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EFFECT OF SOME AMINO ACIDS AND MINERAL NUTRIENTS TREATMENTS ON GROWTH AND PRODUCTIVITY OF ROSEMARY PLANT (*Rosmarinus officinalis*, L.)

BY

Youssef, A.S.M.
Hort. Dept., Fac. Agric., Moshtohor, Benha University, Egypt.

ABSTRACT

A two- year field trial was carried out during 2006 and 2007 seasons at the Experimental Farm, Horticulture Dept., of Agric Fac., Benha Univ., to study the effect of some amino acids i. e., tryptophan and glutamic acid each at 200 ppm and some mineral nutrients i. e., Fe, Zn, Mn and B each at 150 ppm on vegetative growth, essential oil and its main components as well as chemical constituents of rosemary plants. The obtained results showed that, different applied treatments of amino acids and/or mineral nutrients led to significant increase of growth parameters such as plant height, number, fresh and dry weights of branches/plant as well as fresh and dry weights of leaves/ plant. Interaction effect between amino acids and mineral nutrients obviously increased leaves total chlorophylls, total carbohydrates, N, P, and Kcontents of treated plants. In addition, the obtained vigrous growth of rosemary plants with different treatments was accompanied by pronounced increase in leaves volatile oil content. Moreover, volatile oil % was increased by spraying with all application of amino acids and mineral nutrients as well as their combination. Moreover, all tested treatments increased the total components of volatile oil, especially the combined treatment between tryptophan and Zn followed in descending order by the combined treatment between glutamic and Fe. Anyway, the major constituents of leaves volatile oil of rosemary were Camphene, 1,8-Cineole and Borneol, respectively. The highest value of 1,8-Cineole was observed in the combined treatment between glutamic and Zn as well as the highest recored of Borneol was obtained by the combined treatment between glutamic and Fe.

Consequently, it is preferable spray rosemary plants with tryptophan and glutamic each at 200 ppm as well as Fe and Zn each at 150 ppm and their combinations for enhancing growth and oil productivity.

Key words: Rosemary, tryptophan, glutamic acid, mineral nutrients, vegetative growth, oil productivity.

INTODUCTION

Nowadays, the extension of aromatic and medicinal plants cultivation to face the current demands of the foreign markets, has become urgent. This makes medicinal and aromatic plants of great importance as exportable crops and source of hard currency. Moreover, they offer the raw materials for some of our important industries such as; pharmaceutical, perfume and cosmetics, soap and food industries (Mostafa, 2006). Rosemary (*Rosmarinus officinalis*, L.) plants is a perennial plant, belongs to Family Laminaceae and grown in Egypt as ornamental plant. This plant is considering as one of the most valuable aromatic and medicinal plant. The herb of rosemary is a popular spice and its oil is used as a flavoring agent in many food and pharmaceutical industries. Fresh or dried leaves and oil are used as a tonic in the treatment digestive disorders, diuretic, aromatic, stomachic, carminative, antispasmodic, chalagogue. Antiseptioc, and emmenagogue. A leaf infusion has a wide variety of internal application as indicated. The oil may be used externally as an insect repellent in varous soothing embrocations and diluted as an antiseptic gargle and is particularly effective in neuralgia in meat dishes. The oil is also employed widely in the cosmetic industry. Leaves may be used in both mixtures and aromatic preparations and in meat dishes, (Guenther, 1961).

Many researches pointed out the importance of amino acids and nutrient elements in enhancing growth, yield and chemical composition of some economic plants among them, El-Sherbeny and Hassan (1987) on *Datura stramonium,* Mohamed (1992) on *Dahlia pinnata* plants, Gamal El-Din *et al.* (1997) on lemongrass plants, El-Khayat (2001) on *Hibiscus sabdariffa* plant, Wahabe *et al.* (2002) on *Antholyza aethiopica* plants, Youssef *et al.* (2004) on Datura plants and Balbaa and Talaat (2007) on rosemary plants. Tryptophan (a precursor of indole acetic acid) is known as growth regulating factor that influence many biological processes, Phillips (1971) suggested several alternative roles of IAA synthesis in plants, all starting from tryptophan, thus when tryptophan is supplied to most plant tissues, IAA was formed, Mohamed and Wahba (1993) stated that tryptophan at 100 ppm gave the highest oil content of *Rosmarinus officinalis* plants, Gomaa, (2001) found that, foliar spray of *Antholyza aethiopica* plants with some amino acids increased all growth and yield parameters and Balbaa and Talaat (2007) stated that, foliar spray with ascorbic acid, phenylalanine and ornithine at the concentrations 50, 100 and 150 mg/L. on rosemary plants increased plant height, number of branches/plant fresh and dry weights of herb/plant, N, P and K.% content of herb.

