*J. Plant Production, Mansoura Univ., Vol. 7 (4): 433 - 441 , 2016*

# Alleviation of High Temprature in Cabbage Plants Grown in Summer Season Using Some Nutrients, Antioxidants and Amino Acids As Foliar Application with Cold Water.

**Mohamed, M. H. M[*] and R. M. Y. Zewail [**]**
***Horticulture Department, Faculty of Agriculture, Benha University, Egypt.**
****Botany Department, Faculty of Agriculture, Benha University, Egypt.**
**Corresponding author: mustafa.mohamed@fagr.bu.edu.eg.**

## ABSTRACT

Two field experiments were conducted during 2014 and 2015 summer seasons in the experimental farm of the Faculty of Agriculture at Moshtohor, Benha University to study the effects of spraying cabbage plants (*Brassica oleracea var. capitata*) cv. Balady with mineral nutrients i.e., potassium ($K_2O$) at 2g/l, chelated calcium (Ca) at 2g/l, micronic sulphur (S) at 5g/l, boric acid at 100mg/l and antioxidants salicylic acid (SA) at 50mg/l, citric acid at 2g/l and amino acids at 2ml/l all of these materials are dissolved before spraying either in normal water (30±1) or in cold water (4±1). Growth and head production including some quality characteristics were investigated. The obtained results revealed that cold water showed positive and significant effect in case of non- consumable outer leaves and those inner and consumable ones as well as the fresh weight of formed heads. As for the interaction effects of nutrients and the antioxidants dominantly were significantly and positively affects different estimated growth and productivity aspects. Also, results confirmed the beneficial effects of applying such low costs treatments to minimize different disorders those facing cabbage production in high temperature summer plantings. These beneficial effects of such applied treatments were prolonged to the quality characteristic of formed heads with high and rich edible value.

**Keywords:** Cabbage, minerals, antioxidants, amino acids, yield and chemical constituents.

## INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata*) is a popular vegetable through the world because of its adaptability to a wide range of climatic conditions and soil, ease of production and storage, and its food value. In Egypt, cabbage is grown country-wide, but production is more concentrated in the Delta and the north regions. According to the recorded data obtained from the Department of Agricultural Economics and Statistics, Ministry of Agriculture and land Reclamation, Egypt, the cultivated area of cabbage in 2013-2014 reached about 40965 fed. which yielded 515,749 tons with an average of about 12.59t/fed. A rosette of sessile leaves arises as the growing point continues to form leaf primordial. The outer leaves are green in color and the inner ones are white and represent the edible, consumable and the economic part of the plant.

As the plant grows, the leaves increase in number, forming a ball-shaped "head" in the center of the plant formed by overlapping of numerous leaves developing over the growing point of its shortened stem. Botanically, when cabbage plants go through irregular growth periods as well as in high temperature and/or calcium deficiency, the leaves especially the newest ones in the center tends to grow vegetatively without overlapping or even the plants form bolts (Ghosh and Madhavi, 1998). In this respect, temperature over 23C$^o$ can induce "bolting" in cabbage (www.aces.edu) but varieties differ in their susceptibility to this disorder. Bolting is the process in which the plant switches from vegetative growth (heading) to reproductive growth (formation of flowers and seeds). So, in Egypt under the prevailing of high temperature especially during spring, summer and fall season plantings; bolting as well as the continuity of leaves to form without they being overlapped are the evident disorders for cabbage production in Egypt during the high temperature plantations. In general, most soils are rich in calcium, so plants have access to plenty of this nutrient. However, when plants go through irregular growth periods, calcium is not adequately transported to younger inner leaves and this causes the leaf edges "to burn" or turn brown (Smith, 1995 and Tiwari *et al.* 2003), therefore chelated calcium was also applied as one of the present study materials.

Elemental sulfur (S) is a natural material and can be applied to improve availability of nutrients and decline their deficiencies in calcareous and alkaline soils (Hunashikatti *et al*,.2000 ). Sulphur has a vital role in activation of photosynthesis process, carbohydrate metabolism and certain enzyme systems in plants, and can enhance growth, yield and chemical compoition (Yadav et al., 2013). Also, sulphur contributes to the cooking smell of cabbage (Smith, 1995). In this respect, sulphur as well as potassium have been reported to economically affect positively growth, yield and quality of cabbage by several studies (Eid, 2011 and Ramadan, 2012). In addition, recently salicylic acid as one of the common antioxidants inserted to many agricultural systems have been recorded to stimulate growth and productivity of cabbage as well as many other plants. In this respect, e.g. Sunaina and Singh (2014) and Iqbal *et al.*, (2015) reported that salicylic acid significantly increased the antioxidant enzymes under salinity due to oxidative damage but the graded concentrations of SA played protective role against the plant stress.

Boron (B) is one of the important micronutrients, which has basic role in stabilizing certain constituents of cell walls structure and function and activity of plasma membrane, enhancement of cell division, tissue differentiation. Thus, boron could be directly associated with cell growth (Goldbach *et al.*, 1990). Also, boron has been involved in metabolism of nucleic acid, carbohydrate, protein, auxin and phenol. Moreover, boron has been role in sugar translocation, nucleic acids synthesis and pollen tube growth. Also, Boron plays a key role in higher plants by facilitating the short - and long- distance transport of sugar via the formation of borate- sugar complexes (Marschner, 1997; Goldbach and Wimmer, 2007 and Ganie *et al.*, 2013). In addition, Ganie *et al.* (2013) reported that application of boron increased net photosynthetic rate which may be attributed to the increase in chlorophylls content of leaves.

Recently, a group of substances known as antioxidants or oxygen free radical scavengers were applied to protect against adverse effects of environment, reactive oxygen spices (ROS) and oxidative stress such as ascorbic acid, citric acid, α tocopherol and vitamins (Chen and Gallie, 2006). On the other hand, antioxidants are one of the new methods enhanced plant growth and development, increased photosynthetic pigments thereby increased chlorophyll and productivity as well.

Amino acids have traditionally been considered as precursors and constituents of proteins. Many amino acids also act as precursors of other nitrogen containing compounds, e.g., nucleic acids. Amino acids can play wide roles in plants including acting as regulatory and signaling molecules. Amino acids also affect synthesis and activity of some enzymes, gene expression, and redox homeostasis (Rai, 2002). Many studies have reported that foliar application of amino acids caused an increase in the growth and development of plants.

Hence, the present study aimed to accelerate headings in cabbage plants during periods of high temperature fluctuation by using simple and low cost foliar spraying with certain nutrients, antioxidants and amino acids dissolved in either normal or cold water. That is a simple idea and technique to minimize or prevent bolting, head splitting in mature cabbage and make heads well overlapped with good quality.

## MATERIALS AND METHODS

Two field experiments were carried out during the two successive summer seasons of 2014 and 2015 at the vegetable farm of the Faculty of Agriculture, Moshtohor, Benha University, to investigate the effects of spraying cabbage plants cv. Balady with potassium oxide ($K_2O$), chelated calcium, micronic sulphur, boric acid, salicylic acid, citric acid and amino acids dissolved in cold water (4±1) $^oC$ or normal water (30±1) $^oC$ on vegetative growth, chemical composition and yield. In this respect, cabbage seeds were sown on 1$^{st}$ and 5$^{th}$ of April in both seasons, respectively. Uniform transplants were obtained after 45 days from seeds sowing in both seasons. Transplants were planted at 40cm apart on one side of ridge, 80 cm in width. The experimental plot consisted of 4 rows each 4m long and 0.8 m wide with an area of about 11.8m$^2$, a guard ridge was left between each adjacent plot. The soil of the experimental farm was clay loam in texture with pH 7.9 according to Jackson (1973) and Black *et al.* (1982) Soil mechanical and chemical analyses are shown in Table a wlile Table b showed the air temperature in Qalubia region during the two seasons of study.

