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Studies on Storage Behavior of Cabbage Head as Influenced by Organic Amendments and Inorganic Fertilizers

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Abstract**—**The influence of organic amendments and inorganic fertilizers on cabbage head was investigated to determine their effect on storage behavior and organoleptic quality. Field cabbage was raised by combining fourteen different treatments comprising of organic amendments and inorganic fertilizers at different levels. The result showed that nutrient schedule of the crop significantly influenced the physiological loss in weight (PLW) and organoleptic quality of cabbage head and judicious selection of nutrient combination can extend the storage life and reduce the post harvest detoriaration of head. The nutrient schedule comprising of higher level of FYM (16 t ha^{-1}) along with 75% of recommended inorganic fertilizers in conjugation with seedling inoculation of biofertilizer emerged as potential nutrient source for improving storage life, marketability and maintaining nutritional and organoleptic quality under ambient storage condition.

Keywords**—**Cabbage head, Organic amendments, Organoleptic quality, Physiological loss in weight (PLW).

I. Introduction

CABBAGE (*Brassica oleracea* L. var. *capitata* L.) is the most widely cultivated cole crop in the world and valued for its minerals, vitamins, antioxidants and dietary fibers. Consumption of cabbage is known to reduce the risk of several cancers due to presence of organosulphur phytochemicals [1]. 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 head weight but often promote succulence that adversely affects the head quality and storage life [2]. Cabbage head is highly perishable product and loss of moisture significantly affects the keeping quality, marketability and organoleptic qualities. Organic amendments provides more balanced and regulated delivery of nutrition for plant growth through the gradual decomposition of the organic matter by microorganisms and slower mineralization and release of nutrients that it contains [3], [4]. Research findings suggested that organic amendments particularly farmyard manure and vermicompost in combination with reduced level of inorganic nitrogen can improve the nutritional and keeping quality of cabbage head [5], [6]. Farmyard manure act as a store house of plant nutrients, improves the soil physical properties and provides favourable soil condition for root development, healthy growth, higher crop yield and quality produce [7]. Vermicompost is the cast obtained from the ingested biomass by earthworm after undergoing physical, chemical and microbial transformations. It contains nutrients in forms that are readily taken up by the plants and 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 [8]. Biofertilizers are the products, containing living cells of different types of micro organism which are capable of mobilizing nutritive elements from insoluble to soluble form through biological processes [9]. However literatures regarding the type of organic amendments, their optimum dose as well as their interaction effect in combination with inorganic fertilizers on post harvest storage life and organoleptic quality aspects of cabbage head are scanty under moist humid climate of eastern Himalayan region. The present work was formulated to determine the impact of different organic amendments and inorganic fertilizers on post harvest shelf life and organoleptic quality of cabbage head.

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II. Materials and Methods

The study was conducted at UBKV, Pundibari, CoochBehar, West Bengal, India (89°23′53″ E longitude and 26°19′86″ N latitude) during 2005-2006 and 2006-2007. Cabbage cultivar Golden Acre was raised in the field during winter season (November to February) of both the years. Organic amendments namely farmyard manure (FYM) and vermicompost at different levels were applied in combination with 100% and 75% of recommended dose of inorganic fertilizers in presence and absence of biofertilizer. Thus 14 treatment combinations were laid out in Randomized Block Design (RBD) with three replications. The Treatments were T_1-100% Recommended Fertilizer Dose (R.F.D) of 150 N:80 P:75 K kg/ha ; T_2-100% R.F.D + 8 tonnes/ha farmyard manure + biofertilizer ; T_3-100% R.F.D + 2.5 tonnes/ha vermicompost + biofertilizer;T_4-100% R.F.D + 4 tonnes/ha farmyard manure + 1.25 tonnes/ha vermicompost + biofertilizer ; T_5 -75% R.F.D + 8 tonnes/ha farmyard manure ;T_6 -75% R.F.D + 8 tonnes/ha farmyard manure + biofertilizer;T_7-75% R.F.D + 2.5 tonnes/ha vermicompost;T_8-75% R.F.D+2.5 tonnes/ha vermicompost +

