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Response of different organic nutrient management schedules on productivity, head quality, nutrient uptake and economics of organic cabbage

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Abstract

Field experiments were conducted to explore the possibility of improving the productivity of organic cabbage by evaluating the response of different organic nutrient schedules comprising of enriched farmyard manure, vermicompost and poultry manure as basal and top-dressing during winter season of 2017-18 and 2018-19 at UBKV, Pundibari, West Bengal. The experiment consisted of 8 treatment combinations and laid out in randomized block design with three replications. The results revealed that the use of *Azophos* biofertilizer enriched poultry manure (5t/ha) as basal along with 2-times top dressing (1 t/ha) at 30 and 45 days after transplanting significantly increased the head yield (1.64 kg/plant and 42.76 t/ha) along with superior head quality in terms of maximum vitamin A (126.01 IU/100 g), vitamin C (44.02 mg/100 g) and TSS (6.50 °Brix) of organic cabbage. The treatment combination comprised of *Azophos* biofertilizer enriched vermicompost (2.5 t/ha) and enriched poultry manure (2.5 t/ha) as basal along with 2 times top dressing of both (0.5 t/ha) at 30 and 45 days after transplanting proved to be the second-best option for organic cabbage cultivation of the region.

Keywords: *Azophos* biofertilizer, Enriched organic manures, Organic cabbage, Poultry manure, Vermicompost

Introduction

Cabbage (*Brassica oleracea* var. *capitata*; Family-Cruciferae) is one of the most popular Cole group vegetables throughout the world. Cabbage head is frequently consumed either as salad, cooked, sauerkraut, pickle, stew or as braise cabbage. Sometimes, also used as stuffed cabbage and pierogi (filled dumplings). Nutritionally, cabbage head is a good source of protein with high biological value and digestibility along with reasonable amount of vitamins and minerals. Cabbage is also reported to have significant anti-cancerous properties (Gaafar et al. 2014). Cabbage is a high input responsive crop and demand higher amount of plant nutrients particularly nitrogen for head development. To supply the essential plant nutrients and to produce higher yield, vegetable growers are indiscriminately using straight fertilizers especially nitrogen containing fertilizers. However, excess supply of nitrogen through inorganic fertilizers although increases the total dry weight but adversely affects the head quality by producing coarse and loose head as well as reducing keeping quality of head (Ojetayo et al. 2011). Excessive use of nitrogenous fertilizers also leads to nitrate accumulation in cabbage. Apart from these, the additional chemical fertilizers adversely affecting the activities of different anti-oxidants, beneficial secondary metabolites and encourage the attack of more insects, diseases and weeds in the field. The deteriorating soil health due to reduced soil microbial population and contamination of the surrounding water bodies and environment become the threat to the sustainability of the production system. With the increasing awareness on ill effect of chemical inputs on human health and environment, the demand of organic cabbage for salad and other preparation is increasing sharply both in domestic and international market. Consumers showing interest towards consumption of organic food with perception of being safe, healthy and hazard free besides having superior organoleptic quality. To catch the growing market, farmers are gradually adopting organic cabbage in different parts of the country. However, organic cabbage production by use of traditional farmyard manure suffers from deficiency of essential nutrients, resulting in poor head yield and quality.

Several works suggested that apart from farmyard manure, vermicompost and poultry manure can be used as valuable source of organic nutrients (Ghuge et al.