**Table a. Mechanical and chemical analyses of the experimental soil as an average of the two seasons of study.**

| Physical analysis | | Chemical analysis | | | |
|---|---|---|---|---|---|
| | | Cations meq/l | | Anions meq/l | |
| Coarse sand | 7.14% | $Ca^{++}$ | 7.26 | $CO_3^{--}$ | Zero |
| Fine sand | 17.26% | $Mg^{++}$ | 3.02 | $HCO_3^-$ | 4.14 |
| Silt | 23.20% | $Na^+$ | 5.36 | $Cl^-$ | 4.81 |
| Clay | 52.40% | $K^+$ | 0.83 | $SO_4^{--}$ | 7.52 |
| Texture class clay loam | | | | | |
| Soil pH | 7.83 | Available N | | 21.3 mg/kg | |
| E.C, dS/m | 1.65 | Available P | | 8.43 mg/kg | |
| Organic matter | 2.16% | Available K | | 117.4 mg/kg | |

**Table b: Monthly air temperature in Qalubia region during two seasons of the experimental.**

| Months | First season 2014 | | | Second season 2016 | | |
|---|---|---|---|---|---|---|
| | Max °C | Min °C | Average °C | Max °C | Min °C | Average °C |
| April | 38 | 10.8 | 20.9 | 29.5 | 6.2 | 17.3 |
| May | 44.1 | 16.5 | 25.7 | 40.8 | 11.5 | 24.6 |
| June | 39.9 | 18.7 | 27.1 | 39 | 18.6 | 28 |
| July | 40.8 | 21.8 | 29.3 | 38.1 | 17.8 | 26.6 |
| August | 43.9 | 23.9 | 31.3 | 37.7 | 17.4 | 27.4 |
| September | 39.3 | 22.2 | 30.2 | 38.4 | 17.7 | 27.8 |

Each experiment included 16 treatments resulted from the combinations of two spray method and eight spray substances as follows.

**a. Spray method treatments:**

1. Spray with cold water. 2-Spray with normal water.

**b. spraying substances:**

1-Potassium oxide ($K_2O$) at 2g/l.
2- Chelated calcium at 2g/l
3 Micronic sulphur at 5g/l.
4- Boric acid at 100 mg/l
5- Salicylic acid at 50 mg/l. 6- Citric acid at 2g/l.
7- Amino acid at 2ml/l. 8- Control.

Where the abovementioned eight substances were dissolved either in or in cold water at 4±1Cº or normal water 30±1Cº just before spraying in the two seasons. In this experiment, randomized complete block design(RCBD) with three replicates was adopted. The spray treatments were started after 30 days from transplanting and every 15$^{th}$ days by intervals to the end of the experiment (i.e., normal and cold waters were sprayed five times for each).

All other agricultural practices required for cabbage production were carried out according to the recommendations of the Ministry of Agriculture of Egypt.

**Data recorded:**

**1. Vegetative growth characteristics.**

Random representative samples, each of five plants were taken from each experimental plot at harvesting stage (110 days after transplanting). Plants were separated into stem and leaves to determine the following characteristics:

a. plant height, stem length, number of outer leaves, number of inner leaves/plant

b- Chemical constituents of plant leaves: - total chlorophyll (SPAD) were determined according to Hoel and Solhaug (1998), total carbohydrates% were determined according to Herbert et al. (1971), total sugars%, and vitamin C were determined calorimetrically as described in A. O. A. C. (1990). While, total N, P, K, Ca, S percentages and B ppm were determined according to Pregl (1945), John (1970) and Brown and Lilleland (1946), Rowell (1995) in case of N, P, K and Ca, respectively while, S and B contents were determined by atomic absorption as described by Chapman and Paratt (1961).

C. yield and head characteristics: at harvest time, all plants reached to harvesting stage were taken and the following parameters were recorded i.e., head fresh weight, stem fresh weight, plant fresh weight, head length, diameter and circumference.

**Statistical analysis:**

All data obtained in both seasons of study were subjected to analysis of variance as factorial experiments in complete randomized block. L.S.D. method was used to differentiate means according to Snedecor and Cochran (1991).

## RESULTS AND DISCUSSION

**1-Vegetative growth parameters:**

Data in Table (1) clearly indicate that each of plant height and stem length responded insignificantly with applying the cold water treatment when compared with the normal water (control). Since, insignificant increases of these two parameters were recorded in cabbage plants with the low temperature (i.e., cold water treatment). In this respect, values were 69.05, 73.03 and 20.45, 22.12 cm with normal water spraying but rose up to 69.41,73.59 and 20.75, 22.65 cm with cold water spraying for plant height and stem length, in the first and second seasons, respectively. The same data in Table 1 indicate that spraying cabbage plants five times during the growth seasons with nutrient elements ($K_2O$ at 2g/l, micronic sulphur at 5g/l, calcium at 2g/l, boric acid at 100mg/l and antioxidants i.e., salicylic acid at 5mg/l, citric acid at 2g/l and amino acids at 2ml/l) significantly increased both plant height and stem length compared with the control in both seasons of study. In addition, amino acids exhibited the highest values followed by salicylic acid, potassium oxide and calcium in descending order during the two seasons of study. The superiority of amino acids, salicylic acid, potassium oxide and calcium may be attributed to its affect on auxin biosynthesis, protecting the plant against abiotic stress and the main role of nutrient elements (K, Ca) all affect cell division and elongation and consequently the continues growth of plant stem in length and thickness which connected with stem weight and leaves formation.

Also, data in Table (1) confirmed the positive effect of cold water when combined with the antioxidants (i.e., salicylic and citric acids), potassium, calcium, micronic sulphur, boric acid and amino acids regarding the above mentioned two growth parameters of cabbage plants. Also, it could be noticed that the amino acids sprayed in cold water gave the highest values of plant height and stem length (i.e., 73.80,81.70 and 25.40,28.20 cm for plant height and stem length, respectively), yet, citric acid at 2g/l gave the lowest values for plant height and stem length, respectively. As for the number of outer leaves (i.e., the complete greenish leaves) and the number of inner leaves (i.e., the greenless leaves) it could be noticed that the repeat subjection of cabbage plants through spraying with low temperature water directly after the transplanting significantly decreased the number of outer leaves (i.e., the green ones but significantly increased the number of inner leaves i.e., the greenless leaves (the edible and consumable leaves). Since, values of the number of outer green leaves were 11.28 and 12.13with normal water meanwhile it was decreased to 10.40 and 11.31with repeated cold water treatment. But, the number of consumable greenless leaves (i.e., the inner edible leaves) were 22.95and 24.3 with normal water rose up to reach 24.31and 25.6 with repeated cold water treatment in the first and second seasons, respectively. Also, the same data in Table 1 reveal that spraying cabbage plants with all tested spraying materials (antioxidants and nutrient elements) significantly decrease the outer leaves (non-consumable leaves). On contrast it significantly increased the inner leaves (the edible part) compared with the control treatment in both seasons of study. In addition, using amino acids reflected the highest values for inner leaves followed by salicylic acid and potassium oxide and calcium. Increasing in inner leaves was connected the slow continuous increase in stem length as a result of terminal bud development and growth as a result of auxin bio-synthesis and in turn increased interior leave and head growth.

On the other hand, the cold water in combination with antioxidants as well as with other applied chemicals i.e., potassium, micronic sulphur and amino acids significantly decreased the number of non-consumable green outer leaves. In general, there was a positive interaction effect between cold water in the two seasons and the desirable characteristics of grown cabbage leaves especially the greenless and good white curled inner leaves as compared with normal water in combination with spray substances. Also, the specific effect of the applied treatments is being evident.

**Table 1: Effect of spray method and some nutrients, antioxidants, amino acids and their interaction on vegetative characteristics of cabbage plants grown in summer season during 2014 and 2015 seasons.**

