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Influence of Micronutrients and Growth Regulators on Shelf-life of Cabbage

A.V. Kotecha[1], Jignesh Patel[2] and J.J. Dhruve[2*]

[1]Department of Horticulture, B.A. College of Agriculture,
Anand Agricultural University, Anand, India
[2]Department of Biochemistry, B.A. College of Agriculture,
Anand Agricultural University, Anand, India
**Corresponding author email id:*

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A B S T R A C T

A field experiment was undertaken on cabbage cv. Golden Acre at Horticultural Research cum Demonstration Farm, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand in order to evaluate the performance of micronutrients (Zn and Fe) and growth regulators (Gibberellic acid and Naphthalene acetic acid) alone and their combinations applied as foliar spray for shelf life of cabbage. Among different treatments of micronutrients, zinc sulphate 0.5% recorded significantly minimum physiological head weight loss (17.94%), higher head compactness (6.13 grade) and green head color (5.97 grade) after 12th days of storage of cabbage head at ambient temperature. Among different levels of growth regulators, GA_3 @ 100 ppm recorded significantly minimum physiological head weight loss (18.15 %), higher head compactness (6.02 grade) and green color head (5.78 grade) after 12th days of storage of cabbage head at ambient temperature. Among all the interactions of micronutrients and growth regulators treatments, the interaction M_1G_2 (zinc sulphate 0.5% + GA_3 100 ppm) recorded significantly higher grade of head compactness (6.33 grade) and green head color (6.60 grade) during storage at ambient temperature.

Introduction

Cabbage (*Brassica oleracea*L.var. *capitata*) is one of the important leafy vegetable crop and used as salad, cooked, pickling as well as dehydrated vegetable. The word "Cabbage" is derived from the French word "coboche" means head. The cabbage belongs to *cruciferae* family. It is grown in kitchen and truck gardens. It is mostly employed as culinary and dietary article which is used alone or mixed with potatoes for vegetable purpose.

It is also used for feeding stock of chicken. The "Sauerkraut" is favourite food in Russia, Germany and U.S.A. which is made by fermenting chopped, ground or sliced cabbage in its juice with little salt added to it and from the nutritional point of view, it ranks very high. The cabbage head is rich source of vitamin A, B, C and also contains minerals. It has cooling effect and helps in preventing constipation, increase appetite, speed up digestion and very useful for patients of diabetes (Yadav *et al.*, 2000).

The cabbage covers about 4% of the total area under vegetables. India ranks next to China in cabbage production (Anon., 2009a). The major cabbage growing states in India are Gujarat, U.P., Orissa, W.B., Assam, Maharashtra and Karnataka. In Gujarat, cabbage crop is cultivated in almost all the districts with major cultivation in Bhavnagar, Anand, Kheda, Junagadh, Sabarkantha, Banaskantha, and Ahmedabad districts. In India, cabbage is cultivated in about an area of 309.0 thousand hectares with an annual production of 6809.0 thousand MT with the productivity of 22.04 t/ha (Anon, 2009b). In Gujarat, it is cultivated in about an area of 22.96 thousand hectares with an annual production of 404.6 thousand MT having productivity of 17.26 t/ha (Anon., 2009c). So there is tremendous scope to increase the productivity in Gujarat state.

Sillanpaa was estimated that about 30% of the agricultural soils of the world are zinc deficient (Sillanpaa, 1982). Severe zinc deficiency symptoms with corresponding decrease in yield, especially of vegetables and cereals, are found mainly in crops grown on calcareous soil of arid and semi-arid regions of India (Takkar and Randhawa, 1978) as well as depression in leaf production and a leaf mottling, developed after about two weeks later. The factors which are predominantly responsible for low availability of zinc to plant roots are high pH and high levels of $CaCO_3$, and low levels of organic matters and soil moisture etc.

Shelf-life of cabbage head is very important because it is used as a green salad as well as in cooked form. Shelf- life is judged on the basis of colour changes, decay and physiological weight loss. Shelf-life can be improved with the foliar spraying of growth regulators and micro nutrient. Many studies have been conducted with respect to effect of growth regulators and micro nutrients on yield and quality of cabbage but study on effect of growth regulators and micro nutrients on shelf-life of cabbage seems to be lacking. Hence, an experiment was conducted to study the effect of foliar application of growth regulators and micro nutrient on shelf-life of cabbage head.

