



Enhancement of head yield and quality of cabbage (*Brassica oleracea*) by combining different sources of nutrients

RANJIT CHATTERJEE¹, J C JANA² and P K PAUL³

Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal 736 165

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ABSTRACT

The present study was aimed to study on influence of different nutrient sources on important quality attributes of cabbage cv. Golden Acre. The field experiment was conducted during 2005–06 and 2006–07 with 14 different treatments by combining inorganic and different organic sources of plant nutrients. The marketable cabbage heads from different treatments were studied for yield and different quality attributes. The pooled result revealed that cabbage head yield and its shelf life, TSS, vitamin A and vitamin C contents were significantly influenced by the application of different sources of nutrients. Vermicompost emerged as better organic nutrient source over farmyard manure. Inoculation with *Azophos*, a commercial biofertilizer preparation containing the *Azotobacter* and phosphate-solubilizing bacteria exerted more positive result over uninoculated treatments and benefits of biofertilizer application were more in presence of vermicompost as compared to farmyard manure. The maximum head yield (27.86 tonnes/ha), shelf-life (12 days), head firmness (93.32 kg/cm²) as well as TSS (4.18° Brix), vitamin A (126.76 µg/100g), vitamin C (44.62 mg/100g) and lowest nitrate content of head (217.17 mg/kg) were realized for the plants grown with the application of 75% of recommended inorganic fertilizers along with vermicompost (5 tonnes/ha) in presence of biofertilizers. Substitution of 25% recommended inorganic nitrogen with higher levels of organic manure and biofertilizer prolonged shelf-life as well as improved nutritional qualities of cabbage heads.

Keywords: Biofertilizer, Cabbage yield and quality, Farmyard manure, Inorganic fertilizer, Vermicompost

Cabbage (*Brassica oleracea* L. var. *capitata* L.) is the most widely cultivated cole crop in the world and can be used as fresh (salad) or cooked vegetable and preparation of processed products. The head is an excellent source of vitamins, minerals and dietary fibers. The crop demands higher amount of plant nutrients, particularly nitrogen for head production. 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, reducing keeping quality and enhancing the nitrate nitrogen content of head (Ojetayo *et al.* 2011). Some study indicates that application of higher amount of organic manure along with reduced levels of inorganic nitrogen fertilizer can improve the nutritional and keeping quality of cabbage head (Londhe 2002, Yadav *et al.* 2001). Therefore, integrated nutrient management practices will be beneficial for improvement of overall quality of head. Vermicompost

contains nutrients in form that are readily taken up by the plants such as nitrates, exchangeable phosphorus, and soluble potassium, calcium, and magnesium (Edwards and Burrows 1988). The water soluble components of vermicompost such as humic acid, growth regulators, vitamins and micronutrients increases the availability of plant nutrients resulting in increased growth, higher yield and better quality produce (Atiyeh *et al.* 2002). In addition to vermicompost, farmyard manure and biofertilizer also plays vital role as organic nutrient sources for sustainable soil health and crop growth. However, information regarding type of organic manure, their optimum dose as well as their interaction effect in combination with inorganic fertilizers and biofertilizer on yield and quality aspects of cabbage head is still meager. Keeping the above in view, the present work was undertaken to study the impact of different combination of nutrient sources on yield and important quality attributes of cabbage.

MATERIALS AND METHODS

The field experiment was conducted at the Instructional Farm of UBKV, Pundibari, Coochbehar, West Bengal during winter season (November to February) of 2005–06 and 2006–07. The site is located at 89°23'53" E longitude and 26°19'86"

¹Assistant Professor (e mail: ranchat22@rediffmail.com),

²Associate Professor and Head (e mail: janajc@rediffmail.com), Department of Vegetable and Spice Crops, ³Assistant Professor (e mail: prodyut24@yahoo.com), Department of Pomology and Post Harvest Technology