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2007; Gopinath et al. 2009 and Shree et al. 2014). Vermicompost is the cast obtained from the ingested biomass by earthworm after undergoing physical, chemical and microbial transformations. It contains humic acid, growth regulators, vitamins, micronutrients and beneficial microbes (Attiyeh et al. 2002). Poultry manure is the faeces and urine of chickens used as an organic *fertilizer.* It contains higher amount of available nitrogen, phosphorus, and potassium as well as several micronutrients used by plants. Nutrient elements in poultry manure enhance the physical and chemical properties of the soil by increasing moisture holding capacity. Apart from organic manure, biofertilizers played significant role as organic nutrient sources for sustainable soil health and crop growth in several vegetable crops (Bhattacharya et al. 2000). Application of basal use of organic manure fail to provide long term beneficial effect on organic crop plant as, with the passage of time there is a gradual decline in microbial activity which in turn leads to depletion in enzymatic activity and macronutrient composition. Enrichment of organic manures with biofertilizers provide several advantages which include increase in essential nutrient content, microbial load, enzyme activity, decomposition and mineralisation that increased the availability of nutrients for a longer period. Keeping in view the growing demand of organic cabbage, there is an urgent need to standardise the nutrient management schedule for organic cabbage cultivation. Information on comparative performance of different enriched organic manure-based cabbage cultivation is still meagre. Therefore, an attempt was made to evaluate different nutrient management schedule and examine their response on growth, head yield, quality and soil health of organic cabbage.

Materials and Methods

The field experiments for the investigation were conducted during winter season of 2017-18 and 2018-19 at Instructional Farm of UBKV, Pundibari, Cooch Behar, West Bengal, India (26°19' N latitude and 89°232 E longitude at an elevation of 43 m above msl). The initial pH and organic carbon content of soil were 5.78 and 0.76%, respectively. The available N, P and K contents were 117.60, 14.98 and 104.26 kg/ha, respectively. The climatic condition was ideal for cultivation of organic cabbage during the winter months (Fig.1). The experiment consisted of sole and combined application of enriched farmyard manure (FYM), vermicompost (VC) and poultry manure (PM) thus 8 treatment combinations were laid out in Randomized Block Design (RBD) with three replications. The treatments were T_1: FYM (20t/ha) as basal + FYM (5t/ha) as top dressing at 30 and 45 DAT (Control); T_2: Enriched FYM (20 t/ha) as basal + enriched FYM (5t/ha) as top dressing at 30 and 45 DAT; T_3: Enriched vermicompost (5 t/ha) as basal + enriched vermicompost (1t/ha) as top dressing at 30 and 45 DAT; T_4: Enriched Poultry manure (5t/ha) as basal + enriched poultry manure(1 t/ha) as top dressing at 30 and 45 DAT; T_5: Enriched FYM (10 t/ha) and enriched vermicompost (2.5 t/ha) as basal + top dressing of enriched FYM (2.5 t/ha) and enriched vermicompost (0.5 t/ha) at 30 and 45 DAT; T_6: Enriched FYM (10 t/ha) and enriched poultry manure (2.5 t/ha) as basal + top dressing of enriched FYM (2.5 t/ha) and enriched poultry manure (0.5 t/ha) at 30 and 45 DAT; T_7: Enriched vermicompost (2.5 t/ha) along with enriched poultry manure (2.5 t/ha) at 3 weeks before transplanting + enriched vermicompost (0.5 t/ha) along with enriched poultry manure (0.5 t/ha) each at 30 and 45 DAT; T_8: Enriched FYM (7 t/ha), enriched poultry manure (2 t/ha) and enriched vermicompost (2 t/ha) as basal + top dressing of enriched FYM (2 t/ha), enriched vermicompost (0.25 t/ha) and enriched poultry manure (0.25 t/ha) at 30 and 45 DAT. Enriched organic manures were prepared by mixing well decomposed moist organic manure (farmyard manure, vermicompost, poultry manure) (Table 1) with *Azotobacter chroococcum* and Phosphate solubilizing bacteria (*Acinetobacter sp*) containing *Azophos* biofertilizer having standard microbial population (5×10^8) at the rate of 2 kg/ton of organic manure and kept in shade for 20 days before field application.Cabbage seedlings of the variety Green Express were transplanted on 10th November for both the years in 3 m x 3 m plots with a both side spacing of 60 cm.The crop was raised adopting standard cultural practices. Neem cake (2 t/ha) was used as basal and neem oil (5 ml/l) was used uniformly as and when required for all the treatments. Hand weeding was