Materials and Methods

A field experiment was conducted on cabbage cv. Golden Acre at Horticultural Research cum Demonstration Farm, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, and Anand during the *Rabi* season with Factorial Randomized Block Design. The treatments comprised of three levels of micronutrients i.e. (1) Control (2) Zinc sulphate 0.5%, and (3) Ferrous sulphate 0.5% and five levels of growth regulators i.e. (1) Control (2) GA_3 @ 50ppm, (3) GA_3 @100 ppm, (4) NAA @ 100ppm, (5) NAA @ 200ppm) total fifteen combinations were applied as foliar sprays at 3rd and 5thweek after transplanting of cabbage.Just after harvest, fresh weights of representative samples from each treatment was taken on physical balance and subsequent weight was measured at 9 days and 12 days for recording weight loss and it was expressed as percentage as method given by Sarma *et al*. (2005).

The change in compactness of head representative from each treatment was evaluated by visual scoring method (1-10) by a panel of five members. Higher score were given for compact head and lower score was given for loose head. The change of color of heads was evaluated by scoring method (1 to 10) by a panel of five members. Higher score were given for green colors head and lower score was given for yellow colored head.

Results and Discussion

The data on physiological weight loss as influenced by micronutrient and plant growth regulator treatments during 1st and 2nd year as well as on pooled basis at 9days and 12days are presented in the (Table 1). The effect of micronutrient levels on physiological weight loss was found significant during 1stand 2nd year but non-significant on pooled basis. Significantly, the maximum and minimum physiological weight loss content was recorded under the treatment M_0 (16.68%) and M_1 (15.28 %) at 9days whereas M_0 (18.30%) and M_1 (17.03%) at 12 days respectively during 1st year. The physiological weight loss was recorded maximum and minimum during 2nd year under the treatment M_1 (15.77%) and M_0 (14.29%) at 9days whereas M_0 (20.32%) and M_1 (18.85%) at 12days. On the basis of pooled analysis the maximum PLW was recorded in M_1 (15.53) at 9days whereas M_0 (19.31%) at 12days whereas micronutrient M_2 (15.03%) at 9days and M_1 (17.94%) at 12days was recorded minimum physiological weight loss.

The plant growth regulators treatments showed significant effect on physiological weight loss of cabbage head at 9th and 12th days after storage during1st and 2nd year as well as on pooled basis, except at 12 days after storage in pooled analysis. The treatment G_2 (GA_3 100 ppm) recorded significantly the lowest percentage of physiological weight loss i.e. 14.49, 13.82 and 14.16 at 9 days after storage of head during 1st and 2nd year as well as on pooled basis and it remained at par with G_1(GA_3 50 ppm) i.e. 15.74, 14.45 and 15.09%.

At 12th days after storage, significantly the lowest physiological weight loss i.e. 16.53% and 18.42% were recorded with the treatment G_2 (GA_3 100 ppm) during 1st and 2nd year respectively. Tiwari *et al.*(2003) reported that application of GA_3 @ 25 ppm after transplanting significantly gave higher TSS, while physiological weight loss was lowest with the application of NAA @ 50 ppm as compared to control in onion.

The compactness of head at 9th and 12th days after storage during 1st and 2nd year as well as in pooled basis were presented in table-2.The treatment of micronutrients M_1 (zinc sulphate 0.5%) recorded significantly the highest grade i.e. 7.18, 6.98, 7.08 and 6.18, 6.09, 6.13 at 9th and 12th days after storage of head during 1st and 2nd year as well as on pooled basis respectively Whereas the treatment of plant growth regulator G_2 (GA_3 100 ppm) recorded highest grade of compactness of head i.e. 7.07, 6.73, 6.90 and 6.07, 5.99, 6.02, at 9 and 12 days after storage during 1st and 2nd year as well as on pooled basis respectively.

After 9th and 12th days, the interaction effect between micronutrient and plant growth regulator for compactness of head were found significantly during 1st and 2nd year. At 9th days after storage (Table-3 & 4), interaction of M_1G_2 (zinc sulphate 0.5% + GA_3 100 ppm) recorded significantly higher grade during 1st year (7.40) and during 2ndyear(7.42). At the same on 12th days after storage, interaction of M_1G_2 (zinc sulphate 0.5% + GA_3 100 ppm)recorded higher grade of compactness of head during 1st year (6.40) and during 2nd year (6.27) and 6.68 during on pooled basis respectively. Chhonkar and Singh (1964) conducted an experiment on 'Late Drumhead' variety of cabbage at Sabour (Bihar).

