ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 45(1): 293-306, (2007).

PLANT FRESH WEIGHT, NITROGENOUS FRACTIONS AND SHELF-LIFE OF FRESH-CUT SALADS OF CABBAGE AS AFFECTED BY MICRONUTRIENTS APPLICATIONS

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ABSTRACT

Two field experiments were conducted during November to January 2004/2005 and 2005/2006 on cabbage (*Brassica oleracea* var. *capitata* L.) to study the effect of soil and foliar applications of boron, molybdenum and zinc individually and their combination on nitrogenous fractions of fresh-cut salads of cabbage, shelf-life and plant fresh weight. The response of cabbage plants to micronutrients at 30, 60 and 90 days after transplanting was determined. The results showed that the concentration of nitrogenous fractions, i.e., total nitrogen, soluble nitrogen and insoluble nitrogen, were at a maximum in the early stage of plant growth. The concentrations of total free amino acids and phosphate buffer soluble protein, however, were found to be highest in the latter growth stages. This shows that the accumulation of nitrogenous fractions in the active growth stages of plants are converted to amino acids and proteins. The activities of nitrate reductase and protease were increased at 60 days after transplanting and depleted at 30 and 90 days after transplanting. Long shelf-life of fresh-cut salads was recorded under both soil and foliar application of zinc-sulphate, it was more than 10 days compared to untreated plants which was 5 days. The highest values of plant weight were obtained under foliar applications, especially with boron and when the micronutrients were in combination.

INTRODUCTION

Micronutrients play specific roles that enhance the production of vegetable crops. Wallace and Romney (1997) reported that due to synergistic trace metal effects in plant, any individual trace element, when supplied at low or high quantity, affects the concentration of other elements in plants. Among the micronutrients, zinc (Zn) has become increasingly significant in crop production (Latha and Reddy, 2001). Zinc is a constituent of several enzymes that are very important for various metabolic processes of plant.

Boron (B) is a membrane integral and helps in cell wall development, cell division, cell extension and pollen tube growth (Tandon, 2002). Boron deficiency can usually be detected in the growing points of roots, shoots, and youngest leaves of deficient plants (Duffek, 2004).

Molybdenum (Mo) is a component of metaprotein nitrogenase and helps in N_2 fixation. Molybdenum is also essential in symbiotic nitrogen fixation and in the reduction of nitrate nitrogen to the amine form. Thus, Mo deficiency can cause nitrogen deficiency in plants (Gupta and Vyas, 2004).

The present study investigated the effect of various concentrations of B, Mo and Zn on plant fresh weight, total nitrogen (TN), soluble nitrogen (SN), insoluble nitrogen (IN), total free amino acids (TFAA), phosphate buffer soluble protein (PBSP), nitrate reductase (NR), protease (PR) activity and shelf-life of fresh-cut salads of cabbage (*Brassica oleracea var. capitata L.*).

MATERIALS AND METHODS

Two field experiments were conducted in Nubaria area, Alex-Desert Road, during the November to January of 2004/2005 and 2005/2006 to test the effect of micronutrients on plant weight, various nitrogenous fractions and shelf-life of fresh-cut salads of cabbage.

In both seasons, seeds of cabbage (*Brassica oleracea* var.*capitata* L. cv. Balady) (local Egyptian cultivar) were sown on mid-September in both seasons and transplanting was carried out at 3-4 leaf stage (50 days later). The chemical and physical properties of the soil, according to methods described by Black, (1965) are shown in Table (1). The analysis of irrigation water, using the methods reported by Chapman and Pratt (1961) are shown in Table (2). Drip irrigation water was used in both seasons.

Table (1): Physical and chemical characteristics of the site experimental soil.

Season	Physical properties				Chemical properties				
	Clay %	silt %	Sand %	Texture	pH	EC (ms)	Soluble cations (Meq $^{L-1}$)		
							Na+	Ca^{2}+	Mg^{2}+
2004/2005	8.15	4.27	87.58	Sandy	8.1	2.08	11.11	4.32	2.52
2005/2006	10.78	7.29	81.93	Sandy	8.1	2.15	11.23	4.43	2.60

Soluble anions					
	SO_4	CL	CO_3+HCO_3	$CaCO_3$ %	O.M. %
2004/2005	11.68	7.61	2.92	3.96	0.25
2005/2006	11.92	7.63	3.16	4.02	0.23

Table (2): Physical and chemical characteristics of the irrigation water used.