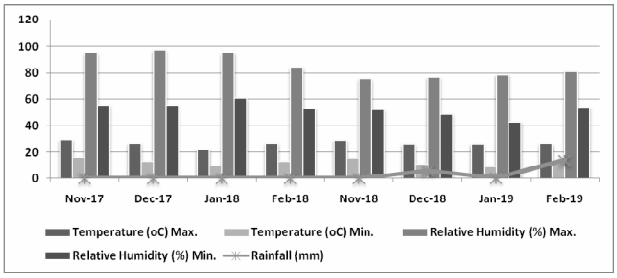

Figure 1: Meteorological monthly parameters during the crop period

Table 1: Nutrient composition of different organic manures used in the field experiment

Organic manures	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Farmyard manure	0.50	0.20	0.50
Vermicompost	2.40	0.80	1.20
Poultry manure	3.03	2.63	1.40

practiced keeping the crop weed free. The observations were recorded on ten randomly selected plants from each plot for different growth, yield and quality attributes (Table 2 and 3). The total soluble solids (TSS) present in head juice was measured by using Hand Refractometer (0-32 °B) (ERMA, Japan). The vitamin A was estimated by analyzing the beta carotene content of the head (Ranganna, 1986) and dividing the value with 0.6 to obtain the vitamin A content of the head. The vitamin C content of head was assessed by the procedure given by Ranganna (1986). Soil samples were also drawn after harvest for studying the post-harvest fertility of soil. The collected soil samples were dried, powered and sieved for different chemical analysis following standard procedures. Two years' data were collected from different treatments were subjected to statistical analysis by adopting the randomized block design (RBD) as suggested by Panse and Sukhatme (2000) with the help of OPSTAT statistical package. The data for individual year was used for pooled analysis over two years and the mean were compared at 0.05% levels for statistical significance (Gomez and Gomez, 1984).

Results and Discussion

Growth parameters: The different nutrient management schedule showed significant response of growth attributes during both years of study (Table 2). In general, the nutrient sources comprising of *Azophos* biofertilizer enriched farmyard manure, vermicompost and poultry manure performed much better compared to control (T_1). The nutrient schedule comprising of combined use of enriched farmyard manure (7 t/ha), enriched poultry manure (2 t/ha) and enriched vermicompost (2 t/ha) as basal dose along with top dressing of enriched farmyard manure (2 t/ha), enriched vermicompost (0.25 t/ha) and enriched poultry manure (0.25 t/ha) at 30 and 45 DAT (T_8) recorded the highest plant height (34.44 cm) and maximum number of non-wrapper leaves (18.17). The result revealed that the treatment T_8 recorded 26% higher plant height and 20% higher non-wrapper leaves over the control (T_1). The enrichment of organic manure might have ensured slow release of essential nutrients throughout the growth period and promoted higher plant height. The results are in conformity with the earlier findings of Shree et

Table 2: Response of different organic nutrient schedules on growth, yield and quality attributes of cabbage (pooled data of two years)

