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

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Abstract

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, GA₃ @ 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 M₁G₂ (zinc sulphate 0.5% + GA₃ 100 ppm) recorded significantly higher grade of head compactness (6.33 grade) and green head color (6.60 grade) during storage at ambient temperature.

Keywords
Physiological loss in weight, compactness of head (grade), colour change (grade).

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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 CaCO₃ 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) GA₃ @ 50ppm, (3) GA₃ @100 ppm, (4) NAA @ 100ppm, (5) NAA @ 200ppm) total fifteen combinations were applied as foliar sprays at 3rd and 5th week 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 1\textsuperscript{st} and 2\textsuperscript{nd} year as well as on pooled basis at 9 days and 12 days are presented in the Table 1. The effect of micronutrient levels on physiological weight loss was found significant during 1\textsuperscript{st} and 2\textsuperscript{nd} year but non-significant on pooled basis. Significantly, the maximum and minimum physiological weight loss content was recorded under the treatment M\textsubscript{0} (16.68\%) and M\textsubscript{1} (15.28\%) at 9 days whereas M\textsubscript{0} (18.30\%) and M\textsubscript{1} (17.03\%) at 12 days respectively during 1st year. The physiological weight loss was recorded maximum and minimum during 2\textsuperscript{nd} year under the treatment M\textsubscript{1} (15.77\%) and M\textsubscript{0} (14.29\%) at 9 days whereas M\textsubscript{0} (20.32\%) and M\textsubscript{1} (18.85\%) at 12 days. On the basis of pooled analysis the maximum PLW was recorded in M\textsubscript{1} (15.53) at 9 days whereas M\textsubscript{0} (19.31\%) at 12 days whereas micronutrient M\textsubscript{2} (15.03\%) at 9 days and M\textsubscript{1} (17.94\%) at 12 days was recorded minimum physiological weight loss.

The plant growth regulators treatments showed significant effect on physiological weight loss of cabbage head at 9\textsuperscript{th} and 12\textsuperscript{th} days after storage during 1\textsuperscript{st} and 2\textsuperscript{nd} year as well as on pooled basis, except at 12 days after storage in pooled analysis. The treatment G\textsubscript{2} (GA\textsubscript{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 1\textsuperscript{st} and 2\textsuperscript{nd} year as well as on pooled basis and it remained at par with G\textsubscript{1} (GA\textsubscript{3} 50 ppm) i.e. 15.74, 14.45 and 15.09%.

At 12\textsuperscript{th} days after storage, significantly the lowest physiological weight loss i.e. 16.53\% and 18.42\% were recorded with the treatment G\textsubscript{2} (GA\textsubscript{3} 100 ppm) during 1\textsuperscript{st} and 2\textsuperscript{nd} year respectively. Tiwari et al.(2003) reported that application of GA\textsubscript{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 9\textsuperscript{th} and 12\textsuperscript{th} days after storage during 1\textsuperscript{st} and 2\textsuperscript{nd} year as well as on pooled basis were presented in Table 2. The treatment of micronutrients M\textsubscript{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 9\textsuperscript{th} and 12\textsuperscript{th} days after storage of head during 1\textsuperscript{st} and 2\textsuperscript{nd} year as well as on pooled basis respectively Whereas the treatment of plant growth regulator G\textsubscript{2} (GA\textsubscript{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 1\textsuperscript{st} and 2\textsuperscript{nd} year as well as on pooled basis respectively.