N latitude and at 43 m above mean sea level. The soil was sandy loam (61%, 20% and 18% sand, silt and clay respectively) in texture and slight acidic in reaction (pH 5.71). The initial soil organic carbon was 0.83% and available N, P and K contents were 154.28, 21.17 and 124.48 kg/ha respectively. The treatments were selected for sole and combined application of varied levels of vermicompost and farmyard manure along with 100% and 75% of recommended dose of inorganic fertilizers in presence and absence of biofertilizer and thus 14 treatment combinations were laid out in randomized block design (RBD) with three replications. The Treatments were T₁-100% recommended fertilizer dose (R.F.D) of 150 N:80 P:75 K kg/ha; T₂-100% R.F.D + 8 tonnes/ha farmyard manure + biofertilizer; T₃-100% R.F.D + 2.5 tonnes/ha vermicompost + biofertilizer; T₄-100% R.F.D + 4 tonnes/ha farmyard manure + 1.25 tonnes/ha vermicompost + biofertilizer; T₅-75% R.F.D + 8 tonnes/ha farmyard manure; T₆-75% R.F.D + 8 tonnes/ha farmyard manure + biofertilizer; T₇-75% R.F.D + 2.5 tonnes/ha vermicompost; T₈-75% R.F.D + 2.5 tonnes/ha vermicompost + biofertilizer; T₉-75% R.F.D + 4 tonnes/ha farmyard manure + 1.25 tonnes/ha vermicompost + biofertilizer; T₁₀-75% R.F.D + 16 tonnes/ha farmyard manure; T₁₁-75% R.F.D + 16 tonnes/ha farmyard manure + biofertilizer; T₁₂-75% R.F.D + 5 tonnes/ha vermicompost; T₁₃-75% R.F.D + 5 tonnes/ha vermicompost + biofertilizer and T₁₄-75% R.F.D + 8 tonnes/ha farmyard manure + 2.5 tonnes/ha vermicompost + biofertilizer. Cabbage seedlings of the cultivar Golden Acre were transplanted in 3 m × 3 m plots with both ways spacing of 60 cm. Vermicompost and farmyard manure were applied to the respective plots at the time of transplanting. *Azophos*, a commercial biofertilizer preparation containing the *Azotobacter* and phosphate-solubilizing bacteria was applied as seedling root dipping (250 g/litre water) just before transplanting using rice gruel as adhesive. The recommended doses of inorganic fertilizers were applied in the form of urea (N- 46%), single super phosphate (P- 16%) and muriate of potash (K- 60%). Full dose of P and K along with half N were applied as basal and rest N was top dressed in two equal splits at 30 and 45 days after transplanting. The crop was raised adopting standard cultural practices. The shelf-life of the cabbage head was determined by a panel of 10 judges (J₁ to J₁₀). Head freshness (P₁), visual colour (P₂), firmness (P₃) and presence/absence of defects (P₄) were considered as consumer acceptability parameters. A score of maximum 10 was allotted for each parameter. The scores were taken at 2 days intervals up to 14 days. The average room temperature and relative humidity of storage room were 21°C and 82% respectively. The overall score was converted to a 10-point scale at every observation day with the following mathematical expression

$$\text{Overall score} = \frac{\sum J_i P_i}{400} \times 10$$

Where, J_iP_i was the value given by the ith judge for the ith parameter. The day at which the score went below 5 was considered as maximum shelf-life. The chlorophyll content of the head was measured by portable chlorophyll meter (SPAD 502). The head firmness was measured by using a Texture Analyzer (Model: TA-XT plus) with a 2 mm cylindrical probe. For biochemical analysis 10g head samples from all the plots were taken during harvesting. The total soluble solids (TSS) present in head juice was measured by using Erma Hand Refractometer (0-32°B) (ERMA, Japan). The observed reading was corrected using temperature correction chart to obtain TSS value at 20°C. The Vitamin A was estimated by analyzing the β-carotene content of the head and then dividing the value with 0.6 to obtain the vitamin A content of the head (Srivastava and Kumar 2002). The vitamin C content was determined titrimetrically, using 2, 6 dichlorophenol indophenol dye as per method suggested by Ranganna (1986). Nitrate content of harvested cabbage head was estimated by the method suggested by Woolley *et al.* (1960). The observations recorded were statistically analyzed using INDOSTAT statistical package.