The role of iron is incorporated directly into the cytochromes, into compounds necessary to the electron transport system in mitochondria and into ferredaxin (Nason and Mc-Elory, 1963). Concerning iron, Mousa and El-Lakany (1984) indicated that, foliar application of iron to *Tagetes erecta* increased flower yield, weight and length of flower stalk, also Mohamed (1992) found that foliar spray with iron increased vegetative growth, flowering and carbohydrates content of *Dahlia pinnata* plants.

Zinc is one of the essential microelements for growth and flowering of plants (Chandler, 1982; Gomaa, 1997 and Youssef, 2000). Many investigatores reported the stimulating effect of applied micronutrients as soaking or foliar spray on growth and flowering of different ornamental plants; Mohamed (1985) found that Mn at 75 or 375 ppm. and Zn at 45 or 225 ppm. increased the vegetative growth, flowering and tubrous roots production of *Dahlia hybrida* cv. "Moon Light sonata". Andon (1973) concluded that foliar application of Mn and Zn to tobacoo and to hybrid petunia stimulated flower formation and seed production. Savva (1977) revealed that foliar application of Mn to *Dianthus chinensis* improved yields quality and seed yield. Mousa and El-Lakany (1984) indicated that foliar application of Fe, Zn and Mn to *Tagates erecta* increased flower yield, weight and length of flower stalk.

Boron caused a gradual hyperpolarization of the plasma membrane in root tips and stimulate boron secretion and the activity of plasma membrane NADH oxidase. Thus, boron could be directly associated with cell growth (Goldbach *et al.* 1990). Many investigators reported that stimulating effect of applied micronutrients as foliar spray on growth and flowering of different plants. Adams, *et al.* (1979) concluded that the application of boron to carnation cv. Willam Sim and Pink Sim increased number of flowers. Maharana and Pradhan (1980) stated that the application of boron to hybrid rose improved the number of leaves, shoots and flowers. Mohamed (1985) found that boron at (30 or 150 ppm) increased the vegetative growth, flowering, tuberrous roots production of Dahlia hybrida cv. Moon Light Sonata. Gomaa and Mady (2008) reported that spraying *Matricaria chamomilla* plants with boron at 50 and 75 ppm succeded in increasing growth parameters such as plant height, stem diameter, number, fresh and dry weights of branches and leaves/ plant. Moreover, oil % and oil yield/plant were increased.

The aim of the present study is to evaluate the effect of foliar spray with some amino acids and mineral nutrients treatments on growth, volatile oil content and chemical composition of rosemary (*Rosmarinus officinalis*, L.) plants.

MATERIALS AND METHODS

This experiment was conducted at the Experimental Farm and in the Laboratory of Horticulture Department Faculty of Agriculture at Moshtohor, Benha Univ., during 2006 and 2007 seasons to study the influence of some amino acids i.e., tryptophan (200 ppm) and glutamic acid (200ppm), some mineral nutrients i.e., Fe, Zn, Mn and B each at 150ppm as well as their combinations on vegetative growth, essential oil and its main components as well as chemical constituents of rosemary plants.

Rosemary seedlings were obtained from Floriculture Farm, Horticulture Department, Faculty of Agriculture, Benha Univ., then seedlings were transplanted in clay loam soils on mid March in both seasons in plots (1x1 m) containing two rows (50 cm. inbetween) each row contained two hills (50 cm. apart). Soil was directly irrigated to provide suitable moisture for growth. All the normal cultural practices for growing rosemary plants were followed as recommended in this region.