Season	pH	EC Ds/m	K_2O ppm	CaO ppm	MgO ppm	Na Meq/L	CO_3 Meq/L	HCO_3 Meq/L	SO_4 ppm	Cl Meq
2004/2005	8.2	1.81	6.13	41.73	19.7	15.6	0.5	2.6	115	9.27
2005/2006	8.1	1.74	5.91	40.67	18.6	14.6	0.5	2.8	123	10.31

The experimental plots were laid out in a randomized block design with four replications each with a plot area of 26.25 m^2, containing 5 rows, each 7m long and 0.75m wide, and plants were spaced 30cm apart. At the time of soil preparation, 20m^3/fed of farm- yard manure were added 20 cm deep under plant rows along, mixed with 300 kg calcium superphosphate, 100kg potassium sulfate and 100kg/fed. ammonium nitrate. All agricultural practices took place as recommended for cabbage production.

Treatments:

Boron, Mo, Zn and their mixture (TM) were applied on the soil and foliage at different stages of plant development of cabbage (*Brassica oleracea* var. *capitata* L.) as following:

A- Soil application:

T_1 Control (without micronutrients).
T_2 B-borax, 10 kg/fed.
T_3 Mo-ammonium molybdate, 8 kg/fed.
T_4 Zn-zinc sulphate, 5kg/fed.
T_5 TM_1-their mixture.

Application of these micronutrients on soil was done before transplanting. As recommended by ministry of agriculture, each of these micronutrients to be more efficient and regular distribution along planting rows, was mixed with 1m^3 of sandy soil collected from the same site of the present study.

B- Foliar application:

Foliar application was done at 25 and 50 days after transplanting (DAT) using the tested micronutrients, i.e., B, Mo, Zn and their mixture at 10, 15, 50 and 75ppm in the form of Boric acid ($H_3 BO_4$), molybodic acid ($Mo O_3$), and zinc sulphate ($Zn SO_4 . 7H_2O$), as well as their mixture (TM_2). They were T_6, T_7, T_8, and T_9, respectively. Each experimental unit was received 5L solutions of each concentration using spreading agent (Super film at 1cm/L).

Data recorded:

A- Nitrogenous fractions:

1- Nitrogen content:

The content of total (TN), soluble (SN), as well as insoluble nitrogen (IN), in the leaves of cabbage were determined at 30, 60 and 90 DAT by following the microkjeldahl method of Lang (1958). The amounts were calculated by comparing with standard curve of $(NH4)_2 SO_4$.

2- Total Free Amino Acids (TFAA):

The estimation of TFAA was done by the method of Yemm and Cooking (1955). The amount of TFAA was calculated with the help of a calibration curve prepared from glycine and is expressed as mg amino acids per g dry weight of the sample.

3- Phosphate Buffer Soluble Proteins (PBSP):

The PBSP was estimated in fresh leaves at 30, 60 and 90 DAT by following the method of Lowery *et al.* (1951).

4- Nitrate Reductase (NR):

Studies of NR enzyme activities were conducted with the modification of the methods given by Hagemen and Hucklesby (1971). The NR activities were calculated in terms of m mol NO_2 produced g/fresh leaf weight. The NO_2^- value was calculated from a standard curve drawn from sodium nitrite ($NaNO_2$).

5- Protease enzyme activity (PR):

The PR enzyme activity was assayed with the modified method given by Mahadevan and Sridhar (1982). The enzyme activity was calculated by using a standard curve prepared from tryptophan.

B-Plant weight:

At apparent market maturity, 100 days after transplanting, 10 cabbage plants per each experimental unit were chosen randomly, and harvested with their intact leaves, weighed and average plant weight was determined.