Treatments*	Plant height (cm)	Number of non-wrapper leaves/ plant	Days to head maturity	Head weight (kg)	Head yield/ (tones/ha)	TSS (°Brix)	Vitamin A (IU/100g)	Vitamin C (mg/100g)
T_1- FYM as basal (20 t/ha) + top dressing (5 t/ha) at 30 and 45 DAT	27.28	15.07	64.47	1.21	31.66	4.70	112.98	36.86
T_2-Enriched FYM as basal (20 t/ha) + top dressing (5 t/ha) at 30 and 45 DAT	30.62	16.10	62.12	1.27	33.03	4.96	117.38	37.99
T_3- Enriched VC as basal (5 t/ha) + top dressing (1 t/ha) at 30 and 45 DAT	30.38	15.96	54.76	1.34	35.01	5.55	120.10	40.10
T_4- Enriched PM as basal (5 t/ha) + top dressing (1 t/ha) at 30 and 45 DAT	28.60	15.20	56.40	1.64	42.76	6.50	126.01	44.02
T_5- Enriched FYM (10 t/ha) and VC (2.5 t/ha) as basal+ top dressing of enriched FYM (2.5 t/ha) and enriched VC (0.5 t/ha) at 30 and 45 DAT	33.11	17.57	57.73	1.30	33.81	5.33	119.13	39.59
T_6- Enriched FYM (10 t/ha) and PM (2.5 t/ha) as basal+ top dressing of enriched FYM (2.5 t/ha) and enriched PM (0.5 t/ha) at 30 and 45 DAT	31.46	16.85	60.19	1.41	36.69	6.02	122.86	42.61
T_7- Enriched VC (2.5 t/ha) and PM (2.5 t/ha) as basal+ top dressing of enriched VC (0.5 t/ha) and enriched PM (0.5 t/ha) at 30 and 45 DAT	29.32	15.44	57.44	1.50	39.09	6.22	124.32	43.01
T_8- Enriched FYM (7 t/ha), enriched PM (2 t/ha) and enriched VC (2 t/ha) as basal + top dressing of enriched FYM (2 t/ha), enriched VC (0.25 t/ha) and enriched PM (0.25 t/ha) at 30 and 45 DAT	34.44	18.17	59.32	1.36	35.40	5.84	121.15	42.15
SEm±	0.52	0.32	0.98	0.06	2.38	0.21	3.58	1.12
CD (0.05)	1.50	1.07	2.92	0.17	6.89	0.60	7.52	3.31
CV (%)	4.65	2.74	2.35	5.20	5.20	3.43	3.84	4.14

*FYM-Farmyard manure; VC-Vermicompost; PM-Poultry Manure

al. (2014) where *Azospirillum* biofertilizer enriched farmyard manure and poultry manure recorded the highest plant height of cauliflower. In contrast, the treatment comprising of sole enriched vermicompost (5 t/ha) as basal along with enriched vermicompost (1 t/ha) as top dressing at 30 and 45 DAT (T_3) recorded the minimum days to marketable head maturity (54.76 days) and the treatment T_3 recorded 17% advancement in days to marketable head maturity over the control (T_1). Vermicompost in the presence of *Azophos* biofertilizer have increased the available nitrogen and phosphorous content of the soil, besides beneficial microbes increased the nutrient uptake and availability, released growth promoting substances which might have accelerated early head formation and subsequently early head maturity. Chatterjee (2009) studied the effect of organic manure on days to head formation and maturity of cabbage and reported that vermicompost emerged superior in advancement of the head formation and head maturity of cabbage.

Yield parameters: A perusal of pooled data on yield parameters (Table 2) depicted that among the different nutrient management schedule, the treatment comprising of sole use of enriched poultry manure (5 t/ha) as basal along with enriched poultry manure (1 t/ha) as top dressing at 30 and 45 DAT (T_4) exerted positive influence and recorded the highest individual head weight (1.64 kg) followed by the treatment T_7 (1.50 kg). The same treatment surpassed the others and resulted the highest marketable head yield (42.76 t/ha). The treatments T_4 recorded 35% and 23% higher head weight and head yield over the control (T_1) respectively. Again, use of enriched vermicompost (2.5 t/ha) along with enriched poultry manure (2.5 t/ha) as basal along with top dressing of enriched vermicompost (0.5 t/ha) and enriched poultry manure (0.5 t/ha) at 30 and 45 DAT (T_7) also recorded second highest individual head weight (1.50 kg) and head yield (39.09 t/ha). The findings further showed that performance of *Azophos* biofertilizer was influenced by the forms of organic manures. In case of enrichment of poultry manure with *Azophos* biofertilizer (T_4) resulted in 23% and 18% higher head yield over the *Azophos* biofertilizer enriched farmyard manure (T_2) and vermicompost (T_3) respectively. Moyin-Jesu (2015) stated that poultry manure has balanced nutrient composition and quick mineralization rate that helps higher nutrient uptake and faster accumulation of edible biomass. Biofertilizer enriched poultry manure might have promoted sustained availability of essential nutrients as well as reduced loss of applied nutrients. The increased uptake of essential plant nutrients and favourable soil biota expected to increase the biosynthesis of various metabolites and subsequently expressed in higher head weight. The results are in consonance with the earlier findings of Londhe (2002); Kumar et al. (2018) and Bahadur et al. (2004).