Mechanical and chemical analyses of the experimental soils are presented in Tables (a) and (b), mechanical analysis was estimated according to Jackson, (1973), whereas chemical analysis was determined according to Black *et al.* (1982).

Table (a): Mechanical analysis of the experimental soil.

Parameters	Unit	Seasons	
		2006	2007
Coarse sand	%	5.48	5.94
Fine sand	%	16.97	17.63
Silt	%	26.46	24.32
Clay	%	51.09	52.11
Textural class	----	Clay loam	Clay loam

Table (b): Chemical analysis of the experimental soil:

Parameters	Unit	Seasons	
		2006	2007
$CaCO_3$	%	1.77	1.85
Organic matter	%	1.57	1.82
Available nitrogen	%	0.86	0.97
Available phosphorus	%	0.11	0.13
Available potassium	%	0.68	0.73
E.C	ds/m	1.43	1.52
pH	----------	7.68	7.72

Experimental layout.

This experiment included 15 treatments were set up in a split plot design with three replicates. The main plots were sprayed with tryptophan and glutamic each at 200 ppm. Whereas, the sub plots were sprayed with Fe, Zn, Mn, and B each at 150ppm .All treatments of amino acids were applied as foliar spray at 50, 65 and 80 days after transplanting, respectively, whereas the treatments of mineral ntrition were applied as foliar spray at 55, 70 and 85 days after transplanting, respectively. Treated plants were sprayed till run off,whereas control plants were sprayed with tap water.

Data recorded.

In both seasons, two cuts were taken i.e., the first cut was taken in mid-August, whereas the second one was performed in mid-November. The following measurements were calculated in each cut as follow; plant height (cm.), number of branches/plant, fresh and dry weights of branches/plant (g), fresh and dry weights of leaves/plant (g). Also, total chlorophylls (a&b) was determined in the fresh leaves of rosemary plants according to the method described by A.O.A.C. (1980). The percentage of N,P,K, and total carbohydrates were determined in the dry matter leaves, whereas total nitrogen was determined using the modified MicroKieldahl method according to A.O.A.C. (1980). While, total carbohydrates percentage was determined according to Dubois *et al.* (1956). Leaves volatile oil percentage. The essential oil of each treatment was extracted by hydro-distillation according to Guenther (1961).

The GLC analysis of the leaves volatile oil (second cut) was carried out using Gas chromatograph, (Hewlett packard GC. Model 5890) equipped with a flame ionization detector (FID). A fused silica capillary (HP-5), (30 m length x 0.53 mm internal diameter (i.d.) x 0.88 um film thickness), was used for the separation in the GC. The identification of the different constituents was achieved by comparing their retention times with those of the authentic samples.

Statistical analysis.

The obtained data in both seasons of study were subjected to analysis of variance as a factorial experiment in split plot design. LSD method at 5% level was used to compare between means according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

Effect of amino acids and mineral nutrients treatments on growth and productivity of rosemary plants.

I- Vegetative growth measurements:

I-1- Plant height (cm):

Data in Table (1) show that all applications of amino acids i.e., glutamic and trypyohan each at 200 ppm significantly increased the height of rosemary plants as compared with control in both seasons with the superiority of tryptophan. This trend was true in both cuts of this study. Moreover, in the first and second cuts it was observed that all tested applications of mineral nutrients i.e., Fe, Zn, Mn and Boron each at 150 ppm succeeded in increasing plant height, especially Zn treatment when compared with control in both seasons. However, all applied combinations between amino acids and mineral nutrients caused a significant increment in this parameter in the first and second cuts as compared with control in most cases. This trend was true in both seasons. Anyway, the highest value of plant height was recorded by using the combined treatment between tryptophan and Zn. That was true in the two cuts in both seasons.

I-2- Branch parameters:

Data in Tables (1 & 2) indicate that number of branches/plant, fresh and dry weights of branches / plant were increased by using the treatments of amino acids. However, in the first and second cuts, the highest number of branches per plant was registered by glutamic treatment in both seasons, while the heaviest fresh and dry weights were obtained by tryptophan treatment in both seasons. Moreover, all tested applications of mineral nutrients showed significant increments of these parameters. Anyway, in the first and second cuts the highest values of branch parameters were gained by Fe treatment in both seasons as compared with control.