C- Shelf-life of processed cuts:

According to methods described by Stephen (1996), on the second day of harvest, all processing operations and practices took place as recommended for fresh-cut salad production. Under recommended conditions of cold temperatures for fresh-cut salads of cabbage (5 ^{0}c), shelf-life of processed salad products (15 samples/each experimental unit) was recorded throughout 15 days. Data were recorded daily (twice/a day) in the morning and in the evening on defected and non-defected processed samples. Average of number of days for free and non-defected treatments was recorded. The defected treatments included brown spots, yellowish, oxidation, microbial and fungus activity....etc.

The obtained data were subjected to the analysis of variance proposed by Gomez and Gomez (1976). Differences were indicated to be significant at a 5% level and means were separated by the LSD test.

RESULTS AND DISCUSSION

A-Nitrogenous fractions:

Nitrogen is one of the important elements occurring in all living organisms. It is a component of amino acids, proteins, nucleic acids and other organic compounds.

1- Nitrogen content:

The content of TN in the dry leaves of tested plants were variable. In the earlier (30 days) and later (90 days) developmental stage, the highest TN values were 1.66 mg/g and 1.20 mg/g, respectively, and occurred when the plants received the treatment T_9 (total micronutrient foliar spray). At 60 DAT, the highest TN concentration was observed in the plants treated with molybdenum as a foliar spray (T_7) and plants growing in soil receiving Zn. The lowest TN concentration was recorded by plants in T_1 (control) plants in all age groups (Table 3).

Table (3): Effect of boron, molybdenum, zinc and total micronutrients on total nitrogen content at different stages of cabbage.

Treatments	Content of total nitrogen (mg/g leaf dry wt) Plant age (days)					
	30		60		90	
	2004/5	2005/6	2004/5	2005/6	2004/5	2005/6
T_1	0.75	0.77	0.63	0.65	0.48	0.48
T_2	1.59	1.60	0.74	0.70	0.64	0.60
T_3	1.37	1.42	0.75	0.76	0.77	0.77
T_4	0.94	0.90	1.03	1.08	0.61	0.59
T_5	1.15	1.10	0.85	0.87	0.61	0.61
T_6	1.10	1.07	0.62	0.57	0.65	0.66
T_7	1.11	1.10	0.97	0.95	0.63	0.60
T_8	1.55	1.53	0.80	0.75	1.04	1.02
T_9	1.62	1.66	0.87	0.84	1.15	1.20
LSD at 5%	**0.06**	**0.05**	**0.03**	**0.04**	**0.02**	**0.03**

Soluble nitrogen was, in general, the highest with all the treatments including control plants at 30 DAT and it was gradually decreased at 60 and 90 DAT. The maximum concentration occurred with T_3 (0.77mg/g); that is Mo soil treated plants. The concentration was significantly higher than control plants at 30 DAT. At 60 DAT, the highest SN concentration (0.45mg/) was recorded in T_4 (Zn soil treated). At the later stage (90 DAT), TM_2 through foliar spray of micronutrients mixture resulted in the highest SN concentration (0.48 mg/g) over the other treatments (Table 4).

Table (4): Effect of boron, molybdenum, zinc and total micronutrients on soluble nitrogen content at different stages of cabbage.

Treatments	Content of soluble nitrogen (mg/g leaf dry wt) Plant age (days)					
	30		60		90	
	2004/5	2005/6	2004/5	2005/6	2004/5	2005/6
T_1	0.31	0.32	0.22	0.23	0.16	0.15
T_2	0.65	0.68	0.29	0.27	0.21	0.18
T_3	0.75	0.77	0.32	0.35	0.30	0.32
T_4	0.42	0.39	0.42	0.45	0.22	0.23
T_5	0.51	0.48	0.36	0.37	0.28	0.26
T_6	0.62	0.62	0.27	0.25	0.31	0.34
T_7	0.37	0.38	0.41	0.39	0.26	0.25
T_8	0.67	0.69	0.35	0.33	0.42	0.41
T_9	0.73	0.74	0.40	0.39	0.46	0.48
LSD at 5%	**0.16**	**0.15**	**0.11**	**0.12**	**0.13**	**0.14**

The concentration of IN was highest with T_2 (0.94mg/g), B soil treated plants at 30 DAT. At 60 DAT, the highest concentration (0.63mg/g) was obtained with T_4 (Zn soil treated) and at 90 DAT, the maximum amount (0.72 mg/g) was recorded with T_9 (TM_2 foliar spray) (Table 5).