Quality parameters: The observation recorded on TSS, vitamin A and vitamins C of cabbage head at harvest are presented in the Table 2. The treatment consisting of enriched poultry manure (5 t/ha) as basal along with enriched poultry manure (1t/ha) as top dressing at 30 and 45 DAT (T_4) recorded the highest TSS (6.50 °Brix) followed by the treatment T_7 (6.22 °Brix). The same treatment (T_4) also recorded the highest vitamin A (126.01 IU/100g) and maximum vitamin C (44.02 mg/100g) of head. The result revealed that the treatment T_4 recorded 38% higher TSS, 11% greater vitamin A and 19% additional vitamin C content over the control (T_1). The results are in conformity with the earlier findings of Chaterjee *et al*. (2005) where biofertilizer (*Azotobacter* + phosphate solubilizer + potash mobilizer) enriched poultry manure recorded the highest ascorbic acid content in cauliflower curds. The increased TSS in poultry manure enriched treatment combination might be attributed to greater moment and availability of essential nutrients to the plants that might helped in higher TSS of the cabbage head. Application of enriched poultry manure might have accelerated the synthesis and accumulation of photosynthates which could have mobilized the biosynthesis of vitamin A and vitamin C in cabbage head.

Soil parameters: After two year of treatments imposition, the treatment comprising of sole farmyard manure (20 t/ha) as basal along with top dressing (5 t/ha) at 30 and 45 DAT (T_1) recorded the maximum nitrogen (126.43 kg/ha), phosphorous (28.11 kg/ha) and potassium (167.43 kg/ha) content of the soil (Table 3). In the treatment T_1 the uptakes of major nutrients were low which might have increased the availability of the

Table 3: Response of different organic nutrient schedules on soil parameters of cabbage field (pooled data of two years)

Treatments*	Soil pH	Organic Carbon (%)	Available N(kg/ha)	Available P (kg/ha)	Available K (kg/ha)
T_1	5.78	0.82	126.43	28.11	150.30
T_2	5.82	0.87	121.77	26.72	163.76
T_3	5.81	0.86	114.05	25.04	167.43
T_4	5.8	0.85	110.85	22.02	148.36
T_5	5.81	0.86	119.04	25.75	162.25
T_6	5.8	0.85	116.83	26.40	159.18
T_7	5.79	0.84	112.84	23.73	154.03
T_8	5.79	0.83	113.83	25.52	152.14
SEm±	--	--	0.95	0.86	1.14
CD (0.05)	NS	NS	3.23	2.53	3.86
CV (%)	--	--	1.15	7.12	1.79

*Treatment details are in materials and methods; NS: Non-significant

major nutrients in the post harvest soil. The different nutrient management schedule showed non-significant variations on soil pH and organic carbon content of soil after cabbage harvest, however in all the cases the organic carbon percentage was increased compared to the initial value. The build up in organic carbon content in soil might be due to beneficial soil properties of different organic manures.

Economics of production: A perusal of data on economics of organic cabbage production (Table 4) revealed that gross return and net return of cabbage was greatly influenced by the different nutrient management schedule. The *Azophos* biofertilizer enriched poultry manure (5 t/ha) as basal along with enriched poultry manure (1t/ha) as top dressing at 30 and 45 DAT (T_4) fetched the highest gross return (Rs. 299299.00), maximum net return (Rs. 208499.00) and the highest benefit: cost ratio (2.30). The treatment T_7 also recorded higher benefit cost ratio (2.01). The results further showed that among the different organic manures, only enriched poultry manure showed positive impact on economic return compared to control.

