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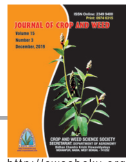

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Influence of different nutrient management schedules on physiological attributes of organic cabbage (*Brassica oleracea* var. *capitata* L.)

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ABSTRACT

A field experiment was conducted to study the influence of different nutrient management schedules on various physiological attributes of organic cabbage during 2017-18 and 2018-19 at Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari, Cooch Behar, West Bengal, India by combining 8 treatments in randomized block design with 3 replications. The results revealed that the treatment comprising of combined use of enriched farmyard manure (7t ha^{-1}), enriched poultry manure (2t ha^{-1}) and enriched vermicompost (2t ha^{-1}) as basal dose along with top dressing of enriched farmyard manure (2t ha^{-1}), enriched vermicompost (0.25t ha^{-1}) and enriched poultry manure (0.25t ha^{-1}) at 30 and 60 DAT (T_8) recorded the maximum leaf area index of cabbage (2.70). The treatment comprising of sole enriched vermicompost (5t ha^{-1}) as basal along with enriched vermicompost (1t ha^{-1}) as top dressing at 30 and 60 DAT (T_3) recorded maximum dry matter accumulation (11.43%). Again, the treatment comprising of sole use of enriched poultry manure (5t ha^{-1}) as basal along with enriched poultry manure (1t ha^{-1}) as top dressing at 30 and 60 DAT (T_4) recorded maximum chlorophyll content (73.03 SPAD value) as well as highest head weight (1.64 kg), head yield per hectare (42.76 t). The maximum harvest index (71.30%) was also recorded by this treatment. The study suggested that application of Azophos biofertiliser enriched poultry manure (5t ha^{-1}) as basal along with 2 times top dressing of biofertiliser enriched poultry manure (1t ha^{-1}) exerted maximum influence on different physiological attributes of organic cabbage.

Keywords: *Azophos* biofertiliser, nutrient management, organic cabbage, physiological attributes, enriched poultry manure

Cabbage is one of the most popular cole group vegetables. Cabbage head is eaten either as salad, cooked, pickle, sauerkraut or stew cabbage. The characteristic flavour of cabbage is due to glucosinolates, a class of sulfur-containing glucosides which include sulforaphane and other glucosinolates that have significant anti-cancer activity (Beecher, 1994). Cabbage demand higher amount of plant nutrients particularly nitrogen for the development of head. To supply the essential plant nutrients and to produce higher yield, the growers are indiscriminately using nitrogen containing fertilizers. Although, excessive use of nitrogen through inorganic fertilizers increases the total dry weight but adversely affects the quality of head by producing loose and coarse head as well as reducing the keeping quality of head (Ojetayo *et al*., 2011). Excessive use of chemical fertilizers adversely affects the human health when consumed in raw form as salad.With the increasing awareness on ill effect of chemical fertilizers on human health and environment, the demand for organic cultivation of cabbage is increasing both in domestic and international market with the perception of being 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. Several research works suggested that farmyard manure, vermicompost and poultry manure can be used as organic nutrient sources (Ghuge *et al*., 2007; Gopinath *et al*., 2009 and Shree *et al*., 2014). These organic sources increase the availability of plant nutrients resulting in increased growth, higher yield and better quality produce (Atiyeh *et al*., 2002).They also increase the availability of nutrient uptake by the plants, and suppress the harmful effect of soil pathogen. Apart from organic manure, biofertilizers played significant role as organic nutrient source for sustainable soil health and crop growth in several vegetable crops (Bhattacharya *et al*., 2000). Enrichment of organic manures with biofertilisers provide several advantages which include increase in microbial population, nitrogen, phosphorous and potassium content, enzyme activity and increase the fertility status.Some earlier findings suggested that more amount of organic nutrient sources and minimum use of inorganic fertilizers can enhance the physiological efficiency of pea (Reddy *et al*., 1998), okra (Paramasivan, 2005) and tomato (Chatterjee, 2013). However, information regarding enrichment of organic manures with biofertiliser and their influence on physiological and yield attributes of cabbage is very scanty. Hence, the present work was formulated with the objective to evaluate different nutrient management

Short Communication

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schedule and examine their responses on physiological and yield characters of organic cabbage.