Table (5): Effect of boron, molybdenum, zinc and total micronutrients on insoluble nitrogen content at different stages of cabbage.

Treatments	Content of insoluble nitrogen (mg/g leaf dry wt) Plant age (days)					
	30		60		90	
	2004/5	2005/6	2004/5	2005/6	2004/5	2005/6
T_1	0.44	0.45	0.41	0.42	0.32	0.33
T_2	0.94	0.92	0.45	0.43	0.43	0.42
T_3	0.62	0.65	0.43	0.41	0.47	0.45
T_4	0.52	0.51	0.61	0.63	0.39	0.36
T_5	0.64	0.62	0.49	0.50	0.33	0.35
T_6	0.48	0.45	0.35	0.32	0.34	0.32
T_7	0.74	0.72	0.56	0.56	0.37	0.35
T_8	0.88	0.84	0.45	0.42	0.62	0.61
T_9	0.89	0.92	0.47	0.45	0.69	0.72
LSD at 5%	**0.14**	**0.15**	**0.12**	**0.13**	**0.13**	**0.14**

Similar results were obtained by Bose *et al.*(1992), they reported that the higher production of SN, IN and TN was in the test plants treated with micronutrients as foliar spray and soil application. This might be due to the key roles played by these micronutrients in the indispensable vital role of physiological process of growth. Moreover, the increase of nitrogen led to an increase in photosynthetic rate that might increase photosynthetic products in the plants. Increased N_2 might result in the increased rate of protein synthesis, which ultimately results in larger amounts of tissue formation, and more large leaves, which are the chief organs of photosynthesis. Also, Singh and Joshi (2001) reported that at the early stages of growth, the plants required B, Mo and Zn. Boron influences cell development by the control it exerts on polysaccharide formation and the formation of starch by combining with the active site of phosphorylase.

Due to Zn deficiency the concentration of protein nitrogen decreased and resulted in an accumulation of SN. In this respect, Cocucci and Rossi (2002) observed decreased levels of protein under zinc deficiency suggesting its involvement in protein synthesis.

2- Total Free Amino Acids (TFAA):

The level of TFAA in the dry leaves of treated plants was measured at 30, 60 and 90 DAT. At 30 DAT, the maximum concentration was obtained with T_4 (1.51 mg/g), Zn soil treated plants, at 60 DAT, with T_3 (1.81), Mo soil treated plants at 90 DAT with B treated soil (T_2) (1.77 mg/g). It seems that at different stages of plant growth, these three micronutrients play very important roles in plants (Table 6).

Table (6): Effect of boron, molybdenum, zinc and total micronutrients on total free amino acids content at different stages of cabbage.

Treatments	Content of total free amino acids (mg/g leaf dry wt) Plant age (days)					
	30		60		90	
	2004/5	2005/6	2004/5	2005/6	2004/5	2005/6
T_1	0.60	0.61	0.46	0.45	0.76	0.77
T_2	0.94	0.92	0.97	0.98	1.75	1.77
T_3	0.66	0.65	1.79	1.81	0.78	0.79
T_4	1.51	1.49	0.85	0.88	0.96	0.98
T_5	1.37	1.36	1.70	1.71	1.00	1.01
T_6	1.15	1.13	1.32	1.31	0.62	0.64
T_7	0.95	0.92	1.26	1.22	0.94	0.98
T_8	0.98	0.96	1.61	1.63	1.24	1.28
T_9	1.39	1.35	1.70	1.69	1.11	1.13
LSD at 5%	**0.18**	**0.17**	**0.13**	**0.14**	**0.15**	**0.16**

As Bould *et al.* (2003) mentioned that amino acids are the basic structural units of protein. They contain both amine and carboxylic acid as functional groups. Amino acids are synthesized within tissues from their appropriate precursors. Free amino acids are products of assimilation and photosynthesis. They were considered useful indicators, especially in foliar diagnosis.

