crop resulting from its solublization called by organic acid and produced from the decaying of the organic matter. The increase in protein may also be due to the increased activity of nitrate reductase enzymes which might helped in synthesis of amino acids and protein (Yadav and Vijaya kumari 2004 and Choudhary *et al.* 2012) [12, 2]. The increase in Vitamin-C content in cabbage might be due to increase in microbial activity of soil which might have added growth regulators, vitamins and hormones to the plants. Similar findings have also been observed by Mohapatra *et al.* (2013) [9].

Biofertilizers

Yield and Yield Attributes

The maximum values of these yield and yield attributes *i.e.* average head diameter, average weight of head, volume of head, yield of head per plot and yield of head per hectare were recorded with the inoculation with *Azotobacter* + PSB over control. These results are in conformity with the findings of Kachari and Korla (2009) [6] in cauliflower. The increase in yield and yield attributes by the inoculation with biofertilizers might be due to availability of sufficient amount of nitrogen through direct addition and solubility of natural status of nutrient present in soil and different increasing nitrogen levels favored the large uptake of nutrients and effective utilization of utilized nutrients for increased metabolism and synthesis of carbohydrates, greater vegetative growth and subsequent partitioning and translocation from leaf (source) to the head (sink) and also release of energy rich organic compounds by the biofertilizers which ultimately increased auxin activities, growth and activity of microbial saprophytes and phosphates activity which ultimately influenced the yield and yield attributes Sood and Vidyasagar (2007) [10] in cabbage

Quality Parameters

The result of present investigation revealed that Ascorbic acid content in head, protein content in head and N content in head significantly increased by the inoculation with different biofertilizers. the treatment B_3 *i.e. Azotobacter* + PSB registered maximum ascorbic content, protein content and N content in head as compared to control (Table 1) which might be due to adequate nutrient availability environment in the root zone and soil plant system developed due to utilization of atmospheric nitrogen by *Azotobacter* and solubilization of native phosphate status of the soil by PSB. Biofertilizers enhance the availability of the nitrogen and phosphorus to plants and give rise better utilization of the nutrient by the crop which might have in turned greater oot development and higher nitrogen fixation in the soil by Chatterjee (2010) [1] in cabbage.

Table 1: Effect of organic manures and bio-fertilizers on yield and quality attribute of cabbage

Treatment	Average diameter of head (cm)	Average weight of head (g)	Average volume of head (cc)	Yield per plot (kg)	Yield per hectare (q/ha)	Ascorbic acid (mg/100g)	N content in head (%)	Protein content (%)
Organic manures								
M_0 (Control)	10.15	569.00	558.00	12.00	214.32	25.81	0.311	1.945
M_1 (FYM @ 25 t ha^{-1})	11.69	667.00	765.00	13.87	247.60	29.91	0.434	2.715
M_2 (VC @ 8.5 t ha^{-1})	12.78	868.00	934.00	17.33	305.51	35.15	0.498	3.111
M_3 (FYM @ 2/3 *i.e.*16.5 t ha^{-1} + VC @ 1/3 *i.e.* 2.8 t ha^{-1})	12.58	833.75	912.00	16.54	295.24	33.52	0.472	2.950
SEm±	0.29	11.42	16.59	0.27	4.88	0.73	0.010	0.058
CD (P=0.05)	0.82	32.98	47.90	0.77	14.09	2.11	0.028	0.168
Biofertilizers								
B_0 (Control)	10.15	687.50	538.00	13.90	248.18	25.54	0.255	1.593
B_1 (*Azotobacter*)	11.70	730.50	775.00	14.88	265.75	30.38	0.445	2.783
B_2 (PSB)	12.62	743.00	912.00	15.08	267.56	33.38	0.497	3.104
B_3 (*Azotobacter* + PSB)	12.73	776.75	945.00	15.88	281.18	35.10	0.519	3.241
SEm±	0.29	0.013	16.59	0.27	4.88	0.73	0.010	0.058
CD (P=0.05)	0.82	0.039	47.90	0.77	14.09	2.11	0.028	0.168

Conclusion

On the basis of results of present investigation following conclusion may be drawn that combined application of vermicompost @ 8.5 t ha^{-1} along with inoculation of *Azotobacter* + PSB provided maximum yield and quality for cabbage crop.

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