The field experiment was conducted at Instructional Farm of Department of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India (26°192 N latitude and 89°232 E longitude) at an elevation of 43 meters above mean sea level during November to February of 2017-2018 and 2018-2019.The soil was sandy loam having acidic pH, organic carbon content 0.76% and available N, P_2O_5, K_2O were 117.6 kg ha^{-1}, 14.98 kg ha^{-1} and 104.26 kg ha^{-1} respectively.The treatments consisted of 8 combinations of different nutrient sources and was laid out in randomized block design with three replications. The treatment combinations were T_1: FYM (20t ha^{-1}) as basal + FYM (5t ha^{-1}) as top dressing at 30 and 45 DAT (Control); T_2: Enriched FYM (20 t ha^{-1}) as basal + enriched FYM (5t ha^{-1}) as top dressing at 30 and 45 DAT; T_3: Enriched vermicompost (5t ha^{-1}) as basal + enriched vermicompost (1t ha^{-1}) as top dressing at 30 and 45 DAT; T_4: Enriched poultry manure (5t ha^{-1}) as basal + enriched poultry manure(1t ha^{-1}) as top dressing at 30 and 45 DAT; T_5: Enriched FYM (10 t ha^{-1}) and enriched vermicompost (2.5 t ha^{-1}) as basal + top dressing of enriched FYM (2.5 t ha^{-1}) and enriched vermicompost (0.5 t ha^{-1}) at 30 and 45 DAT; T_6: Enriched FYM (10 t ha^{-1}) and enriched poultry manure (2.5t ha^{-1}) as basal + top dressing of enriched FYM (2.5 t/ha) and enriched poultry manure (0.5 t ha^{-1}) at 30 and 45 DAT; T_7: Enriched vermicompost (2.5t ha^{-1}) along with enriched poultry manure (2.5 t ha^{-1}) at 3 weeks before transplanting + enriched vermicompost (0.5 t ha^{-1}) along with enriched poultry manure (0.5 t ha^{-1}) each at 30 and 45 DAT; T_8: Enriched FYM (7 t ha^{-1}), enriched poultry manure (2 t ha^{-1}) and enriched vermicompost (2 t ha^{-1}) as basal + top dressing of enriched FYM (2 t ha^{-1}), enriched vermicompost (0.25 t/ha) and enriched poultry manure (0.25 t ha^{-1}) at 30 and 45 DAT. Cabbage seedlings (cv.Green Express) were transplanted in 3m×3m plots with a spacing of 60 cm within and between rows. Enrichment of organic manure was made by mixing moist organic manure (FYM, Vermicompost, Poultry manure) with the microbial inoculants *Azophos* containing *Azotobacter chroococcum* and Phosphate Solubilizing Bacteria (*Acinetobacter* sp.) with standard microbial population (5x 10^8) at the rate of 10g biofertilizer per kg of organic manure. The mixer was kept in shade for 20 days before field application and applied as per treatment combination. The crop was raised adopting standard cultural practices.The chlorophyll content of cabbage leaves was measured by using portable leaf chlorophyll meter (Minolta, Japan) and expressed in terms of SPAD 502 value. The leaf area index (LAI) was determined with standard procedure (Watson, 1952) after measuring the area of leaves by using leaf area meter (Model 22, Systronics). To estimate dry matter, fresh whole plant samples were taken from each plot and were oven dried individually at 65^0C ± 2^0C till constant weight was recorded. The recorded data was analyzed statistically with the help of Opstat statistical package.

Physiological parameters

Chlorophyll content of leaves: The observation recorded on leaf chlorophyll content of cabbage (SPAD value) at harvest has been presented in the Table 1. The treatment comprising sole use of enriched poultry manure (5t ha^{-1}) as basal along with enriched poultry manure (1t ha^{-1}) as top dressing at 30 and 60 DAT (T_4) recorded the highest leaf chlorophyll content (73.03) followed by the treatment (T_7) having chlorophyll content of 71.48. The lowest leaf chlorophyll content (59.52) at harvest was recorded by the treatment containing sole farmyard manure (20t ha^{-1}) as basal along with top dressing (5t ha^{-1}) at 30 and 60 DAT (T_1).The result revealed that the treatment T_4recorded 22% higher leaf chlorophyll content over the control (T_1). Qureshi *et al.* (2014) stated that enrichment of poultry manure with biofertiliser increased the availability of macro and micro nutrient to the plants. The increased availability of essential nutrients might have enhanced the photosynthetic ability of the plant and subsequently higher chlorophyll content.