In the present investigation, the highest amount of TFAA was recorded with T4 (5 kg of Zn/fed.), T3 (10 kg of Mo/fed.) and T2 (10 kg of Bc/fed.) with values higher than the control at 30, 60 and 90 DAT, respectively (Table 6). The present finding reveals that individual micronutrients have more pronounced effect on the production of TFAA, than that of synergistic actions of TM. The present results are in conformity with the findings of Ashmead *et al.* (1986), they reported that this is might be due to the invigorating role of individual micronutrients at different stages of physiological and biochemical life processes.

Considerable information is available on the binding of amino acids with Zn and other trace elements. Due to Zn application, as Zn SO4, to soil (T3), protein content increased to some extent. A possible reason may be that Zn is involved in protein synthesis. A similar trend was also observed by Thalooth *et al.* (1989). They also reported that Zn-metalloproteins are also available and many Zn containing protein and many alcohol dehydrogenises are found in the early periods of cabbage growth and Zn is involved in protein production.

Bould *et al.*(2003) reported that insufficient amounts of B result in abnormalities in flowering, fruiting and other subsequent development. Boron has a special function in reproduction and reproductive growth. It is required throughout the growth of the plant. Boron is clearly required for the formation of tissues but apparently in not required for the maintenance of tissues already matured. Actively growing plants require larger amounts of B than do slow growing plants.

Sharma and Minhas (2005) found that in the middle growth stage of leguminous plants, Mo is required for N_2 fixation and continues the process of reduction of nitrate nitrogen to the amine form. Thus Mo deficiency may result in deficiency of nitrogen in plants.

3- Phosphate Buffer Soluble Proteins (PBSP):

All the treatments used as soil application or foliar spray with either the individual micronutrient or in combinations produced significantly higher protein contents.

The levels of PBSP in fresh leaves of tested plants increased up to 60 DAT and then decreased slightly at 90 DAT. The highest concentration was obtained with T_9 (TM_2 spray, 0.44 mg/g) at 30 DAT. At 60 DAT, the maximum level was recorded in T8 (0.93 mg/g) with Zn foliar-sprayed plants. A similar trend was also observed at 90 DAT with T8 (0.88 mg/g), in which the values were significantly higher than those for the control plants (Table 7).

In the present investigation, at 30 DAT, TM_2 applied as foliar spray (T9) shows maximum PBSP concentration compared to the control. The present result shows that cabbage requires a combination of micronutrients for synthesis of protein during its early stages. Again at 60 DAT, Zn sprayed plants (0.1% of Zn) showed maximum efficiency of protein synthesis (0.93mg/gfwt). Also, at 90 DAT, the highest protein concentration was observed on plants treated with Zn as a foliar application (Table 7). The findings show a significant effect of Zn in protein synthesis in cabbage. Zn is essential for the healthy growth of cabbage and gives a quality crop, when it is enriched in the plant Ghildiyal *et al.*, 1991). This is in conformity with findings of Muradidharudu and Singh (1999) on sesame and Sharma and Minhas (2005) on soybean.

4- Nitrate Reductase (NR):

The levels of NR was increased from 30 to 60 DAT, followed by a sharp decline at 90 DAT. Maximum NR activity occurred with T9 (TM_2 foliar spray) at 30 DAT. At 60 DAT, the highest activity was found in T3 (Mo soil treated). At 90 DAT the highest activity was observed in T7 (Mo foliar spray). The lowest activity was observed in control plants for all plant ages; 30, 60 and 90 DAT (Figure 1).

The NR is the first enzyme that converts NO_3^- into NO_2^-. Nitrate reductase is an inducible enzyme and is located in the cytosol. Hence, it is very likely that in the process of absorption, the agrochemical comes in contact with the NR present in the cytosol (Ghildiyal *et al.*, 1991). In the present study, the highest NR activity was found in T9, TM_2 (2.10 m mol/h/g), T3, Mo (2.62 m mol/h/g) and T8, Zn (1.43 m mol/h/g) at 30, 60 and 90 DAT, respectively, higher than control. The minimum NR activity was recorded in the control as 0.52 m mol/h/g, 0.93 m mo/h/g and 0.35 m mol/h/g at 30, 60 and 90 DAT, respectively (Figure 1).

Table (7): Effect of boron, molybdenum, zinc and total micronutrients on phosphate buffer soluble protein concentration at different stages of cabbage.