RESULTS AND DISCUSSION

The mean data of the Table 1 revealed that head yield was significantly influenced by the combination of different sources of nutrients and it tended to increase with the application of higher amount of organic manure inoculated with biofertilizer. The highest head yield (27.86 tonnes/ha) was recorded for the treatment T₁₃ (75% R.F.D + 5 tonnes/ha vermicompost + biofertilizer) which was 135% higher over the sole chemical fertilizers (T₁). The findings further showed that performance of biofertilizer was influenced by the forms and levels of organic manures. In case of higher level of farmyard manure, presence of biofertilizer (T₁₁) resulted 8% more head yield over the uninoculated treatment combination T₁₀, where as for higher level of vermicompost, addition of biofertilizers (T₁₃) resulted in 16% improvement in head yield over the uninoculated treatment combination T₁₂. Superiority of vermicompost over farmyard manure is due to its nutritional richness, quick mineralization and more availability of nitrogen and other plant nutrients (Mujahid and Gupta, 2010). Vermicompost in presence of *Azotobacter* influenced the plant metabolism of cabbage by enhancing the solubility and availability of applied nutrients and moisture retention capacity (Akbar *et al.* 2009). Similar increase in head yield of cabbage due to balance application of inorganic fertilizers, organic manures and biofertilizers was also reported by Londhe (2002) as well as Bahadur *et al.* (2004).

The result on shelf-life of cabbage head (Table 1) showed an increasing trend with the increased level of organic manure and reduced level of inorganic fertilizer in presence of biofertilizer. The shelf-life of cabbage head was high for the treatments having 75% inorganic fertilizer combinations (T₅ to T₁₄) over the head from the treatments containing

Table 1 Effect of nutrient source on physical estimates of cabbage head (pooled data of two years)

Treatment	Head yield (tonnes/ha)	Shelf-life (days)	Head firmness (kg/cm ²)	Chlorophyll content (SPAD value)
T ₁ -100% RFD (150N : 80N : 75P kg/ha)	11.88	7.31	57.31	27.71
T ₂ -100% RFD + 8 tonnes FYM/ha + Biofert.	20.65	8.12	65.24	31.81
T ₃ -100% RFD + 2.5 tonnes VC/ha + Biofert.	21.38	8.57	71.19	33.14
T ₄ - 100% NPK + 4 tonnes/ha FYM + 1.25 tonnes/ha VC + Biofert.	21.18	8.39	69.27	32.48
T ₅ -75% RFD + 8 tonnes FYM/ha	16.39	8.83	74.23	29.21
T ₆ -75% RFD + 8 tonnes FYM/ha + Biofert.	17.60	9.51	77.54	30.63
T ₇ -75% RFD + 2.5 tonnes VC/ha	19.33	9.12	82.43	31.14
T ₈ -75% RFD + 2.5 tonnes VC/ha + Biofert.	21.54	9.68	84.59	32.27
T ₉ -75% RFD + 4 tonnes FYM/ha + 1.25tonnes VC/ha + Biofert.	19.75	9.23	82.32	31.78
T ₁₀ - 75% RFD + 16 tonnes FYM/ha	23.74	10.41	85.51	34.61
T ₁₁ -75% RFD + 16 tonnes FYM/ha + Biofert.	25.57	11.12	88.36	35.43
T ₁₂ -75% RFD + 5 tonnes VC/ha	24.04	11.34	90.27	37.17
T ₁₃ -75% RFD + 5 tonnes VC/ha + Biofert.	27.86	12.17	93.32	38.62
T ₁₄ -75% RFD + 8 tonnes FYM/ha + 2.5 tonnes VC/ha + Biofert.	26.46	10.69	89.63	36.23
S Em (±)	0.85	0.19	0.87	1.10
CD (P = 0.05)	2.41	0.52	2.49	4.28

100% inorganic fertilizers (T₁ to T₄). Again within the 75% inorganic fertilizer treatment combinations, higher amount of organic manures containing treatments (T₁₀ to T₁₄) have longer shelf-life for all the days of storage. The maximum shelf-life of 12 days was recorded by the treatment T₁₃, followed by T₁₂ and T₁₄. Performance of vermicompost in prolonging shelf-life of cabbage was better as compared to farmyard manure. Higher shelf-life in the treatments containing 75% inorganic fertilizers in combination with higher amount of organic manure and biofertilizer could be due to slower rate of respiration and transpiration which might have prevented the moisture loss from the head surface resulted in delay in loosening of head therefore retained the head freshness for the longer period.