| Treatments | | Frist season 2014 | | | | Second season 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|
| Treatment | Spray | Plant height (cm) | Stem length (cm) | No.of outer leaves | No.of inner leaves | Plant height (cm) | Stem length (cm)) | No.of outer leaves | No.of inner leaves |
| Cold water | | 69.41 | ٢٠.٧٥ | ١٠.٤٠ | ٢٤.٣١ | ٧٣.٥٩ | ٢٢.٦٥ | ١١.٣١ | ٢٥.٦ |
| Normal water | | 69.05 | ٢٠.٤٥ | 11.28 | ٢٢.٩٥ | ٧٣.٠٣ | ٢٢.١٢ | ١٢.١٣ | ٢٤.٣ |
| | LSD at 5% | N.S | N.S | ٠.٦٠ | ١.٠٨ | N.S | N.S | ٠.٦٩ | ١.٠٤ |
| | $K_2O$ at 2g/l | ٧١.٦٢ | ٢١.٦٧ | ١١.٣٠ | ٢٤.٩٥ | ٧٤.٣٥ | ٢١.٤٠ | ١١.٧٥ | ٢٥.٧٣ |
| | Ca at 2g/l | ٧٠.٦٥ | ٢٢.٠٢ | ١٠.٧٢ | ٢٤.٢٧ | ٧٧.٠٠ | ٢٣.٤٧ | ١١.٩٥ | ٢٦.٠٥ |
| | micronic sulphur at 5g/l | ٦٨.٣٧ | ١٩.٤٢ | ٩.٩٨ | ٢٢.١٠ | ٧١.٦٥ | ٢٠.٣٦ | ١٠.٩٥ | ٢٣.٢ |
| | Boric acid at 100 mg/l | ٧١.٣٣ | ٢٠.٠٢ | ١٠.٦٢ | ٢٣.٥٠ | ٧٥.٤٠ | ٢٢.٤٢ | ١١.٤٥ | ٢٤.٧ |
| | SA at 50 mg/l | ٧١.٨٩ | ٢٢.٤٧ | ١٢.٠ | ٢٦.٠٥ | ٧٨.٥٣ | ٢٤.٧٥ | ١٣.٣٧ | ٢٧.٢ |
| | Citric acid at 2g/l | ٦٤.٩٨ | ١٨.٧٠ | ٩.٦٣ | ٢٠.١٢ | ٦٤.٤٥ | ٢١.١٠ | ١٠.٥٢ | ٢١.٩ |
| | Amino acids at 2ml/l | ٧٤.٧٠ | ٢٤.٩٥ | ١٣.٠٧ | ٢٩.٤٢ | ٨١.٣٠ | ٢٧.٦٥ | ١٣.٨٥ | ٣٠.٠ |
| | Control | ٦٠.٢٨ | ١٥.٥٥ | ٩.٤١ | ١٨.٦٣ | ٦٣.٨٠ | ١٧.٩٣ | ٩.٩٥ | ٢٠.٥٥ |
| | LSD at 5% | ٢.٧٨ | ١.٨١ | ١.٢٠ | ٢.١٧ | ٢.٤٥ | ٢.٠٧ | ١.٣٩ | ٢.٠٩ |
| Cold water | $K_2O$ at 2g/l | ٧٢.٤٢ | ٢١.٩٠ | ١١.١٠ | ٢٥.٨ | ٧٤.٦٠ | ٢١.٧٠ | ١١.٤٠ | ٢٦.٣ |
| | Ca at 2g/l | ٧١.٢٠ | ٢٢.٢٠ | ١٠.٢٠ | ٢٤.٨ | ٧٧.٧٠ | ٢٣.٨٠ | ١١.٠ | ٢٦.٥ |
| | micronic sulphur at 5g/l | ٦٨.٤٠ | ١٩.١٠ | ٩.٣٠ | ٢٢.٩ | ٧٢.٠٠ | ١٩.٨٠ | ١٠.٦٠ | ٢٣.٩ |
| | Boric acid at 100 mg/l | ٧١.٣٠ | ١٩.٧٠ | ١٠.٢٠ | ٢٤.١ | ٧٥.٣٠ | ٢٢.٢٠ | ١١.١٠ | ٢٥.٣ |
| | SA at 50 mg/l | ٧١.٥٣ | ٢٢.٦٠ | ١١.٩٠ | ٢٦.٧٠ | ٧٨.٩٠ | ٢٤.٩٠ | ١٣.١٠ | ٢٨.٣ |
| | Citric acid at 2g/l | ٦٥.٥٠ | ١٩.٢٠ | ٩.١٠ | ٢٠.٧ | ٦٤.٦٠ | ٢٢.٤٠ | ١٠.١٠ | ٢٢.٥ |
| | Amino acids at 2ml/l | ٧٣.٨٠ | ٢٥.٤٠ | ١٢.٣٠ | ٢٩.٩ | ٨١.٧٠ | ٢٨.٢٠ | ١٣.٤٠ | ٣٠.٦ |
| | Control | ٦١.١٠ | ١٥.٩٠ | ٩.١٠ | ١٩.٦ | ٦٣.٩٠ | ١٨.٢٠ | ٩.٦٠ | ٢١.٤ |
| Normal water | $K_2O$ at 2g/l | ٧٠.٨٢ | ٢١.٤٣ | ١١.٥ | ٢٤.١٠ | ٧٤.١٠ | ٢١.١٠ | ١٢.١٠ | ٢٥.١٧ |
| | Ca at 2g/l | ٧٠.١٠ | ٢١.٨٣ | ١١.٢٣ | ٢٣.٧ | ٧٦.٣٠ | ٢٣.١٣ | ١٢.٧٠ | ٢٥.٦ |
| | micronic sulphur at 5g/l | ٦٨.٣٣ | ١٩.٧٣ | ١٠.٦٧ | ٢١.٣ | ٧١.٣٠ | ٢٠.٩٢ | ١١.٣٠ | ٢٢.٦ |
| | Boric acid at 100 mg/l | ٧١.٣٥ | ٢٠.٣٣ | ١١.٠٣ | ٢٢.٩٠ | ٧٥.٥٠ | ٢٢.٦٣ | ١١.٨٠ | ٢٤.١ |
| | SA at 50 mg/l | ٧٢.٢٥ | ٢٢.٣٣ | ١٢.١٠ | ٢٥.٤٠ | ٧٨.١٧ | ٢٤.٦٠ | ١٣.٦٣ | ٢٧.١ |
| | Citric acid at 2g/l | ٦٤.٤٧ | ١٨.٢٠ | ١٠.١٧ | ١٩.٥٣ | ٦٤.٣٠ | ١٩.٨٠ | ١٠.٩٣ | ٢١.٣ |
| | Amino acids at 2ml/l | ٧٥.٦٠ | ٢٤.٥٠ | ١٣.٨٣ | ٢٨.٩٣ | ٨٠.٩٠ | ٢٧.١٠ | ١٤.٣٠ | ٢٩.٤ |
| | Control | ٥٩.٤٧ | ١٥.٢٠ | ٩.٧٣ | ١٧.٦٧ | ٦٣.٧٠ | ١٧.٦٧ | ١٠.٣٠ | ١٩.٧ |
| | LSD at 5% | ٣.٩٤ | ٢.٥٦ | ١.٦٩ | ٣.٠٦ | ٣.٤٧ | ٢.٩٣ | | ٢.٩٥ |

## 2- Head characteristics:

As shown in Table 2, heads fresh weight with the treatment of cold water was significantly increased when compared with those heads sprayed with normal water. Since, this weight was 7.77 and 9.09kg/head with normal water (30±1ºc) but significantly rose up to 8.25and 9.94kg/head in case of cold water (4±1ºc) sprayed in the two seasons. Also, Table 2 shows that different materials i.e., potassium oxide, chelated calcium, micronic sulphur, boric acid, salicylic acid, citric acid and amino acids had positive specific significant effect upon heads fresh weight as compared to the control. Here, it could also be noticed that spraying amino acids at 2ml/l gave the highest increase of head weight/plant that reached to 10.51and 12.54kg/head but the lowest increase (6.47and 7.57kg/head) was existed with citric acid treatments in the first and second seasons, respectively. Meanwhile, this weight was only 5.87 and 6.83kg/head in case of the control treatment (i.e., only normal water with no materials) in the first and second seasons, respectively. It could be noticed that spraying amino acids at 2ml/l dissolved in cold water gave the highest fresh weight/head that reached 10.91 kg/head and this value was 10.12 kg/head with normal water (30 ±1c) in the first season and 13.12kg/head in case of cold water and 11.94 kg/head in case of normal water in the second season. With regard to the specific effect of water temperature of the sprayed solvent water upon stem fresh weight, only insignificant increase between cold and normal sprayed water. While, this specific effect was exhibited significant increase in stem fresh weight with different applied materials to reach its maximum with amino acids at 2ml/l that reached to 0.88 and 0.97kg/stem during the first and second season, respectively. Meanwhile, its lowest significant increase was existed in case of micronic sulphur at 5g/l that reached only to 0.62 and 0.77kg/stem in the first season and second season. In addition, regarding the stems fresh weight it was significantly and positively interacted with either cold or even normal sprayed water. In this respect, amino acids were more pronounced (gave 0.93 kg/stem with cold water and 0.84 kg/stem with normal water in the first season and 0.96kg in case of cold water and 0.99kg/stem in case of normal water in the second season). As regards the fresh weight/plant, head length, head diameter and head circumference were significantly increased as a result of using cold water in spraying compared with normal water in the two seasons of study. Such increment in all aforementioned measurements are connected with the increase in outer and inner produced leaves by plants (Table1) which reflected on average head parameters. As for the effect of spraying materials the same data in Table 2 indicate that plant fresh weight and head measurements expressed as average head length, diameter and circumference were significantly increased as a result of spraying the plants with all tested spray materials compared with the control treatments in the two seasons of study. In this regard, among different materials were the amino acids at 2ml/l and salicylic acid at 5mM/l followed by potassium oxide at 2g/l were the most effective treatments compared with other tested one in both seasons of growth. Such superiority of these materials on plant fresh weight and head parameters may be attributed to its effect on vegetative growth traits (Table1).