biofertilizer ;T_9-75% R.F.D +4 tonnes/ha farmyard manure +1.25 tonnes/ha vermicompost + biofertilizer ;T_{10} -75% R.F.D +16 tonnes/ha farmyard manure ;T_{11}-75% R.F.D+16 tonnes/ha farmyard manure + biofertilizer ;T_{12}-75% R.F.D + 5 tonnes/ha vermicompost;T_{13}-75% R.F.D +5 tonnes/ha vermicompost + biofertilizer and T_{14}-75% R.F.D+ 8 tonnes/ha farmyard manure +2.5 tonnes/ha vermicompost + biofertilizer. The seedlings were transplanted in 3 m x 3 m plots with both ways spacing of 60 cm. FYM and vermicompost 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 (150 N: 80 P: 75 K kg/ha) 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. To analyze the storage life and organoleptic quality parameters ten freshly harvested cabbage heads for each treatment in each replication were randomly taken and stored under ambient condition with proper ventilation. The average room temperature and relative humidity were 21^oC and 82%, respectively. The physiological loss in weight (PLW) was measured by subtracting the initial head weight from the final weight and was expressed as a percentage (%). To study organoleptic quality, the cabbage heads were evaluated by a panel of ten trained judges using 9 point hedonic scale [10]. Hedonic scale 9: like extremely; 8: like very much; 7: like moderately; 6: like slightly; 5: neither like nor dislike; 4: dislike slightly; 3: dislike moderately; 2: dislike; 1: dislike extremely. For acceptability scoring, judges were asked to consider the appearance, head freshness, firmness, flavor, and texture of the head. Score value of 5 was considered as critical limit for acceptance. The PLW and organoleptic values were recorded at 3 days intervals up to 12 days. The chlorophyll content of the head during storage intervals was measured by using portable chlorophyll meter (SPAD 502; Minolta, Japan). The vitamin C content during storage was determined titrimetrically, using 2, 6 dichlorophenol indophenol dye as per method suggested by [11]. The storage data collected from the investigation were analyzed statistically by using complete randomized design. Two years data were pooled and the results were subjected to analysis of variance. The mean differences between the treatments were determined by computing the critical difference at 5% level of significance. All analyses were conducted as per method suggested by Panse and Sukhatme [12].

III. Results and Discussion

The result showed that physiological loss in weight (PLW) of cabbage head (Table I) increased continuously with the advancement of storage period irrespective of treatment combination. The PLW was significantly influenced by the nutrient schedule used for raising the cabbage in the field. Cabbage head grown with 100% chemical fertilizers (T_1 to T_4) recorded higher PLW loss and the highest loss (24.36%) after 12 days of storage was observed for head received only sole 100% chemical fertilizers (T_1). On the contrary, head harvested from the plot received higher amount of organic amendments and 75% inorganic fertilizers combination (T_5 to T_{14}) recorded lower PLW loss and the nutrient schedule comprising of highest amount of FYM along with 75% inorganic fertilizers inoculated with biofertilizers (T_{11}) registered the lowest PLW loss of cabbage head (21.12%) after 12 days of storage. An increased PLW for all the treatments could be due to rapid loss of moisture and drastic reduction in firmness for the active physiological processes like respiration, transpiration and ethylene production [13]. Incorporation of higher amount of organic amendments in combination with reduced inorganic fertilizers and biofertilizer might have slower the rate of respiration and evapo-transpiration thus prevented the moisture loss and retained freshness for longer period. In contrast 100% chemical fertilizers treated head might have encouraged rapid loss of moisture and spoilage resulting shrinkage and accelerated the reduction in shelf life. The superiority of combined application of different organic amendments over sole inorganic fertilizer in reducing PLW loss of onion bulb has been reported by Sankar et al. [14]. Prasanna and Rajan [15] opined that plants raised with higher amount of inorganic fertilizers resulted in rapid loss of moisture from the surface and subsequently results in higher PLW in fresh vegetables. Higher PLW loss with higher doses of nitrogen has also been reported earlier by Gopalkrishnan and Srinivas [16].

TABLE I
INFLUENCE OF DIFFERENT NUTRIENT SOURCES ON PHYSIOLOGICAL LOSS IN WEIGHT (PLW) OF CABBAGE HEADS

Treatments	Initial head wt (g)	PLW (%)			
		Storage interval (days)			
		3rd	6th	9th	12th
T_1	912.26	8.86	15.73	19.84	24.36
T_2	1383.37	7.72	14.82	18.91	23.71
T_3	1417.28	7.19	14.87	18.93	23.79
T_4	1394.48	7.26	14.95	18.97	23.86
T_5	1166.43	6.49	14.38	18.23	23.19
T_6	1231.44	6.31	13.78	17.71	22.87
T_7	1281.44	6.54	14.53	18.36	23.32
T_8	1357.32	6.38	13.96	17.87	22.96
T_9-	1301.22	6.44	14.21	18.04	23.09
T_{10}	1442.62	5.92	13.04	17.11	21.97
T_{11}	1487.36	5.28	12.26	16.59	21.12
T_{12}	1470.76	5.98	13.16	17.23	22.24
T_{13}	1547.34	5.56	12.53	16.94	21.47
T_{14}	1503.44	5.87	12.87	16.78	21.73
CD (P=0.05)	188.47	0.67	0.72	0.78	0.81

Treatment details are given in the text;
CD- Critical difference

The chlorophyll content of head is an important index for freshness. Fig. 1 shows the changes of chlorophyll content at different storage intervals. The chlorophyll content of Cabbage head grown with 100% chemical fertilizers sharply

declined with the extension of storage period. The effect of organic amendments was significantly superior and was prominent in higher levels. The head received higher amount of FYM (16 t/ha) and reduced level of chemical fertilizers in combination with biofertilizer (T_{11}) retained reasonable amount of chlorophyll in the head till the 12th day of storage.