The observation on head firmness (Table 1) revealed that among the 100% inorganic fertilizer plots, plants from the treatment T₃ (100% R.F.D + 2.5 tonnes/ha vermicompost + biofertilizer) recorded the higher firmness of head (71.19 kg/cm²). However, increased levels of organic manures and reduced level of nitrogen fertilizer further increased the firmness of cabbage heads and the maximum head firmness of 93.32 kg/cm² was recorded for the treatment T₁₃. The result on chlorophyll content of head (Table 1) showed that treatments combining 100% inorganic fertilizers along with organic manure and biofertilizer recorded significantly higher chlorophyll in the head compared to 100% inorganic fertilizers alone. However, increased level of organic manures gradually improved the chlorophyll content of head and addition of biofertilizer had further increased the values. The maximum chlorophyll content of head (38.62 SPAD value) was recorded for the treatment T₁₃, however it was statistically at par with all the treatments having higher amount of organic manure

(T₁₀, T₁₁, T₁₂ and T₁₄).

The TSS content of cabbage head (Table 2) revealed that treatments combining 75% inorganic fertilizers along with higher levels of organic manure and biofertilizer recorded higher TSS value and the highest TSS of 4.18 °Brix was recorded by the treatment combining 75% inorganic fertilizers along with vermicompost (5 tonnes/ha) inoculated with biofertilizer (T₁₃), which was 22% higher over the treatment T₁. The increase in TSS content in the vermicompost, inorganic fertilizers and biofertilizer containing treatments may be attributed to greater movement and availability of essential nutrients that might have accelerated the breakdown of complex polysaccharides into simple sugars and directs their accumulation in developing heads.

The observation on vitamin content of cabbage head (Table 2) showed an increasing trend with higher level of organic manure and reduced level of inorganic fertilizer. The highest vitamin A (126.76 µg/100g fresh head) and vitamin C (44.62 mg/100g fresh head) were recorded for the treatment T₁₃ which was 17% and 27% respectively higher over the sole 100% inorganic fertilizers (T₁). The findings further showed that vitamin content of cabbage head was also influenced by the forms and levels of organic manures. Among the 75% inorganic fertilizer treatment combinations, application of organic manure in the form of vermicompost has recorded higher vitamin C in the head compared to farmyard manure based treatments. When higher level of vermicompost (5 tonnes/ha) (T₁₃) was applied, 11% improvement in vitamin C content was recorded over higher level of farmyard manure (16 tonnes/ha) (T₁₁), irrespective of biofertilizer inoculation. Similarly, increase in vermicompost level from 2.5 tonnes/ha (T₈) to 5 tonnes/ha

Table 2 Effect of different sources of nutrients on quality attributes of cabbage head (pooled data of two years)