**Table 2: Effect of spray method and some nutrients, antioxidants, amino acids and their interaction on head yield characteristics of cabbage plants grown in summer season during 2014 and 2015 seasons.**

| Treatments | | Frist season 2014 | | | | | | Second season 2015 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | Spray | Head fresh weight (kg) | Stem fresh weight (kg) | Plant fresh weight (kg) | Head length (cm) | Head diameter (cm) | Head Circum firance | Head fresh weight (kg) | Stem fresh weight (kg) | Plant fresh weight (kg) | Head length (cm) | Head diameter (cm) | Head circumf irance |
| Cold water | | ٨.٢٥ | ٠.٧٢ | ٨.٩٧ | ٢٨.٣٦ | ٤٤.٢٢ | ١٠٥.٧ | ٩.٩٤ | ٠.٨٥ | ١٠.٨٠ | ٣١.٨٠ | ٤٩.٩٩ | ١١٢.٩ |
| Normal water | | ٧.٧٧ | ٠.٧٠ | ٨.٤٧ | ٢٧.٠٤ | ٤٣.٨٦ | ١٠٠.٨ | ٩.٠٩ | ٠.٨٤ | ٩.٩٣ | ٣٠.٢٤ | ٤٨.٣٥ | ١٠٦.٥ |
| LSD at 5% | | ٠.١٠ | N.S | ٠.١٠ | ١.٠٦ | ٠.٨٨ | ١.٢ | ٠.١٤ | N.S | ٠.١٥ | ١.٠٤ | ١.٠٦ | ١.٧ |
| | $K_2O$ at 2g/l | ٩.١٠ | ٠.٧٧ | ٩.٨٧ | ٢٩.١٥ | ٤٦.٢٣ | ١٠٥.٧ | ١٠.٢٥ | ٠.٩٠ | ١١.١٥ | ٣٢.٥ | ٥١.٥ | ١١٣.٨ |
| | Ca at 2g/l | ٧.٨٣ | ٠.٧٢ | ٨.٥٥ | ٢٨.٤٥ | ٤٥.٩ | ١٠٤.٧ | ١٠.٤٠ | ٠.٨٩ | ١١.٣٠ | ٣١.٥ | ٤٩.٨ | ١٠٧.٤ |
| | micronic sulphur at 5g/l | ٧.١٥ | ٠.٦٢ | ٧.٧٨ | ٢٦.٠٥ | ٤٠.٨ | ٩٨.٨ | ٨.١٧ | ٠.٧٧ | ٨.٩٤ | ٢٩.٤ | ٤٦.٠ | ١٠٥.٤ |
| | Boric acid at 100 mg/l | ٧.٥٥ | ٠.٦٦ | ٨.٢٢ | ٢٧.٨٠ | ٤٣.١ | ١٠٣.٨ | ٩.١٠ | ٠.٨٨ | ٩.٩٩ | ٣٠.٨ | ٤٨.٢ | ١١٤.٧ |
| | SA at 50 mg/l | ٩.٦٠ | ٠.٨٠ | ١٠.٤٠ | ٣٠.٢٥ | ٤٨.٧ | ١١٠.٩ | ١١.٢٨ | ٠.٩٢ | ١٢.٢٠ | ٣٣.٩ | ٥٣.٣ | ١١٨.٥ |
| | Citric acid at 2g/l | ٦.٤٧ | ٠.٧١ | ٧.١٨ | ٢٤.٧٥ | ٣٨.٥ | ٩٦.١ | ٧.٥٧ | ٠.٧٩ | ٨.٣٦ | ٢٧.٤ | ٤٣.٦ | ١٠٢.٢ |
| | Amino acids at 2ml/l | ١٠.٥١ | ٠.٨٨ | ١١.٤٠ | ٣٣.٣٢ | ٥٤.٣ | ١١٦.٨ | ١٢.٥٤ | ٠.٩٧ | ١٣.٥١ | ٣٧.٨ | ٥٨.٥ | ١٢٢.٦ |
| | Control | ٥.٨٧ | ٠.٥١ | ٦.٣٩ | ٢١.٨٥ | ٣٤.٦ | ٨٨.٨ | ٦.٨٣ | ٠.٦٢ | ٧.٤٦ | ٢٤.٦ | ٣٨.١ | ٩٢.٨ |
| | LSD at 5% | ٠.٢١ | ٠.٠٥ | ٠.٢٠ | ٢.١٣ | ١.٧ | ٢.٤ | ٠.٢٩ | ٠.٠٧ | ٠.٣٠ | ٢.٠٩ | ٢.١ | ٣.٤ |
| Cold water | $K_2O$ at 2g/l | ٩.١٦ | ٠.٧٩ | ٩.٩٥ | ٢٩.٩ | ٤٦.١ | ١٠٨.٣ | ١٠.٧٠ | ٠.٩١ | ١١.٦١ | ٣٣.٢ | ٥١.٤ | ١١٦.٤ |
| | Ca at 2g/l | ٨.١٣ | ٠.٧٣ | ٨.٨٦ | ٢٩.١ | ٤٦.١ | ١٠٦.٧ | ١٠.٨٣ | ٠.٩٢ | ١١.٧٥ | ٣٢.٣ | ٥٠.١ | ١٠٥.٨ |
| | micronic sulphur at 5g/l | ٧.٤١ | ٠.٦١ | ٨.٠٢ | ٢٦.٨ | ٤٠.٧ | ١٠١.٤ | ٨.٧١ | ٠.٧٤ | ٩.٤٥ | ٣٠.٢ | ٤٥.٩ | ١٠٨.٢ |
| | Boric acid at 100 mg/l | ٧.٨٦ | ٠.٦٤ | ٨.٥٠ | ٢٨.٥ | ٤٢.٩ | ١٠٥.٧ | ٩.٤٥ | ٠.٨٧ | ١٠.٣٣ | ٣١.٧ | ٤٨.١ | ١٢٢.٣ |
| | SA at 50 mg/l | ٩.٨٤ | ٠.٧٩ | ١٠.٦٣ | ٣٠.٩ | ٤٨.٩ | ١١٣.٥ | ١١.٧١ | ٠.٨٩ | ١٢.٦٠ | ٣٤.٨ | ٥٣.٤ | ١٢١.٣ |
| | Citric acid at 2g/l | ٦.٤٨ | ٠.٧٥ | ٧.٥٩ | ٢٥.٤ | ٣٨.٩ | ٩٦.٦ | ٨.١١ | ٠.٨٣ | ٨.٩٤ | ٢٨.٣ | ٤٣.٨ | ١٠٥.٣ |
| | Amino acids at 2ml/l | ١٠.٩١ | ٠.٩٣ | ١١.٨٤ | ٣٣.٩ | ٥٤.٥ | ١١٨.٩ | ١٣.١٣ | ٠.٩٦ | ١٤.٠٩ | ٣٨.٧ | ٥٩.١ | ١٢٥.٧ |
| | Control | ٥.٨٩ | ٠.٥٦ | ٦.٤٥ | ٢٢.٤ | ٣٥.٧ | ٩٢.١ | ٦.٩٢ | ٠.٦٩ | ٧.٦١ | ٢٥.١ | ٤٠.١ | ٩٨.١ |
| Normal water | $K_2O$ at 2g/l | ٩.٠٥ | ٠.٧٥ | ٩.٨٠ | ٢٨.٤ | ٤٦.٣ | ١٠٣.١ | ٩.٨٠ | ٠.٨٩ | ١٠.٦٩ | ٣١.٨ | ٥١.٧ | ١١١.٢ |
| | Ca at 2g/l | ٧.٥٤ | ٠.٧١ | ٨.٢٥ | ٢٧.٨ | ٤٥.٨ | ١٠٢.٧ | ٩.٩٨ | ٠.٨٧ | ١٠.٨٥ | ٣٠.٧ | ٤٩.٥ | ١٠٩.١ |
| | micronic sulphur at 5g/l | ٦.٩٠ | ٠.٦٤ | ٧.٥٤ | ٢٥.٣ | ٤٠.٩ | ٩٦.٥ | ٧.٦٤ | ٠.٨٠ | ٨.٤٤ | ٢٨.٧ | ٤٦.١ | ١٠٢.٧ |
| | Boric acid at 100mg/l | ٧.٢٥ | ٠.٦٩ | ٧.٩٤ | ٢٧.١ | ٤٣.٣ | ١٠١.٨ | ٨.٧٦ | ٠.٩٠ | ٩.٦٦ | ٢٩.٩ | ٤٨.٤ | ١٠٧.١ |
| | SA at 50 mg/l | ٩.٣٦ | ٠.٨٢ | ١٠.١٨ | ٢٩.٦ | ٤٨.٥ | ١٠٨.٣ | ١٠.٨٦ | ٠.٩٥ | ١١.٨١ | ٣٣.١ | ٥٣.٢ | ١١٥.٧ |
| | Citric acid at 2g/l | ٦.١٠ | ٠.٦٨ | ٦.٧٨ | ٢٤.١ | ٣٨.٢ | ٩٣.٥ | ٧.٠٣ | ٠.٧٦ | ٧.٧٩ | ٢٦.٦ | ٤٣.٤ | ٩٩.١ |
| | Amino acids at 2ml/l | ١٠.١٢ | ٠.٨٤ | ١٠.٩٦ | ٣٢.٧ | ٥٤.٢ | ١١٤.٧ | ١١.٩٤ | ٠.٩٩ | ١٢.٩٣ | ٣٦.٩ | ٥٨.٤ | ١١٩.٥ |
| | Control | ٥.٨٦ | ٠.٤٧ | ٦.٣٣ | ٢١.٣ | ٣٣.٦ | ٨٥.٥ | ٦.٧٥ | ٠.٥٦ | ٧.٣١ | ٢٤.٢ | ٣٥.٩ | ٨٧.٦ |
| LSD at 5% | | ٠.٢٩ | ٠.٠٧ | ٠.٢٩ | ٣.١ | ٢.٥ | ٣.٤ | ٠.٤١ | ٠.١٠ | ٠.٤٢ | ٢.٩ | ٣.٠١ | ٤.٨ |