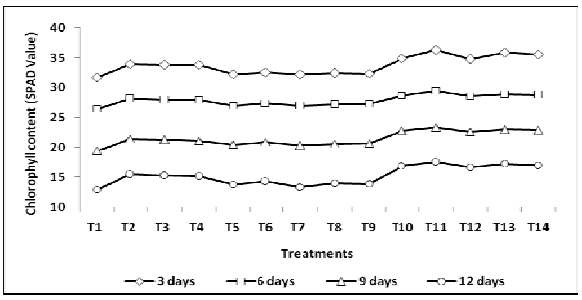

Fig. 1 Effect of different nutrient sources on changes in chlorophyll content of cabbage head (treatment details are given in the text)

The amount of vitamin C (Fig. 2) was decreased sharply with duration of storage period. The reduction rate was faster in sole 100% chemical fertilizers containing heads, whereas the decline rate was slower for the cabbage heads where higher amount of organic amendments was used in the field. Higher dose of vermicompost (T_{13}) have favorable effect on vitamin C content and retained the highest level of vitamin C among all the treatments after 12 days of storage. Higher retention of vitamin C in vermicomost loaded treatment could be ascribed to the slower biological activities and delayed senescence.

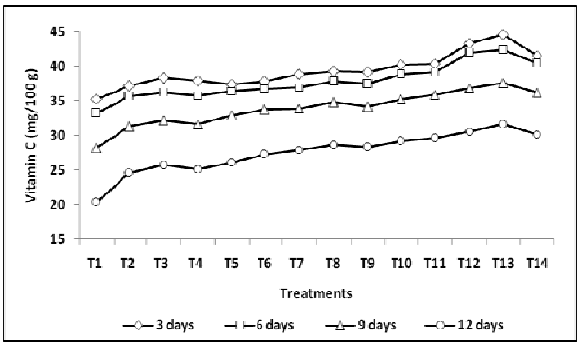

Fig. 2 Effect of different nutrient sources on changes in vitamin C content of cabbage head (treatment details are given in the text)

The observation reported by panel of ten judges regarding organoleptic quality or consumer acceptability (Table II) clearly demonstrated that there was continuous decrease in overall acceptability rating with the advancement of storage period and no head was acceptable after 9th days of storage due to loss of texture, decrease in firmness and dull appearance of the head. The acceptability of head harvested from sole 100% inorganic fertilizers (T_1) was drastically reduced after 3rd day of storage and become unacceptable on 6th days of storage. The acceptability was higher for the head harvested from higher organic amendments containing plots (T_{10} to T_{14}) compared to lower level of organic amendments plots (T_2 to T_9).

TABLE II
INFLUENCE OF DIFFERENT NUTRIENT SOURCES ON ORGANOLEPTIC RATING OF CABBAGE HEAD

Treatments	Organoleptic Rating			
	Storage interval (days)			
	3rd	6th	9th	12th
T_1	5.74	x	x	x
T_2	6.29	5.31	x	x
T_3	6.22	5.27	x	x
T_4	6.14	5.16	x	x
T_5	6.84	5.71	x	x
T_6	7.16	5.93	x	x
T_7	6.76	5.62	x	x
T_8	7.03	5.85	x	x
T_9-	6.89	5.78	x	x
T_{10}	7.76	6.54	5.41	x
T_{11}	8.32	7.12	5.82	x
T_{12}	7.51	6.31	5.29	x
T_{13}	8.13	6.89	5.46	x
T_{14}	7.87	6.67	5.69	x
CD (P=0.05)	0.36	0.31	0.22	-

Treatment details are given in the text;
CD-Critical difference

The maximum consumer acceptability on 9th days of storage was recorded under higher level of FYM (16 t/ha) and reduced level of chemical fertilizers in combination with biofertilizer (T_{11}) without any objectionable change in freshness, colour and firmness. An increase in organoleptic score by the organic amended plots may be due to acceptable freshness, better firmness of the heads, delayed shrinkage and checking of various enzymatic and microbial activities during storage thus maintained the acceptability even on 9th days of storage. Superior organoleptic quality in presence of higher amount of organic amendments has been reported earlier by Thamburaj [17] in tomato, Rajasekar [18] in okra and Nirmala [19] in cucumber.

IV. CONCLUSION

The study showed that soil nutrient status of the crop field particularly nutritional source has direct impact on the storage behavior of cabbage head. Organic amendments can contribute for the improvement of post harvest storage life. Higher amount of FYM was found effective over vermicompost in delaying post harvest deterioration. The nutrient schedule comprising of higher level of FYM (16 t ha^{-1}) along with 75% inorganic fertilizers in conjugation with seedling inoculation of biofertilizer may be practiced for cabbage production to achieve extended storage life, marketability and maintaining nutritional and organoleptic quality under ambient storage condition.

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