Leaf area index (LAI): The observation recorded on leaf area index of cabbage at harvest has been presented in the Table 1. The treatment comprising of combined use of enriched farmyard manure (7t ha^{-1}), enriched poultry manure (2t ha^{-1}) and enriched vermicompost (2t ha^{-1}) as basal dose along with top dressing of enriched farmyard manure (2t ha^{-1}), enriched vermicompost (0.25t ha^{-1}) and enriched poultry manure (0.25t ha^{-1}) at 30 and 60 DAT (T_8) recorded the highest leaf area index (2.70) followed by the treatment T_5 (2.51). The lowest leaf area index at harvest (2.14) was recorded by the treatment comprising sole farmyard manure (20t ha^{-1}) as basal along with top dressing (5t ha^{-1}) at 30 and 60 DAT (T_1).The result revealed that the treatments T_8 and T_5 recorded 26% and 7% higher leaf area index over the control (T_1) respectively.

Dry matter accumulation (g plant^{-1}): The observation recorded on dry matter accumulation of cabbage at harvest has been presented in the Table 1. The treatment comprising of sole use of enriched vermicompost (5t ha^{-1}) as basal along with enriched vermicompost (1t ha^{-1}) as top dressing at 30 and 60 DAT (T_3) recorded the highest head dry matter (11.43%) followed by the treatment T_4 (11.10%). The lowest head dry matter (9.11%) at harvest was recorded by the treatment containing sole farmyard manure (20t ha^{-1}) as basal along with top dressing (5t ha^{-1}) at 30 and 60 DAT (T_1).The pooled result revealed that the treatments T_3 and T_4 recorded 25% and 21% highest dry matter accumulation over the control (T_1) respectively. The maximum dry matter content in the treatment comprising

Table 1: Response of different organic nutrient schedules on physiological and yield attributes of cabbage (pooled data of two years)

Treatments*	Leaf area index (LAI)			Leaf chlorophyll content (SPAD value)			Dry matter accumulation (%)			Average head weight (kg)			Head yield (t ha^{-1})			Harvest index (%)		
	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P	Y1	Y2	P
T_1	2.16	2.13	2.14	58.74	60.30	59.52	9.12	9.10	9.11	1.19	1.24	1.21	31.07	32.25	31.66	61.93	65.35	63.64
T_2	2.43	2.33	2.38	60.19	61.75	60.97	9.23	9.15	9.19	1.25	1.28	1.27	32.64	33.42	33.03	63.65	67.10	65.38
T_3	2.26	2.23	2.25	64.31	65.87	65.09	11.27	11.60	11.43	1.31	1.38	1.34	34.12	35.90	35.01	64.92	68.65	66.78
T_4	2.20	2.15	2.17	72.25	73.81	73.03	11.24	10.95	11.10	1.58	1.70	1.64	41.26	44.26	42.76	69.31	73.29	71.30
T_5	2.55	2.47	2.51	63.01	64.57	63.79	10.77	10.47	10.62	1.27	1.32	1.30	33.16	34.47	33.81	64.23	67.86	66.05
T_6	2.46	2.35	2.41	70.40	71.96	71.18	9.84	9.49	9.67	1.37	1.44	1.41	35.77	37.60	36.69	67.16	71.03	69.09
T_7	2.23	2.17	2.20	70.70	72.26	71.48	10.90	10.82	10.86	1.41	1.58	1.50	36.90	41.27	39.09	67.84	71.76	69.80
T_8	2.91	2.48	2.70	68.58	70.14	69.36	9.96	10.14	10.05	1.32	1.40	1.36	34.38	36.43	35.40	66.28	70.01	68.14
SEm±	**0.09**	**0.04**	**0.07**	**1.31**	**1.31**	**0.91**	**0.48**	**0.32**	**0.39**	**0.05**	**0.05**	**0.06**	**1.40**	**1.18**	**2.38**	**1.10**	**1.27**	**1.03**
CD (0.05)	**0.28**	**0.12**	**0.23**	**4.01**	**4.01**	**2.65**	**1.46**	**0.98**	**1.10**	**0.16**	**0.14**	**0.17**	**4.29**	**3.61**	**6.89**	**3.39**	**3.91**	**2.98**