Table 4: Response of different organic nutrient schedules on economics of organic cabbage cultivation (pooled data of two years)

Treatments*	Head yield (t/ha)	Gross return# (Rs.)	Treatment cost (Rs.)			Net return (Rs.)	Benefit: cost ratio
			Fixed cost	Variable cost	Total cost		
T_1	31.66	221618	45300	35000	80300	141318	1.76
T_2	33.03	231214	45300	40500	85800	145414	1.69
T_3	35.01	245075	45300	45500	90800	154275	1.70
T_4	42.76	299299	45300	45500	90800	208499	2.30
T_5	33.81	236697	45300	43000	88300	148397	1.68
T_6	36.69	256803	45300	43000	88300	168503	1.91
T_7	39.09	273603	45300	45500	90800	182803	2.01
T_8	35.40	247816	45300	41000	86300	161516	1.87

*Treatment details are in materials and methods; #Sale price of cabbage heads @ Rs.7.00/kg

Conclusion

Based on the findings of 2 years study, it may be concluded that enriched poultry manure emerged as best organic nutrient source over enriched vermicompost and farmyard manure and adoption of *Azophos* biofertilizer enriched poultry manure (5 t/ha) as basal along with 2 times top dressing of biofertilizer enriched poultry manure (1t/ha) at 30 and 45 days after transplanting have pronounced influence and exerted maximum head yield along with superior head quality of organic cabbage, hence can successfully be used in organic cabbage production. The treatment combination comprised of *Azophos* biofertilizer enriched vermicompost (2.5 t/ha) and enriched poultry manure (2.5 t/ha) as basal along with 2 times top dressing of biofertilizer enriched vermicompost (0.5 t/ha) and enriched poultry manure (0.5 t/ha) at 30 and 45 days after transplanting may be selected as second best option for organic cabbage cultivation. The above practice will help to achieve desired yield, quality of organic cabbage and sustainability of production system.

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कार्बनिक विधि से उगायी जाने वाली पत्तागोभी की उत्पादकता वृद्धि की सम्भावना ज्ञात करने के लिए विविध कार्बनिक पोषक तत्वों वाले खादों जैसे–फार्म यार्ड मैन्योर, वर्मीकम्पोस्ट तथा पोल्ट्री मैन्योर का आधारीय तथा छिटकाव रूप में वर्ष 2017–18 एवं 2018–19 के शीतकाल में उत्तरबंगा कृषि विश्वविद्यालय, पूण्डीबारी (पश्चिम बंगाल) में प्रायोगिक परीक्षण किया गया। प्रयोग में कुल 8 उपचारों के संयोज्य किये गये तथा यादृक्षिक खण्ड आकार में 3 बार प्रतिकृति किया गया। परिणाम से स्पष्ट हुआ कि एजोफास जैव उर्वरक युक्त पोल्ट्री मैन्योर (5 टन प्रति हेक्टेयर) का दो बार छिटकाव (1 टन प्रति हेक्टेयर) को पौध रोपड़ के 30 व 45 दिनों बाद करने पर शीर्ष उपज में सार्थक वृद्धि (1.64 किग्रा./पौध तथा 42.76 टन/हे.) वृद्धि पायी गयी एवं शीर्ष में अधिकतम विटामिन ए (126.01 आई यू./100 ग्राम), विटामिन सी (44.02 मिग्रा./100 ग्राम) व कुल विलेय ठोस (6.50 ब्रिक्स) कार्बनिक पत्तागोभी में पाया गया। उपचार संयोज्य जिनमें एजोफास उर्वरक वर्मीकम्पोस्ट (2.5 टन/हे.) तथा पोल्ट्री मैन्योर (2.5 टन/हे.) आधारीय रूप में प्रयोग करने पर व 2 बार छिटकाव (0.5 टन/हे.) पौध रोपड़ के 30 व 45 दिनों बाद करने पर उत्तम पाया गया जो स्पष्ट किया के में संयोज्य क्रमशः प्रथम व द्वितीय का उपयोग इस क्षेत्र में कार्बनिक विधि से पत्तागोभी की खेती को बढ़ाने में सहायक है।

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