As regards the fresh weight/plant (Table 2) obviously it could be noticed that the specific effect of cold and normal water and different applied materials as well as the interactions effect of the applied materials either sprayed with cold or normal water were significantly and positively interacted with this aspect of cabbage growth. Also, it could be noticed that each of cold water either when sprayed alone or in combination with different materials were more pronounced in this respect. In addition, among different materials were the amino and salicylic acids followed by potassium oxide were the most effective treatments. Furthermore, as shown in Table 2 the specific effect of cold water upon the head length, diameter and circumference as well it showed significant increase of all these characteristics. Yet, the same positive specific effect was obtained also in case of different applied salts and antioxidants. In this respect, the amino and salicylic acids were the most effective treatments regarding the all above mentioned characteristics in 2014 and 2015 seasons, as well. With regard to the interaction effects of sprayed water temperature and the applied nutrient salts significant increases in all studied characteristics with different applied treatments were existed. But, also it could be noticed that the amino and salicylic acids were more pronounced in this respect during the two successive seasons of this study. Also, using amino acids followed by salicylic acid either dissolved in cold or normal waters reflected the highest values in all measured plant weight and head parameters compared with other interaction treatments in the two seasons of growth.

**3-Total chlorophylls and some bio constituents**

As shown in Table 3 spraying cabbage plants with cold water (4±1) tended to increase total chlorophyll content, total sugars and total carbohydrates percentage as well as vitamin C content of plant leaves compared with using normal water (30±1) in both seasons of study. Such increases reached the level of significant only in case of total carbohydrate percentage that reached 12.20 and 13.4% in case of cold water as compared with only 10.81and 11.76% in case of normal water in the first and second seasons, respectively. Such enhancing effect of cold water foliar spray may be due to it reduced the respiration rate of plant tissues and consumption of such bio-constituents in respiration under high temperature conditions in summer planation and consequently increased its accumulation in plant cells.

As for the specific effect of different nutrients and antioxidants applied, data in the same Table indicate that all assayed chemical constituents were significantly increased as a result of spraying the plants with all tested nutrients and antioxidants compared with the control treatment in both seasons of study. In addition, spraying the plants with amino acids at 2ml/l reflected the highest values of total chlorophyll during both seasons, while using boric acid at 100ppm exhibited the highest value in total sugars. But the highest values of total carbohydrate was recorded in case of sprayed the plants with potassium oxide. Moreover, the highest vitamin C concentration was registered in case of salicylic acid. Such increases in chlorophyll and bio-constituents of cabbage leaves as a result of using the tested nutrients and antioxidants may be due to such nutrients and antioxidant play an important role as a constituents or aid in their bio assimilation and in turn increased it.

**Table 3: Effect of spray method and some nutrients antioxidants, amino acids and their interaction on total chlorophyll and some bio constituents of cabbage plants grown in summer season during 2014 and 2015 seasons**

| Treatments | | Frist season 2014 | | | | Second season 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Treatment** | **spray** | **Total chlorophyll (SPAD)** | **Total sugars %** | **Total carbohy drat %** | **VitaminC (mg/100 gfw)** | **Total chlorophyll (SPAD)** | **Total sugars %** | **Total carbohy drat%** | **VitaminC (mg/100 gf.w)** |
| Cold water | | ٢٦٥.٦ | ٢.١٣ | ١٢.٢٠ | ٣٥.٢٤ | ٢٧٠.٢ | ٢.٣٠ | ١٣.٤ | ٣٥.٤ |
| Normal water | | ٢٦٢.٩ | ٢.١١ | ١٠.٨١ | ٣٤.٨٢ | ٢٦٧.٨ | ٢.٢٣ | ١١.٧٦ | ٣٤.٨٤ |
| LSD at 5% | | N.S | N.S | 0.54 | N.S | N.S | N.S | 0.52 | N.S |
| | $K_2O$ at 2g/l | ٢٧٤ | ٢.٣٩ | ١٣.٠ | ٣١.٦ | ٢٨٢ | ٢.٣٨ | ١٤.٨ | ٣٢.٧ |
| | Ca at 2g/l | ٢٨١ | ١.٨٨ | ١٢.٠٥ | ٣٥.٥٥ | ٢٧٣ | ٢.٣٩ | ١٢.٥٢ | ٣٥.١ |
| | micronic sulphur at 5g/l | ٢٤٦ | ٢.٠٣ | ١١.٠٥ | ٣٠.٨٥ | ٢٦٠ | ٢.١٦ | ١٠.٧ | ٣٤.١ |
| | Boric acid at 100 mg/l | ٢٦٣ | ٢.٤٢ | ١٢.٨٥ | ٣٤.٧ | ٢٧٠ | ٢.٥٨ | ١٤.٥ | ٣٥.٧ |
| | SA at 50 mg/l | ٢٦١ | ٢.٢٣ | ١٠.٩٥ | ٤٢.٢٥ | ٢٧٠ | ٢.٣٢ | ١١.٢٣ | ٤٠.٤ |
| | Citric acid at 2g/l | ٢٦١ | ١.٩٦ | ١٠.٦ | ٣٨.٩ | ٢٥٣ | ١.٩٩ | ١٣.٠٧ | ٣٨.١ |
| | Amino acids at 2 ml/l | ٢٨٤ | ٢.٣٠ | ١٢.٧٠ | ٣٧.٦ | ٢٩٣ | ٢.٤٣ | ١٤.٢٣ | ٣٧.٣ |
| | Control | ٢٤١ | ١.٧٧ | ٨.٨٥ | ٢٨.٧ | ٢٤٩ | ١.٨٩ | ٩.٦ | ٢٧.٢ |
| LSD at 5% | | ١٢.٤ | ٠.٠٨ | ١.٠٩ | ٢.٧٥ | ١٢.٦ | ٠.١٧ | ١.٠٥ | ١.٧ |
| Cold water | $K_2O$ at 2g/l | ٢٧٦ | ٢.٣٩ | ١٣.٦ | ٣١.٩ | ٢٨١ | ٢.٥٤ | ١٥.٧ | ٣٢.٨ |
| | Ca at 2g/l | ٢٨٣ | ١.٩٢ | ١٢.٨ | ٣٥.٩ | ٢٧٦ | ٢.٤١ | ١٣.٤ | ٣٤.٩ |
| | micronic sulphur at 5g/l | ٢٤٥ | ٢.١٠ | ١٢.٢ | ٣١.١ | ٢٦١ | ٢.١٧ | ١١.٦ | ٣٤.٣ |
| | Boric acid at 100 mg/l | ٢٦٦ | ٢.٤١ | ١٣.٥ | ٣٤.٦ | ٢٧٢ | ٢.٥٧ | ١٥.٤ | ٣٥.٩ |
| | SA at 50 mg/l | ٢٦٤ | ٢.٢٥ | ١١.٦ | ٤٢.٤ | ٢٧٢ | ٢.٣٦ | ١٢.١ | ٤١.٢ |
| | Citric acid at 2g/l | ٢٦١ | ١.٩٦ | ١١.٥ | ٣٩.١ | ٢٥٢ | ٢.٠٢ | ١٤.٠ | ٣٨.١ |
| | Amino acids at 2ml/l | ٢٨٧ | ٢.٣٤ | ١٣.٣ | ٣٧.٨ | ٢٩٦ | ٢.٤٧ | ١٥.١ | ٣٧.٦ |
| | Control | ٢٤٣ | ١.٨١ | ٩.١ | ٢٩.١ | ٢٥١ | ١.٩٢ | ٩.٩ | ٢٨.٤ |
| Normal water | $K_2O$ at 2g/l | ٢٧٣ | ٢.٣٩ | ١٢.٤ | ٣١.٣ | ٢٨٣ | ٢.٢٢ | ١٣.٩ | ٣٢.٦ |
| | Ca at 2g/l | ٢٧٩ | ١.٨٥ | ١١.٣ | ٣٥.٢ | ٢٧١ | ٢.٣٧ | ١١.٦٣ | ٣٥.٢ |
| | micronic sulphur at 5g/l | ٢٤٨ | ٢.٠٦ | ٩.٩ | ٣٠.٦ | ٢٥٩ | ٢.١٦ | ٩.٨ | ٣٤.١ |
| | Boric acid at 100 mg/l | ٢٦١ | ٢.٤٣ | ١٢.٢ | ٣٤.٨ | ٢٦٩ | ٢.٥٩ | ١٣.٦ | ٣٥.٦٤ |
| | SA at 50 mg/l | ٢٥٩ | ٢.٢١ | ١٠.٣ | ٤٢.١ | ٢٦٨ | ٢.٢٩ | ١٠.٣٧ | ٣٩.٧ |
| | Citric acid at 2g/l | ٢٦٢ | ١.٩٧ | ٩.٧ | ٣٨.٨ | ٢٥٤ | ١.٩٧ | ١٢.١٣ | ٣٨.٢ |
| | Amino acids at 2ml/l | ٢٨٢ | ٢.٢٦ | ١٢.١ | ٣٧.٤ | ٢٩١ | ٢.٤٠ | ١٣.٣٧ | ٣٧.١ |
| | Control | ٢٣٩ | ١.٧٤ | ٨.٦ | ٢٨.٣ | ٢٤٧ | ١.٨٦ | ٩.٣ | ٢٦.١ |
| LSD at 5% | | ١٧.٦ | ٠.١١ | ١.٥ | ٣.٨٨ | ١٧.٩ | ٠.٢٤ | ١.٤٩ | ٢.٤٥ |