****Note:** *Y1-2017-18; Y2-2018-19;P-Pooled T_1: FYM (20t ha^{-1}) as basal + FYM (5t ha^{-1}) as top dressing at 30 and 45 DAT (Control); T_2: Enriched FYM (20t ha^{-1}) as basal + enriched FYM (5t ha^{-1}) as top dressing at 30 and 45 DAT; T_3: Enriched vermicompost (5t ha^{-1}) as basal + enriched vermicompost (1t ha^{-1}) as top dressing at 30 and 45 DAT; T_4: Enriched Poultry manure (5t ha^{-1}) as basal + enriched poultry manure(1t ha^{-1}) as top dressing at 30 and 45 DAT; T_5: Enriched FYM (10t ha^{-1}) and enriched vermicompost (2.5t ha^{-1}) as basal + top dressing of enriched FYM (2.5t ha^{-1}) and enriched vermicompost (0.5t ha^{-1}) at 30 and 45 DAT; T_6: Enriched FYM (10t ha^{-1}) and enriched poultry manure (2.5t ha^{-1}) as basal + top dressing of enriched FYM (2.5t ha^{-1}) and enriched poultry manure (0.5t ha^{-1}) at 30 and 45 DAT; T_7: Enriched vermicompost (2.5t ha^{-1}) along with enriched poultry manure (2.5t ha^{-1}) at 3 weeks before transplanting + enriched vermicompost (0.5t ha^{-1}) along with enriched poultry manure (0.5t ha^{-1}) each at 30 and 45 DAT; T_8: Enriched FYM (7t ha^{-1}), enriched poultry manure (2t ha^{-1}) and enriched vermicompost (2t ha^{-1}) as basal + top dressing of enriched FYM (2t ha^{-1}), enriched vermicompost (0.25t ha^{-1}) and enriched poultry manure (0.25t ha^{-1}) at 30 and 45DAT.*

of enriched vermicompost as basal as well as in top dressing may be due to greater uptake of essential plant nutrients throughout the growth period might have increased photosynthetic ability of the plant which in turn favour the increased head dry matter content.

Yield attributes and yield: The observations recorded on average head weight, head yield hectare^{-1} and harvest index of cabbage has been presented in the Table 1. The yield attributing characters were significantly influenced by the sole application of poultry manure. The treatment comprising of sole use of enriched poultry manure (5t ha^{-1}) as basal along with enriched poultry manure (1t ha^{-1}) as top dressing at 30 and 60 DAT (T_4) recorded the highest average head weight (1.64 kg), head yield hectare^{-1} (42.76 t) and highest harvest index (71.30 %). However, the treatment T_7 was statistically at par with the treatment T_4 for all these yield characters. The lowest average head weight (1.21 kg), head yield hectare^{-1} (31.66 t) and harvest index (63.64%) at harvest was recorded by the treatment comprising of sole farmyard manure (20t ha^{-1}) as basal along with top dressing (5t ha^{-1}) at 30 and 60 DAT (T_1).The result revealed that the treatments T_4 and T_7 recorded 35% and 23% higher average head weight, head yield hectare^{-1} and harvest index of cabbage over the control (T_1) respectively.The increased head weight with the application of enriched poultry manure may be attributed to better uptake and availability as well as reduce loss of applied nutrient. Presence of higher amount of N (3.03%), P (2.63%), K (1.4%) in poultry manure along with microbial enrichment might have enhanced the physiological efficiency and subsequently better carbohydrate synthesis as well as effective translocation of these assimilates to the cabbage head. Moyin-Jesu (2015) opined that the highest head yield of cabbage in poultry manure treatment was because of its balanced nutrient composition and the least C/N ratio that will help higher nutrient uptake and faster plant growth.

CONCLUSION

Based on the findings of the present experiment, it may be concluded that adoption of *Azophos* biofertiliser enriched poultry manure (5t ha^{-1}) as basal (3 weeks before seedling transplanting) along with 2 times top dressing of biofertiliser enriched poultry manure (1t ha^{-1}) at 30 and 60 days after transplanting may offer higher physiological efficiency and subsequently maximum head yield along with superior head quality of organic cabbage. The treatment combination comprised of *Azophos* biofertiliser enriched vermicompost (2.5 t ha^{-1}) and enriched poultry manure (2.5 t ha^{-1}) as basal (3 weeks before seedling transplanting) along with 2 times top dressing of biofertiliser enriched vermicompost (0.5 t ha^{-1}) and enriched poultry manure (0.5 t ha^{-1}) at 30 and 60 days after transplanting may be treated as second best option for organic cabbage cultivation in terai zone of West Bengal.

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