Table.1 Effects of micronutrients and growth regulators on physiological weight loss (%) of cabbage head at 9th and 12th days of storage

Treatment	Physiological weight loss of cabbage head at (9 DAS)			Physiological weight loss of cabbage head at (12 DAS)		
	1st Year	2nd Year	Pooled	1st Year	2nd year	Pooled
Micronutrients						
M_0	16.68	14.29	15.49	18.30	20.32	19.31
M_1	15.28	15.77	15.53	17.03	18.85	17.94
M_2	15.70	14.47	15.03	17.92	20.06	18.99
S.Em±	0.38	0.40	0.72	0.28	0.42	0.25
C.D.5 %	1.11	1.16	NS	0.82	1.21	0.72
Growth regulators						
G_0	17.07	15.45	16.26	18.63	20.42	19.52
G_1	15.74	14.45	15.09	17.88	19.83	18.18
G_2	14.49	13.82	14.16	16.53	18.42	18.15
G_3	16.14	14.30	15.22	18.08	19.13	18.60
G_4	15.82	16.20	16.01	17.62	20.92	19.27
S.Em±	0.50	0.52	0.36	0.37	0.54	0.64
C.D.5 %	1.43	1.50	1.01	1.06	1.56	NS
Sig. Int.		MXG	-	-	MXG	-
C.V. %	9.37	10.45	9.89	6.20	8.19	7.38

Table.2 Effects of micronutrients and growth regulators on compactness of head (grade) at 9th and 12th days of storage

Treatment	Compactness of head at (9 DAS)			Compactness of head at (12 DAS)		
	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
Micronutrients						
M_0	6.40	6.00	6.20	5.39	5.38	5.39
M_1	7.18	6.98	7.08	6.18	6.09	6.13
M_2	6.84	6.71	6.78	5.84	5.73	5.79
S.Em±	0.03	0.04	0.07	0.03	0.05	0.03
C.D.5 %	0.09	0.14	0.21	0.07	0.15	0.08
Growth regulators						
G_0	6.60	6.60	6.60	5.60	5.54	5.57
G_1	6.73	6.40	6.57	5.73	5.73	5.73
G_2	7.07	6.73	6.90	6.07	5.99	6.02
G_3	6.80	6.47	6.63	5.79	5.70	5.74
G_4	6.83	6.61	6.72	5.83	5.71	5.77
S.Em±	0.03	0.06	0.07	0.03	0.06	0.04
C.D.5 %	0.10	0.18	NS	0.09	0.18	0.16
Sig. Int.	MXG	MXG	-	MXG	MXG	MXG
C.V. %	2.49	3.85	3.25	2.70	3.31	2.63

Table.3 Interaction effect of micronutrients and growth regulators on compactness of head (grade) at 9th days of storage

Micronutrients	Growth regulators				
	G_0	G_1	G_2	G_3	G_4
First Year					
M_0	6.00	6.30	6.80	6.50	6.40
M_1	7.00	7.10	7.40	7.10	7.30
M_2	6.80	6.80	7.00	6.80	6.80
S.Em±	0.06				
C.D.5 %	0.17				
Second Year					
M_0	5.30	6.00	5.80	6.50	6.40
M_1	7.00	7.10	7.42	6.10	7.30
M_2	6.80	6.80	7.00	6.80	6.13
S.Em±	0.11				
C.D.5 %	0.31				

Table.4 Interaction effect of micronutrients and growth regulators on compactness of head (grade) at 12th days of storage

Micronutrients	Growth regulators				
	G_0	G_1	G_2	G_3	G_4
First Year					
M_0	5.00	5.30	5.80	5.47	5.40
M_1	6.00	6.10	6.40	6.10	6.30
M_2	5.80	5.80	6.00	5.80	5.80
S.Em±	0.06				
C.D.5 %	0.17				
Second Year					
M_0	4.93	5.30	5.80	5.47	5.40
M_1	5.90	6.10	6.27	6.03	6.17
M_2	5.80	5.80	5.90	5.60	5.57
S.Em±	0.11				
C.D.5 %	0.32				
Pooled					
M_0	4.97	5.30	5.80	5.47	5.40
M_1	5.95	6.10	6.68	6.07	6.23
M_2	5.80	5.80	5.95	5.70	6.33
S.Em±	0.06				
C.D.5 %	0.18				