With regard to the interaction effect data in Table 3 show that all assayed chemical constituents were significantly affected as a result of the interaction treatments. In this respect, using cold water in spraying all tested nutrients or antioxidant reflected the highest values compared with using normal water. In addition, using cold water in spraying combined with spraying the plants with each of amino acids, boric acid, potassium oxide and salicylic acid reflected the highest values in total chlorophyll, total sugars, total carbohydrates percentage and vitamin C content, respectively during both seasons of study.

**4-Macro and micro elements content in the inner curled leaves:**

As indicated in Table 4, there were differences in all assayed macro-elements (N, P, K, Ca, S) and micro-elements (B concentration) in inner curled leaves as a result of spraying the plants with water at different temperature. In this respect, such differences reached only the level of significancy in case of potassium percentage in both seasons and boron in the first season as well as sulphur percentage during the second season only. Moreover, spraying the plants five times during the growing season with cold water (4±1Cº) exhibited the highest values in all measured mineral elements compared with using normal water in spraying. This indicate that cold water tended to reduce the abiotic stress of hot summer temperature and encourage the absorption and accumulation of nutrients by plants especially in newly formed inner leaves and in turn increases the nutritional values of edible part of cabbage.

As for the effect of sprayed nutrients and antioxidants, the same data in Table (4) show that all assayed mineral elements were significantly increased as a result of spraying cabbage plants with all tested materials compared with the control treatment in both seasons of study. In this respect, using amino acids and potassium oxide in spraying reflected the highest values of nitrogen, phosphorus and potassium content, whereas, the highest values of calcium, sulphur and boron contents were recorded by Ca at 2g/l, micronic sulphur at 5g/l and boric acid at 100mg/l, respectively compared with other treatments.

**Table 4: Effect of spray method and some nutrients, antioxidants, amino acids and their interaction on some macro and micro nutrients content of cabbage plants grown in summer season during 2014 and 2015 seasons.**