Treatments	Levels of phosphate buffer soluble protein (mg/g leaf fresh wt) Plant age (days)					
	30		60		90	
	2004/5	2005/6	2004/5	2005/6	2004/5	2005/6
T_1	0.20	0.21	0.47	0.43	0.41	0.43
T_2	0.25	0.24	0.62	0.64	0.60	0.61
T_3	0.32	0.33	0.79	0.77	0.64	0.62
T_4	0.21	0.22	0.64	0.61	0.61	0.64
T_5	0.22	0.25	0.65	0.67	0.59	0.56
T_6	0.27	0.24	0.71	0.72	0.69	0.67
T_7	0.28	0.29	0.85	0.88	0.80	0.81
T_8	0.37	0.39	0.93	0.92	0.49	0.46
T_9	0.42	0.44	0.63	0.61	0.88	0.87
LSD at 5%	0.12	0.13	0.17	0.16	0.16	0.17

The present finding indicates the indispensable role of micronutrients in combination for enhancing the production of NR in the early growth stage of cabbage. The activity of micronutrients changes from the combined effect to individuals as the test plant advances in age. During the middle stage Mo is more important in production of NR in cabbage. In the late growth stage the action of Zn dominates over the other micronutrients. This result stresses the key role of Zn in NR production. The findings are in agreement with results of Ghildiyal *et al.* (1991).

5- Protease enzyme activity (PR):

The PR activity in fresh leaves of plants was measured at 30, 60 and 90 DAT. The maximum activity was observed at 30 DAT, T7 (Mo foliar spray). At 60 DAT the highest activity occurred in T3 (Mo soil treated) and at 90 DAT in T2 (B soil treated) plants. The minimum activity was observed in control plants at all ages; 30, 60 and 90 DAT (Figure 2).

Protease is a complex group of enzyme varying in quality of their physiological and catalytic properties. They also play important roles in the catabolic and regulatory processes of eukaryotes and prokaryotes alike (Bose *et al.*, 1992). In the present investigation, the maximum PR activity was observed with T6 (0.94g/30 min/100g), T3 (1.55 g/30 min/100g) and T2 (1.48 g/30 min/100g) at 30, 60 and 90 DAT, respectively, more than the control value. The minimum activity occurred with T1 (0.72g/30 min/100g, 0.80 g/30 min/100g and 1.2 g/30 min/100g) at 30, 60 and 90 DAT, respectively (Figure 2).

Mayer and Poljakoff, (1998) reported that in the early and mature stage B is required for PR enzyme by the lettuce plants. Boron has been reported to increase cell permeability and to promote active salt absorption and photosynthesis. Protease activity makes amino acids available for the young seedlings. The proteolytic enzyme shows great diversity with respect to its specificity for peptide linkage and pH optima.

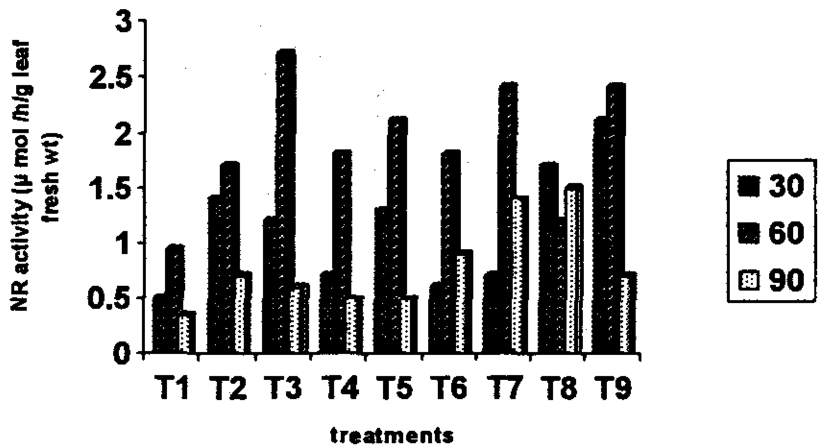

Figure (1): Nitrate reductase (NR) enzyme activity due to the application of micronutrients at different stages of cabbage.