Table.5 Effects of micronutrients and growth regulators on colour change (grade) of cabbage head at 9th and 12th days of storage

Treatment	Color change of head at (9 DAS)			Color change of head at (12 DAS)		
	1st Year	2nd Year	Pooled	1st Year	2nd Year	Pooled
Micronutrients						
M_0	6.16	5.69	5.92	5.01	4.88	4.94
M_1	6.61	6.37	6.49	5.79	6.15	5.97
M_2	6.37	6.34	6.35	5.65	6.12	5.88
S.Em±	0.10	0.09	0.18	0.09	0.09	0.18
C.D.5 %	0.28	0.26	0.54	0.25	0.25	0.53
Growth regulators						
G_0	6.03	5.79	5.91	5.12	5.63	5.38
G_1	6.37	6.14	6.26	5.33	5.43	5.38
G_2	6.53	6.37	6.45	5.72	5.86	5.78
G_3	6.46	6.32	6.39	5.50	5.82	5.77
G_4	6.51	6.03	6.27	5.73	5.83	5.78
S.Em±	0.12	0.11	0.08	0.11	0.09	0.07
C.D.5 %	0.36	0.33	0.24	0.32	0.25	0.20
Sig. Int.	MXG	MXG	-	MXG	MXG	-
C.V. %	5.79	5.58	5.69	6.14	4.50	5.35

Table.6 Interaction effect of micronutrients and growth regulators on color change of head (grade) at 9th days of storage

Micronutrients	Growth regulators				
	G_0	G_1	G_2	G_3	G_4
First Year					
M_0	5.67	6.47	6.40	6.17	6.10
M_1	6.17	6.27	7.37	6.67	6.60
M_2	6.27	6.37	5.83	6.53	6.83
S.Em±	0.21				
C.D.5 %	0.62				
Second Year					
M_0	5.33	5.83	5.80	5.57	5.90
M_1	5.63	6.30	6.86	6.83	6.36
M_2	6.40	6.30	6.60	6.57	5.83
S.Em±	0.20				
C.D.5 %	0.57				

Table.7 Interaction effect of micronutrient and growth regulators on color change of head (grade) at 12th days of storage

Micronutrients	Growth regulators				
	G_0	G_1	G_2	G_3	G_4
First Year					
M_0	4.70	5.23	5.00	4.97	5.13
M_1	5.17	5.27	6.60	6.57	6.27
M_2	5.50	5.50	5.83	5.60	5.80
S.Em±	0.19				
C.D.5 %	0.56				
Second Year					
M_0	4.26	4.70	4.93	5.10	5.40
M_1	6.00	6.10	6.53	6.13	5.97
M_2	6.20	5.93	6.10	6.23	6.13
S.Em±	0.15				
C.D.5 %	0.43				

The plants were sprayed with GA_3 @ 5 and 10 ppm at 2nd and 3rd week after transplanting. The results showed that both the GA_3 concentrations increased number of inner leaves, head diameter, compactness of head, percentage of head formation, earliest of head formation and yield (215.2 q/acre) as compared to control.

Results of the colour change of head at 9th and 12th days after storage during 1st and 2nd year as well as in pooled basis were presented in table-5, 6 & 7. Micronutrients effects on colour of head at 9th and 12th days after storage were found significant during 1st year, 2nd year and in pooled basis (Table 4.14). The treatment M_1 (zinc sulphate 0.5%) recorded highest grade (i.e. 6.61, 6.37, 6.49 at 9days after storage and 5.79, 6.15, 5.97 at 12days after storage during 1st and 2nd year as well as on pooled basis respectively. Among plant growth regulators, treatment G_2 (GA_3 100 ppm) recorded higher grade of colour of head i.e. 6.53, 6.37, 6.45 at 9th days and 5.72, 5.86, 5.78 at 12th days after storage of head during 1st and 2ndyear as well as in pooled basis. Interactions effect between micronutrient and plant growth regulator M_1G_2 (zinc sulphate 0.5% + GA3 100 ppm) on colour change of head were found significant at 9th and 12th days after storage during both the individual 1st and 2ndyear. Sharma *et al.* (2005) studied that the spray of 0.5% zinc sulphate recorded the highest root length and minimum mean weight loss of cabbage head and superior for maintenance of head colour during storage.

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