| Treatments | | Frist season 2014 | | | | | | Second season 2015 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | spray | N% | P% | K% | Ca% | S% | B (ppm) | N% | P% | K% | Ca% | S% | B (ppm) |
| Cold water | | ٢.٤٥ | ٠.٣٠ | ٣.٥٠ | ١.٧٦ | ١.١١ | ٧٠.٩ | ٢.٥٨ | ٠.٢٨ | ٣.٥٦ | ١.٧١ | ١.٣٠ | ٧٣.٥ |
| Normal water | | ٢.٤١ | ٠.٢٨ | ٣.٢٧ | ١.٧٢ | ١.٠٧ | ٦٦.٧ | ٢.٥١ | ٠.٢٧ | ٣.٢٤ | ١.٦٨ | ١.٢٣ | ٧٢.١ |
| LSD at 5% | | N.S | N.S | 0.11 | N.S | N.S | 1.9 | N.S | N.S | 0.09 | N.S | 0.02 | N.S |
| | $K_2O$ at 2g/l | ٢.٥١ | ٠.٣٢ | ٣.٦٥ | ١.٩٣ | ١.٢٣ | ٧١.٨ | ٢.٧٧ | ٠.٣٠ | ٣.٧١ | ١.٩٠ | ١.٤٨ | ٧٣.٢ |
| | Ca at 2g/l | ٢.٧٢ | ٠.٢٩ | ٣.٥٥ | ٢.١٨ | ١.٠٦ | ٧٥.٥ | ٢.٨٠ | ٠.٣٠ | ٣.٤٨ | ٢.١٣ | ١.٣٠ | ٨١.٢ |
| | micronic sulphur at 5g/l | ٢.٣٦ | ٠.٢٦ | ٣.٤٢ | ١.٨٣ | ١.٣٧ | ٦٢.١ | ٢.٤٧ | ٠.٢٦ | ٣.٣٤ | ١.٤١ | ١.٧١ | ٦٢.٣ |
| | Boric acid at 100 mg/l | ٢.١٨ | ٠.٢٦ | ٣.٢٠ | ١.٣٢ | ٠.٨٨ | ٨٥.٣ | ٢.٣٢ | ٠.٢٤ | ٣.٢١ | ١.٧٤ | ٠.٩٨ | ٩٠.٤ |
| | SA at 50 mg/l | ٢.٤٠ | ٠.٣٠ | ٣.٤٩ | ١.٨٠ | ١.١٦ | ٦٤.٠ | ٢.٥٦ | ٠.٢٨ | ٣.٤٣ | ١.٥١ | ١.٣٢ | ٦٤.٣ |
| | Citric acid at 2g/l | ٢.٢٧ | ٠.٣١ | ٣.٣٣ | ١.٥٨ | ٠.٩٣ | ٥٩.٥ | ٢.٤٦ | ٠.٢٨ | ٣.٤٩ | ١.٦٥ | ٠.٩٩ | ٦٣.٢ |
| | Amino acids at 2ml/l | ٢.٩٢ | ٠.٣٥ | ٣.٦٣ | ٢.٠٧ | ١.٣٠ | ٧٧.٨ | ٢.٩٥ | ٠.٣٣ | ٣.٥٩ | ٢.٠٢ | ١.٥٦ | ٨٧.٧ |
| | Control | ٢.١٤ | ٠.٢٢ | ٢.٨٢ | ١.٢٢ | ٠.٨٢ | ٥٥.٠ | ٢.١٧ | ٠.٢٢ | ٢.٩٦ | ١.١٩ | ٠.٨٠ | ٥٩.٩ |
| LSD at 5% | | ٠.٣٠ | ٠.٠٣ | ٠.٢٢ | ٠.١٥ | ٠.٠٨ | ٣.٨ | ٠.٢٧ | ٠.٠٤ | ٠.١٩ | ٠.١٤ | ٠.٠٥ | ٢.٩ |
| Cold water | $K_2O$ at 2g/l | ٢.٥٣ | ٠.٣٤ | ٣.٨٦ | ١.٩٢ | ١.٢٥ | ٧٤.٢ | ٢.٨١ | ٠.٣١ | ٣.٩٢ | ١.٩٢ | ١.٤٧ | ٧٤.٣ |
| | Ca at 2g/l | ٢.٧٦ | ٠.٣٠ | ٣.٦٩ | ٢.١٧ | ١.٠٤ | ٧٨.٦ | ٢.٧٩ | ٠.٣١ | ٣.٧٠ | ٢.١٤ | ١.٣٢ | ٨٣.١ |
| | micronic sulphur at 5g/l | ٢.٤٢ | ٠.٢٦ | ٣.٥١ | ١.٨٦ | ١.٤٢ | ٦٤.٣ | ٢.٥١ | ٠.٢٧ | ٣.٥١ | ١.٤١ | ١.٧٤ | ٦١.٩ |
| | Boric acid at 100 mg/l | ٢.١٧ | ٠.٢٦ | ٣.٢١ | ١.٣٤ | ٠.٩١ | ٨٨.٣ | ٢.٣٣ | ٠.٢٤ | ٣.٣٢ | ١.٧٨ | ١.١٢ | ٩١.٧ |
| | SA at 50 mg/l | 2.4 | ٠.٣١ | ٣.٦٧ | ١.٨٤ | ١.١٩ | ٦٥.٤ | ٢.٦٣ | ٠.٢٩ | ٣.٦٢ | ١.٥٣ | ١.٣٤ | ٦٣.٨ |
| | Citric acid at 2g/l | ٢.٢٦ | ٠.٣٢ | ٣.٤٧ | ١.٦٣ | ٠.٩٢ | ٦١.٧ | ٢.٤٣ | ٠.٢٩ | ٣.٦٩ | ١.٦٧ | ١.٠٢ | ٦٢.٩ |
| | Amino acids at 2ml/l | ٢.٩٩ | ٠.٣٧ | ٣.٧٩ | ٢.١١ | ١.٣٤ | ٧٩.٢ | ٢.٩٤ | ٠.٣٤ | ٣.٨٠ | ٢.٠٤ | ١.٥٩ | ٨٩.١ |
| | Control | ٢.١٥ | ٠.٢٤ | ٢.٨٢ | ١.٢٤ | ٠.٨٣ | ٥٦.١ | ٢.١٩ | ٠.٢٣ | ٢.٩٦ | ١.٢١ | ٠.٨٤ | ٦١.٢ |
| Normal water | $K_2O$ at 2g/l | ٢.٤٩ | ٠.٣١ | ٣.٤٤ | ١.٩٤ | ١.٢١ | ٦٩.٤ | ٢.٧٤ | ٠.٢٩ | ٣.٥١ | ١.٨٩ | ١.٤٩ | ٧٢.١ |
| | Ca at 2g/l | ٢.٦٨ | ٠.٢٨ | ٣.٤٢ | ٢.١٩ | ١.٠٨ | ٧٢.٤ | ٢.٨١ | ٠.٢٩ | ٣.٢٧ | ٢.١٢ | ١.٢٨ | ٧٩.٣ |
| | micronic sulphur at 5g/l | ٢.٣١ | ٠.٢٧ | ٣.٣٤ | ١.٨١ | ١.٣٢ | ٥٩.٨ | ٢.٤٣ | ٠.٢٦ | ٣.١٨ | ١.٤٢ | ١.٦٩ | ٦٢.٨ |
| | Boric acid at 100 mg/l | ٢.١٩ | ٠.٢٧ | ٣.١٩ | ١.٣١ | ٠.٨٦ | ٨٢.٣ | ٢.٣١ | ٠.٢٥ | ٣.١٠ | ١.٧١ | ٠.٨٤ | ٨٩.٢ |
| | SA at 50 mg/l | ٢.٣٤ | ٠.٢٩ | ٣.٣٢ | ١.٧٦ | ١.١٤ | ٦٢.٦ | ٢.٤٩ | ٠.٢٧ | ٣.٢٥ | ١.٥٠ | ١.٣٠ | ٦٤.٩ |
| | Citric acid at 2g/l | ٢.٢٩ | ٠.٣٠ | ٣.١٩ | ١.٥٤ | ٠.٩٤ | ٥٧.٣ | ٢.٥٠ | ٠.٢٧ | ٣.٣٠ | ١.٦٤ | ٠.٩٦ | ٦٣.٦ |
| | Amino acids at 2ml/l | ٢.٨٥ | ٠.٣٤ | ٣.٤٨ | ٢.٠٤ | ١.٢٦ | ٧٦.٤ | ٢.٩٧ | ٠.٣٢ | ٣.٣٩ | ٢.٠١ | ١.٥٤ | ٨٦.٤ |
| | Control | ٢.١٤ | ٠.٢١ | ٢.٨٢ | ١.٢١ | ٠.٨١ | ٥٣.٩ | ٢.١٦ | ٠.٢١ | ٢.٩٦ | ١.١٧ | ٠.٧٦ | ٥٨.٦ |
| LSD at 5% | | ٠.٤٢ | ٠.٠٥ | ٠.٣١ | ٠.٢١ | ٠.١١ | ٥.٤ | ٠.٣٩ | ٠.٠٦ | ٠.٢٧ | ٠.٢٠ | ٠.٠٧ | ٤.١ |

Concerning the specific effect of the interaction the same data in Table 4 indicate that there were significant differences in all estimated elements as a result of the interaction treatments. In this respect, spraying cabbage plants with dissolved nutrients and antioxidants in cold water significantly reflected the highest values in all determined chemical elements. Moreover, using cold water combined with amino acids recorded the highest values in total nitrogen and phosphorus percentage in both seasons. While, using cold water combined with potassium oxide, chelated calcium, micronic sulphur and boric acid recorded the highest content of potassium, calcium, sulphur and boron, respectively in both seasons of study.

Generally, some of the applied treatments especially those of amino acids and some extend salicylic acid exhibited many positive effects in the studied growth aspects, e.g., number of outer green leaves (Table,1). That is prolonged to other growth aspects including the chlorophyll content. This growth enhancement and performance (Table, 2) was prolonged to the improvement of quality characteristics e.g., total sugars, total carbohydrates and vitamin C (Table, 3). Also, different estimated nutrient elements were positively responded (Table, 4). With regard to that above mentioned unique and obvious active effects of amino acids treatment upon difference estimated or measured growth characteristics could be attributed to the facts that of these amino acids is the tryptophan the main precursor for indole acetic acid (IAA) biosynthesis (Taiz and Ziger,2002). Here, shoot apical meristems and young leaves are primary sites of auxin synthesis in which exhibit apex-base structural polarity, and this structural polarity is dependent on the polarity of auxin transport (Salisbury and Ross, 1992). Because, the auxin is the only plant hormone that has been clearly shown to be transported polarly through the vascular parenchyma tissues most those likely associated with the xylem (Vince, 2011). So, the main auxin route or passage from the site of synthesis (i.e., terminal inner shoot bud is the medvin of the leaves and because the fact that unique amount of auxin on both medvin sides due to the light intensity on the both (Hopknis and Huner, 2009).

This situation, makes auxin with its low amount on the outside of medvin more active for cell division and elongation more than in the inhibitor high level of auxin on the inner side leading to the overlapped leaves when they go in growth. Also, studies have been recommended that several compounds are synthesized that can act as auxin transport inhibitors including NPA (1-N- naphthylphtalomic acid), TIBA (2,3,5-triidabenzoic acid), GDP (2- carboxyphenyl -3-phenyl propane-1.3-dione), flavonoids, .etc . (Aloni *et al.*, 2002)

Finally, by applying such safe, natural and low cost treatments i.e., antioxidants, amino acids and cold water in very low temperature) it could be strongly admit economically the use of these treatments to improve growth and productivity of this leafy and most popular plant under high temperature.