Treatment	TSS (°Brix)	Vitamin A (µg/100g)	Vitamin C (mg/100g)	Nitrate content (mg/kg)
T ₁ -100% R.F.D (150N : 80N : 75P kg/ha)	3.42	108.39	35.26	282.41
T ₂ -100% R.F.D + 8 tonnes FYM/ha + Biofert.	3.53	114.46	37.13	274.37
T ₃ -100% R.F.D + 2.5 tonnes VC/ha + Biofert.	3.64	117.21	38.34	263.18
T ₄ - 100% NPK + 4 tonnes/ha FYM + 1.25 tonnes/ha VC + Biofert.	3.59	116.62	37.84	268.46
T ₅ -75% R.F.D + 8 tonnes FYM/ha	3.71	119.17	37.36	256.52
T ₆ -75% R.F.D + 8 tonnes FYM/ha + Biofert.	3.83	120.02	37.73	251.31
T ₇ -75% R.F.D + 2.5 tonnes VC/ha	3.86	121.31	38.87	247.28
T ₈ -75% R.F.D + 2.5 tonnes VC/ha + Biofert.	4.04	122.64	39.26	241.21
T ₉ -75% R.F.D + 4 tonnes FYM/ha + 1.25tonnes VC/ha + Biofert.	3.93	121.87	39.12	245.13
T ₁₀ - 75% R.F.D + 16 tonnes FYM/ha	4.07	123.47	40.23	236.27
T ₁₁ -75% R.F.D + 16 tonnes FYM/ha + Biofert.	4.10	123.94	40.37	231.36
T ₁₂ -75% R.F.D + 5 tonnes VC/ha	4.15	124.57	43.32	226.08
T ₁₃ -75% R.F.D + 5 tonnes VC/ha + Biofert.	4.18	126.76	44.62	217.17
T ₁₄ -75% R.F.D + 8 tonnes FYM/ha + 2.5 tonnes VC/ha + Biofert.	4.13	125.42	41.53	221.46
S Em (±)	0.12	3.32	1.20	2.69
CD (P=0.05)	0.34	9.42	3.38	7.76

(T₁₃) recorded 14% improvement in vitamin C content of the head. On the other hand, increase in farmyard manure level from 8 tonnes/ha (T₆) to 16 tonnes/ha (T₁₁) increased the vitamin C content by 7%. Furthermore, inoculation of biofertilizer with highest level of farmyard manure (T₁₁) resulted in negligible improvement in vitamin C content over the uninoculated treatment T₁₀, whereas inoculation of biofertilizer with highest level of vermicompost (T₁₃) recorded 3% more vitamin C over the uninoculated treatment T₁₂. Improvement in vitamin C content with the application of higher amount of organic manures was reported by Bahadur *et al.* (2003) in broccoli. Presence of more organic manure increases more carbohydrate production and subsequently synthesizes more vitamin C as the ascorbic acid is made from carbohydrate (Worthington 2001). Again inoculation with phosphate-solubilizing biofertilizer helpful in assimilation of carbohydrates and in tern synthesis of ascorbic acid in cabbage (Upadhyay *et al.* 2012).

The results on nitrate content of cabbage head revealed that higher amount of nitrogenous fertilizer have significant effect on head nitrate content. Among the different treatments, 100% inorganic fertilizers treatment combination (T₁ to T₄) recorded comparatively higher levels of nitrate content over the treatments having 75% inorganic fertilizers (T₅ to T₁₄). The sole 100% inorganic fertilizers (T₁) recorded highest level of head nitrate content (282.41 mg/kg), followed by the treatment T₄ and T₂. Among 75% inorganic fertilizers combining treatments increased level of organic manures have reduced the head nitrate content. In T₁₃, where higher level of vermicompost (5 tonnes/ha) was combined with inorganic fertilizers and biofertilizer, recorded 30% reduction

in nitrate concentration over the treatment T₁. On the other side, when higher level of farmyard manure (16 tonnes/ha) was combined with inorganic fertilizers and biofertilizer (T₁₁) recorded 22% reduction in nitrate content over the treatment T₁. Similarly, application of both farmyard manure and vermicompost in higher amount as a source of organic manures in the treatment T₁₄ recorded 28% reduction in nitrate content over T₁. Higher amount of inorganic nitrogen fertilizer increases protein production and the excess is accumulated as nitrate and stored in green leafy part of the plant (Salunkhe and Desai 1988). Similar findings of increased nitrate content under higher nitrogen fertilization were also reported by Aslam and Muhammad (2003) in spinach and Singh (2004) in brinjal.

It may be concluded that substitution of 25% inorganic nitrogen with higher levels of organic manure in presence of biofertilizer have pronounced influenced on head yield, shelf-life, TSS, vitamin A and vitamin C contents and other physical quality attributes of cabbage head. Further, form and level of organic manure have significant effect on head qualities. Higher levels of vermicompost emerged as better organic source over that of farmyard manure. Application of biofertilizer exerted more benefits over the uninoculated treatments.

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