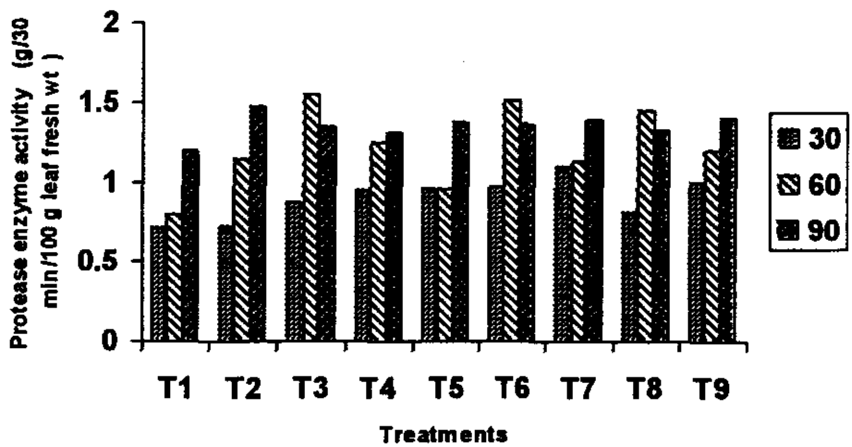

Fig. (2): Protease enzyme activity due to application of micronutrients at different stages of cabbage.

B- Plant fresh weight:

Data presented in Table (8) show that plant fresh weight was significantly affected by soil and foliar applications of micronutrients compared to untreated plants. The highest values were obtained in plants treated by micronutrients combinations at both soil and foliar applications, i.e., T_5 and T_9.

These results coincided with those reported by *Zaki et al.*(1979) on okra, Hassan (1982) on pea and beans, Attia *et al.* (1988) and Morsy (1992) on cantaloupe. They reported that vegetative growth was enhanced and plants responded positively to micronutrient application individually or in combination. Also, Tandon (2002)reported that B is a membrane integral and helps in cell wall development, cell division, cell extension and pollen tube growth and boron deficiency can usually be detected in the growing points of roots, shoots, and youngest leaves of deficient plants.

Table (8): Effect of boron, molybdenum, zinc and total micronutrients on cabbage plant weight and its shelf after processing operation.

Treatments	Plant weight (kg)		Shelf – life (days)*	
	2004/5	2005/6	2004/5	2005/6
T_1	0.865	0.813	5.3	5.1
T_2	1.215	1.183	7.8	7.3
T_3	1.023	1.101	8.1	8.3
T_4	0.981	0.957	10.7	10.3
T_5	1.547	1.492	8.9	8.5
T_6	1.203	1.187	9.9	9.4
T_7	1.176	1.098	12.9	12.2
T_8	1.503	1.456	12.8	12.1
T_9	1.609	1.638	12.8	12.6
L.S.D. at (0.05)	**0.193**	**0.196**	**1.3**	**1.2**

* Number of days after processing operation.

Recently, Duffek, (2004) on cabbage and lettuce plants reported that B influences cell development, increase cell permeability and promote active salt absorption and photosynthesis. Insufficient amounts of B result in abnormalities in flowering, fruiting and other subsequent development. It is required throughout the growth of the plant. Actively growing plants require larger amounts of B than do slow growing plants.

C- Shelf-life

Results presented in Table (8) indicate that shelf-life was strongly influenced by micronutrients application. Both soil and foliar application of zinc-sulphate resulted in long shelf-life for processed cabbage salads, it was more than 10 days compared to 5 days in untreated plants. This increasing in proper consumption period under this treatment may be due to activity of some enzymes and components against or with other enzymes and components as proposed by Tandon (2002). who reported that in the late growth stage of cabbage plants, the action of Zn dominates over the other micronutrients and this result stresses the key role of Zn in nitrate reductase production, whereas protease enzyme level was at minimum, thus result in growth inhibition of fungus and microbial in processed food. Also, Ghildiyal *et al.* (1991) reported that the highest protein concentration was observed on plants treated with Zn as a foliar application and the value increased to 95% over control, show a significant effect of Zn in protein synthesis in mustard and it is essential for the healthy growth of cabbage and gives a quality crop, when it is enriched in the plant. In the present investigation, similar results have been recorded as shown in figures, (1 and 2), nitrate reductase enzyme activity 90 DAT(closed to harvest) was at high level under T_8 treatment (foliar application of zinc), whereas this treatment resulted in low level of protease enzyme activity.