## Acknowledgment

Thanks a lot to Prof Dr. Said Ali El-Desoukey Prof of plant physiology Botany Dept. Faculty Agric. Benha University and prof Dr. Fathy A. Abo Sedera prof of vegetables Horticulture Dept., Benha University helping us during this work.

## REFERENCES

A. O.A. C. 1990. Official Methods of Analysis. Association of Official Analytical Chemists. 15th ed. Washington, D.C, U.S.A.

Aloni, R., K. Schwalm, M. Langhans and C.I. Ullrich. 2002. Gardual shifts in sites and levels of auxin synthesis during leaf primordium development and their role in vascular differentiation and leaf morphogenesis in Aradopsis. Monuscript submitted for puplication.

Black, C.A., D.O. Evans, LE. Ensminger, J.L. White, F.E. Clark and R.C. Dinauer .1982. Methods of soil analysis. part 2. Chemical and microbiological properties. 2nd Ed. Soil Sci.,Soc. of Am. Inc. Publ., Madison, Wisconsin, U. S.A.

Brown, J. and O. Lilleland. 1946. Rapid determination of potassium and sodium in plant material and soil extracts by flame photometric. Proc. Amer. Soc. Hort. Sci., 48: 341- 346.

Chapman, H.D. and P.F. Paratt.1961. Methods of Soil, Plants and Water Analysis. Univ. California, Div. Agric. Sci., 314p.

Chen, Z. and D.R. Gallie. 2006. Dehydro ascorbate reductase affects leaf growth development and function. Plant. Physiol., 142(2):775-787.

Eid, M.A. 2011. Effect of mineral and organic nitrogen fertilization and K-humate addition on soil properties (Orchard field experiment). J. Of American Sci., 7(5):1014-1022 .

Ganie, M.A., F.M.A. Akhter, M.A. Bhat, A.R. Malik and T.A. Bhat 2013: Boron- a critical nutrient element for plant growth and productivity with reference to temperate fruits. Curr. Sci., 104:76-85.

Ghosh , S.P. and D.L. Madhavi 1998. Science and Technology. Production, composition, storage and processing salunkhe , D.K and Kadam , S.S.(Eds.) Marcel Dekker , inc. New Yourk.

Goldbach, H.E. and M.A. Wimmer. 2007. Boron in plants and animals: Is there a role beyond cell-wall structure? J. Plant Nutr. Soil Sci., 170: 39-48.

Goldbach, H.E., D. Hartmann and T. Rotzer.1990. Boron is required for the stimulation of the ferricyanide-induced proton release by auxins in suspension-cultured cells of *Daucus carota* and *Lycopersicon esculentum*. Physiol. Plant., 80: 114-118.

Herbert, D., P.J. Phipps and R.E. Strange. 1971. Determination of total carbohydrates, Methods in Microbiology, 5 (8): 290-344.

Hoel, B.O. and K.A. Solhaug.1998. Effect of irradiance on chlorophyll estimation with the Minolta SPAD-502 leaf chlorophyll meter. Annals of Botany - London 82: 389 – 392.

Hopkins, W.B. and N.P.A. Huner. 2009. Introduction to plant physiology, 4th edition, John Wiley and sons Inc., Hoboken ,USA.

Hunashikatti, M. G., H. T. Channal, P. A. Sarangamath, H. M. Manjunathaiah and P. R. Dharmatti. 2000. Effect of sulphur and molybdenum on yield and quality of cabbage. Fertiliser News, 45(8):53-55.

Iqbal, R. K., M. Fatma, T. S. Per, N.A. Anjum and N. A. Khan. 2015. Salicylic acid-induced abiotic stress tolerance and underlying mechanisms in plants. Front. Plant Sci.,64:1-17.

Jackson, M.L., 1973. Soil Chemical Analysis. Printice-Hall of India. Privat Limited, New Delhi.

John, M.K. 1970. Colorimetric determination of phosphorus in soil and plant material with ascorbic acid. Soil Sci., 109: 214-220.

Marschner, H. 1997. Mineral Nutrition of Higher Plants. 2nd ed. San Diego: Academic Press,379-396.

Pregl, E. 1945. Quantitative organic micro analysis. 4th Ed. J. Chundril, London.

Rai, V.K. 2002. Role of amino acids in plant responses to stresses. Biologia Plantarum, 45(4): 481-487.

Ramadan, M.El. 2012. Effect of sulphur, Magnetite and potassium humate on productivity and quality of cabbage under Ras Seder conditions. Ph.D. Thesis, Dept. Hort., Fac. Agric. Ain shams Univ.

Rowell, D. L. 1995. Soil Science methods and application data. Library of Congress cataloging publication data. New York, NY1058.USA.

Salisbury, F.B. and C.W. Ross. 1992. Plant physiology, Wadshwarth publishing comp., Smith, k. 1995. Keith Smith's classic vegetable catalogue, Thomas C., Lothian (Pty) Ltd. Port Melburne, Austra.

Snedecor, G. W. and W.G. Cocharn. 1991. Statistical methods. 8th Ed., lowa State Univ. press, Lowa. USA.

Sauaina, A. and N.B. Singh. 2014. Effect of salicylic acid on cabbage (*Brassica oleracea var.capitata*) grown under salinity stress. Iranian J. Plant Physioliogy, 4(4):1109-1118.

Taiz L. and E. Zeiger. 2002. Plant physiology, pup:Sinauer Associates , third edition .90 pp. Auxin the growth hormone (pp :423-460).

Tiwari, H.N., P.K. Singh and P.K. Mal. 2003. Effect of drip irrigation on yield of cabbage (Brassica oleracea var. capitata L.) under mulch and non-mulch conditions. Agriculture Water Manag., 58:19-28 .

Unlu, H.O., H. Unlu, Y. Kara Kurt and H. Padern. 2011. Changes in fruit yield and quality in response to foliar and soil humic acid application in cucumber. Sci. Res.and Essays.6(13):2800-2803.

Vince, O. 2011. plant physiology. created by XML mind XSL-FO converted cover plant physiology. Zoltan Mohar AZ Agrarmerroki . MSC szak tananyagfejlesz tese TAMOP-4.1.2-08/1/A-2009-0010 projekt.

Yadav, H., M.A.Shekh, S.S. Takar and B.S. Kherawat. 2013. Effect of phosphorus and sulphur on content, uptake and quality summer soybean. Int. J. Agric. Sci. 9: 91-94.

## تقليل تأثير درجة الحرارة المرتفعه على نباتات الكرنب الناميه فى العروة الصيفيه بإستخدام بعض المغذيات،مضادات الاكسدة والاحماض الامينيه رشا مع الماء البارد.

**مصطفى حمزة محمد محمد و رضا محمد يوسف زويل***
**قسم البساتين –كلية الزراعة جامعة بنها**
***قسم النبات الزرعى –كلية الزراعه –جامعة بنها**

أجريت تجربتان حقليتان بمزرعة الخضر بكلية الزراعه جامعة بنها خلال موسمى النمو ٢٠١٤،٢٠١٥ لدراسة تأثير اكسيد البوتاسيوم بتركيز ٢جم/لتر،الكالسيوم المخلبى بتركيز ٢جم/لتر،الكبريت الميكرونى بتركيز ٥جم/لتر، حمض البوريك، بتركيز ١٠٠مجم/لتر حمض السالسيلك، بتركيز ١٠٠مجم/لتر حمض الستريك بتركيز ٢جم/لتر الاحماض الامينيه بتركيز ٢مل/لتر على نمو وأنتاجية نباتات الكرنب النامية فى العروة الصيفية جميع المعاملات تم أذابتها فى الماء البارد ٤ ±١ والماء العادى ٣٠±١ .أدت المعاملات المختلفة الى تحسين النمو وأنتاج روؤس الكرنب متضمنا بعض صفات الجودة .المعاملة بالماء البارد أدت الى حدوث زيادة معنويه فى التفاف اوراق الكرنب بالاضافة الى زيادة الوزن الطازج للروؤس.كما أدت معاملات المغذيات ،مضادات الاكسدة والاحماض الامينيه مخلوطه مع الماء الباردة الى زيادة معنويه فى صفات النمو والانتاجية.والنتائج تؤكد الاهمية التطبيقية للمعاملات مع تقليل التكلفة المسستخدمه لزيادة أنتاجية الكرنب تحت ظروف الحرارة المرتفعه فى العروة الصيفية. والنتائج المتحصل عليها تؤكد أهمية المعاملات فى زيادة انتاجية الكرنب وتحسين جودته وقيمته الغذائيه.