After 9\textsuperscript{th} and 12\textsuperscript{th} days, the interaction effect between micronutrient and plant growth regulator for compactness of head were found significantly during 1\textsuperscript{st} and 2\textsuperscript{nd} year. At 9\textsuperscript{th} days after storage (Table-3 & 4), interaction of M\textsubscript{1}G\textsubscript{2} (zinc sulphate 0.5\% + GA\textsubscript{3} 100 ppm) recorded significantly higher grade during 1\textsuperscript{st} year (7.40) and during 2\textsuperscript{nd} year (7.42). At the same on 12\textsuperscript{th} days after storage, interaction of M\textsubscript{1}G\textsubscript{2} (zinc sulphate 0.5\% + GA\textsubscript{3} 100 ppm) recorded higher grade of compactness of head during 1\textsuperscript{st} year (6.40) and during 2\textsuperscript{nd} 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** | | | | | | |
| M₀        | 16.68    | 14.29    | 15.49   | 18.30    | 20.32    | 19.31   |
| M₁        | 15.28    | 15.77    | 15.53   | 17.03    | 18.85    | 17.94   |
| M₂        | 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** | | | | | | |
| G₀        | 17.07    | 15.45    | 16.26   | 18.63    | 20.42    | 19.52   |
| G₁        | 15.74    | 14.45    | 15.09   | 17.88    | 19.83    | 18.18   |
| G₂        | 14.49    | 13.82    | 14.16   | 16.53    | 18.42    | 18.15   |
| G₃        | 16.14    | 14.30    | 15.22   | 18.08    | 19.13    | 18.60   |
| G₄        | 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** | | | | | | |
| M₀        | 6.40     | 6.00     | 6.20   | 5.39     | 5.38     | 5.39   |
| M₁        | 7.18     | 6.98     | 7.08   | 6.18     | 6.09     | 6.13   |
| M₂        | 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     | 0.15   |
| **Growth regulators** | | | | | | |
| G₀        | 6.60     | 6.60     | 6.60   | 5.60     | 5.54     | 5.57   |
| G₁        | 6.73     | 6.40     | 6.57   | 5.73     | 5.73     | 5.73   |
| G₂        | 7.07     | 6.73     | 6.90   | 6.07     | 5.99     | 6.02   |
| G₃        | 6.80     | 6.47     | 6.63   | 5.79     | 5.70     | 5.74   |
| G₄        | 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 | First Year |         |         |         |         |
|---------------|-------------------|------------|---------|---------|---------|---------|
|               | G₀                | G₁         | G₂      | G₃      | G₄      |         |
| M₀            | 6.00              | 6.30       | 6.80    | 6.50    | 6.40    |         |
| M₁            | 7.00              | 7.10       | 7.40    | 7.10    | 7.30    |         |
| M₂            | 6.80              | 6.80       | 7.00    | 6.80    | 6.80    |         |
| S.Em+         |                   |            |         | 0.06    |         |         |
| C.D.5 %       |                   |            |         | 0.17    |         |         |
| Second Year   |                   |            |         |         |         |         |
| M₀            | 5.30              | 6.00       | 5.80    | 6.50    | 6.40    |         |
| M₁            | 7.00              | 7.10       | 7.42    | 6.10    | 7.30    |         |
| M₂            | 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 | First Year |         |         |         |         |
|---------------|-------------------|------------|---------|---------|---------|---------|
|               | G₀                | G₁         | G₂      | G₃      | G₄      |         |
| M₀            | 5.00              | 5.30       | 5.80    | 5.47    | 5.40    |         |
| M₁            | 6.00              | 6.10       | 6.40    | 6.10    | 6.30    |         |
| M₂            | 5.80              | 5.80       | 6.00    | 5.80    | 5.80    |         |
| S.Em+         |                   |            |         | 0.06    |         |         |
| C.D.5 %       |                   |            |         | 0.17    |         |         |
| Second Year   |                   |            |         |         |         |         |
| M₀            | 4.93              | 5.30       | 5.80    | 5.47    | 5.40    |         |
| M₁            | 5.90              | 6.10       | 6.27    | 6.03    | 6.17    |         |
| M₂            | 5.80              | 5.80       | 5.90    | 5.60    | 5.57    |         |
| S.Em+         |                   |            |         | 0.11    |         |         |
| C.D.5 %       |                   |            |         | 0.32    |         |         |

#### Pooled

| Micronutrients | Growth regulators |         |         |         |         |         |
|---------------|-------------------|---------|---------|---------|---------|---------|
| M₀            | 4.97              | 5.30    | 5.80    | 5.47    | 5.40    |         |
| M₁            | 5.95              | 6.10    | 6.68    | 6.07    | 6.23    |         |
| M₂            | 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** |         |         |         |         |         |         |
| M₀        | 6.16     | 5.69     | 5.92    | 5.01     | 4.88     | 4.94    |
| M₁        | 6.61     | 6.37     | 6.49    | 5.79     | 6.15     | 5.97    |
| M₂        | 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** |         |         |         |         |         |         |
| G₀        | 6.03     | 5.79     | 5.91    | 5.12     | 5.63     | 5.38    |
| G₁        | 6.37     | 6.14     | 6.26    | 5.33     | 5.43     | 5.38    |
| G₂        | 6.53     | 6.37     | 6.45    | 5.72     | 5.86     | 5.78    |
| G₃        | 6.46     | 6.32     | 6.39    | 5.50     | 5.82     | 5.77    |
| G₄        | 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    |

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

| Micronutrients | Growth regulators |
|----------------|-------------------|
|                | G₀    | G₁    | G₂    | G₃    | G₄    |
| **First Year** |       |       |       |       |       |
| M₀             | 5.67  | 6.47  | 6.40  | 6.17  | 6.10  |
| M₁             | 6.17  | 6.27  | 7.37  | 6.67  | 6.60  |
| M₂             | 6.27  | 6.37  | 5.83  | 6.53  | 6.83  |
| S.Em⁺          |       |       | 0.21  |       |       |
| C.D.5 %        |       |       | 0.62  |       |       |
| **Second Year**|       |       |       |       |       |
| M₀             | 5.33  | 5.83  | 5.80  | 5.57  | 5.90  |
| M₁             | 5.63  | 6.30  | 6.86  | 6.83  | 6.36  |
| M₂             | 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 |
|----------------|------------------|
|                | G0 | G1 | G2 | G3 | G4 |
|                |    |    |    |    |    |
| **First Year** |    |    |    |    |    |
| M0             | 4.70 | 5.23 | 5.00 | 4.97 | 5.13 |
| M1             | 5.17 | 5.27 | 6.60 | 6.57 | 6.27 |
| M2             | 5.50 | 5.50 | 5.83 | 5.60 | 5.80 |
| C.D.5 %        | 0.19 | 0.56 |
| **Second Year**|    |    |    |    |
| M0             | 4.26 | 4.70 | 4.93 | 5.10 | 5.40 |
| M1             | 6.00 | 6.10 | 6.53 | 6.13 | 5.97 |
| M2             | 6.20 | 5.93 | 6.10 | 6.23 | 6.13 |
| C.D.5 %        | 0.15 | 0.43 |

The plants were sprayed with GA3 @ 5 and 10 ppm at 2nd and 3rd week after transplanting. The results showed that both the GA3 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 M1 (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 G2 (GA3 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 2nd year as well as in pooled basis. Interactions effect between micronutrient and plant growth regulator M1G2 (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 2nd year. 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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