CONCLUSION

The present research illustrates the enormous potential effects of micronutrients can have in various vital reactions of physiological and biochemical processes in cabbage. The response of cabbage plants to various micronutrients plays an important role in the nitrogenous fractions, thereby giving a positive enhancement of qualitative and quantitative factors of the plant that result in good yields.

ACKNOWLEDGEMENTS

The present study mentioned in this article was supported by Blue Skies Products Co. It is a British Company located in Egypt for fresh-cut salads and juice. The author thanks all Technical Staff for their helping, especial thanks for Mr. George Hutton, the General Manager.

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الوزن الطازج للنبات والمكونات النيتروجينية لأوراق الكرنب المستخدمة فى السلاطة الطازجة ومدة صلاحيتها وتأثرها بالمغذيات الصغرى

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نفذت تجربتان حقليتان فى الموسم الشتوى للاعوام ٢٠٠٤/٢٠٠٥ ، ٢٠٠٥/٢٠٠٦ فى منطقة النوبارية وذلك لدراسة تأثير معاملة التربة قبل الشتل مباشرة أو رش نباتات الكرنب بعد ٢٥ ، ٥٠ يوم من الشتل بكل من البورون، والمولبدنيم، والزنك بحالة فردية أو خليط منهم على كل من المحصول والمحتوى الكيماوى للأوراق وعلاقة ذلك عند استخدامها فى أطباق السلاطة الطازجة ومدة بقاؤها بعد التصنيع فى صورة صالحة للاستهلاك. وكانت النتائج المتحصل عليها تتلخص فى الآتى:

أ- المحصول

- ادت كل المعاملات تحت الدراسة إلى زيادة معنوية فى وزيادة وزن النبات ، وذلك بالمقارنة بمعاملة الكونترول.
- كانت معاملة البورون رشاً هى الأفضل فى زيادة الوزن الخضرى للنبات .

ب- المحتوى الكيماوى للاوراق

- زاد محتوى الاوراق من كل من النيتروجين الكلى، النيتروجين الذائب والنيتروجين الغير ذائب فى كل النباتات المعاملة بالمقارنة بمعاملة الكونترول وكانت هذه الزيادة بدرجة اكبر فى المراحل الاولى من نمو النبات (بعد ٣٠ يوم من الشتل).
- زاد محتوى الاوراق من الاحماض الامينية الحرة الكلية فى المراحل الاخيرة من نمو النبات (٩٠ يوم من الشتل)، وهذا يؤكد ان المحتوى النيتروجينى للاوراق فى المراحل المبكرة تحول الى احماض امينية وبروتين فى المراحل الاخيرة من نمو النبات.
- زاد محتوى الأوراق من كل من انزيم "البروتيز"، وانزيم "نيتريت ريدوكتيز" فى المرحلة المتوسطة من عمر النبات (٦٠ يوم بعد الشتل) بالمقارنة بالمرحلة المبكرة او المتأخرة مما ساعد على تحويل المحتوى النيتروجينى فى الاوراق الى احماض امينية وبروتين التى لوحظت زيادتها فى المراحل الاخيرة.
- زادت فترة صلاحية الاوراق للاستهلاك الطازج واستعمالها فى السلاطة المبردة لتصل الى ١١ – ١٣ يوم بعد عملية التصنيع بالمقارنة بمعاملة الكونترول والتى وصلت الى ٥ ايام تصبح بعدها الاوراق المصنعة غير قابلة للتسويق الطازج وكان عنصر الزنك سواء كان رشاً أو معاملة التربة أكثر فعالية.

وتوصى الدراسة بمعاملة نباتات الكرنب بمخلوط يحتوي على كل من البورون، والزنك والمولبدنيم ــ لما لهذا المخلوط من آثار ايجابية فى زيادة المحصول بشكل عام، علاوة على زيادة محتوى الاوراق من الاحماض الامينية والبروتينات وزيادة مدة بقاءها في صورة صالحة للاستهلاك بعد التصنيع خاصة اذا ما تم استعمالها ضمن مكونات السلاطة الطازجة المبردة.