As for the interaction effect between amino acid and mineral nutrients, it was found that all combinations between amino acids and mineral nutrients in the first and second cuts led to an increase in the number, fresh and dry weights of branches per plant in both seasons. However, the highest number of branches per plant was recorded by the interaction between glutamic and Fe treatments, whereas the heaviest fresh and dry weights of branches per plant was obtained by the interaction between tryptophan and Fe treatments in both seasons.

Table (1): Effect of some amino acids and mineral nutrients treatments on plant height and number of branches/plant of *Rosmarinus officinalis* plant during 2006 and 2007 seasons.

Parameters	First season (2006)															
	Plant height (Cm.)								Number of branches/plant							
Amino acids / Mineral nutrients	First cut				Second cut				First cut				Second cut			
	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean
Control (0.0)	40.75	43.00	43.50	**42.41**	45.50	46.00	47.00	**46.16**	13.25	14.00	13.50	**13.58**	14.50	16.00	15.50	**15.33**
Fe at 150 PPm	47.75	50.75	51.25	**49.91**	53.25	54.00	56.00	**54.41**	15.75	16.75	16.00	**16.16**	16.75	19.25	17.75	**17.91**
Zn at 150 PPm	52.50	54.75	55.75	**54.33**	55.00	55.75	57.50	**56.08**	15.25	16.25	15.75	**15.75**	16.25	18.50	17.50	**17.41**
Mn at 150 PPm	45.75	47.25	47.75	**46.91**	49.75	50.25	51.25	**50.41**	14.75	15.75	15.25	**15.25**	15.50	18.25	16.75	**16.83**
B at 150 PPm	42.25	44.00	44.75	**43.66**	47.75	48.50	49.25	**48.50**	14.00	14.75	14.50	**14.41**	15.00	18.00	16.25	**16.41**
Mean	45.80	47.95	48.60		50.25	50.90	52.20		14.60	15.50	15.00		15.60	18.00	16.75	
LSD at 5% for	**Amino acids = 0.65**				**0.59**				**0.36**				**0.43**			
	Mineral nutrients = 0.68				**1.25**				**0.56**				**0.60**			
	Interactions = 1.54				**1.33**				**0.81**				**0.98**			
	Second season (2007)															
Control (0.0)	40.50	42.75	43.25	**42.16**	46.50	47.75	48.25	**47.50**	14.00	15.50	14.75	**14.75**	14.25	15.25	14.75	**14.75**
Fe at 150 PPm	45.25	47.25	48.00	**46.83**	51.25	52.50	53.50	**52.41**	15.75	18.75	18.00	**17.50**	16.50	18.75	18.00	**17.75**
Zn at 150 PPm	45.75	48.50	48.75	**47.66**	52.50	53.75	54.75	**53.66**	15.50	18.50	17.50	**17.16**	16.00	18.00	17.50	**17.16**
Mn at 150 PPm	44.50	46.25	46.75	**45.83**	50.25	51.00	52.75	**51.33**	15.25	18.00	17.25	**16.83**	15.75	16.75	16.50	**16.33**
B at 150 PPm	42.75	44.75	45.50	**44.33**	48.25	48.75	49.75	**48.91**	14.75	17.00	15.75	**15.83**	14.75	15.75	15.25	**15.25**
Mean	43.75	45.90	46.45		49.75	50.75	51.80		15.05	17.55	16.65		15.45	16.90	16.40	
LSD at 5%	**Amino acids = 0.38**				**0.40**				**0.46**				**0.40**			
	Mineral nutrients = 0.76				**0.79**				**0.67**				**0.45**			
	Interactions = 0.85				**0.91**				**1.04**				**0.91**			

G= Glutamic T= Tryptophan

Table (2): Effect of some amino acids and mineral nutrients treatments on fresh and dry weights of branches/plant of *Rosmarinus officinalis* plant during 2006 and 2007 seasons.

Parameters	First season (2006)															
	Fresh weight of branches/plant (g)								Dry weight of branches/plant (g)							
Amino acids	First cut				Second cut				First cut				Second cut			
Mineral nutrients	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean
Control (0.0)	39.75	40.50	42.00	**40.75**	43.50	46.50	48.00	**46.00**	7.95	8.10	8.40	**8.15**	9.14	9.77	10.09	**9.66**
Fe at 150 PPm	47.25	48.00	50.25	**48.50**	50.25	53.25	57.75	**53.75**	9.45	9.60	10.05	**9.70**	10.55	11.18	12.12	**11.28**
Zn at 150 PPm	45.75	47.25	48.75	**47.25**	48.75	52.50	55.50	**52.25**	9.15	9.45	9.75	**9.45**	10.25	11.02	11.65	**10.97**
Mn at 150 PPm	44.25	45.75	47.25	**45.75**	46.50	50.25	54.75	**50.50**	8.85	9.15	9.45	**9.15**	9.77	10.55	11.49	**10.61**
B at 150 PPm	42.00	43.50	44.25	**43.25**	45.00	48.75	54.00	**49.25**	8.40	8.70	8.85	**8.65**	9.45	10.25	11.34	**10.34**
Mean	43.80	45.00	46.50		46.80	50.25	54.00		8.76	9.00	9.30		9.83	10.55	11.34	
LSD at 5% for	**Amino acids = 1.09**				**1.31**				**0.21**				**0.27**			
	Mineral nutrients = 1.69				**1.81**				**0.25**				**0.31**			
	Interactions = 2.43				**2.94**				**0.33**				**0.38**			
	Second season (2007)															
Control (0.0)	42.00	44.25	46.50	**44.25**	42.75	44.25	45.75	**44.25**	8.40	8.85	9.30	**8.85**	8.97	9.29	9.61	**9.29**
Fe at 150 PPm	47.25	54.00	56.25	**52.50**	49.50	54.00	56.25	**53.25**	9.45	10.80	11.25	**10.50**	10.40	11.34	11.81	**11.18**
Zn at 150 PPm	46.50	52.50	55.50	**51.50**	48.00	52.50	54.00	**51.50**	9.30	10.50	11.10	**10.30**	10.09	11.02	11.34	**10.81**
Mn at 150 PPm	45.75	51.00	54.00	**50.25**	47.25	49.50	50.25	**49.00**	9.15	10.35	10.80	**10.10**	9.93	10.40	10.55	**10.30**
B at 150 PPm	44.25	49.50	51.75	**48.50**	44.25	45.75	47.25	**45.75**	8.85	9.90	10.35	**9.70**	9.29	9.61	9.93	**9.61**
Mean	45.15	50.25	52.00		46.35	49.20	50.70		9.03	10.08	10.56		9.74	10.33	10.65	
LSD at 5% for	**Amino acids = 2.01**				**1.22**				**0.28**				**0.25**			
	Mineral nutrients = 1.41				**1.37**				**0.33**				**0.28**			
	Interactions = 3.16				**2.74**				**0.40**				**0.39**			

G= Glutamic T= Tryptophan

I-3- Leaf parameters:

Data in Table (3) reveal that fresh and dry weights of leaves per plant were affected by all treatments of amino acids and mineral nutrients in both seasons. However, in the first and second cuts, glutamic and trypto-phan treatments succeeded in increasing the fresh and dry weights of leaves per plant with superiority for tryptophan treatment in both seasons. Moreover, all treatments of mineral nutrients statistically increased the fresh and dry weights of leaves per plant, especially the treatment of Fe in the first and second seasons. As for the interaction effect between amino acids and mineral nutrients, it was observed that all combinations between amino acids and mineral nutrients increased the fresh and dry weights of leaves per plant as compared with control in both seasons. Generally, the heaviest fresh and dry weights of leaves per plant in the first and seconed seasons were recoreded by the combined treatment between tryptophan and Fe in both seasons. This may be due to the combined effects of both tryptophan as a precursor of indole acetic acid which induces cell division and enlargement and glutamic as a growth promoters, in addition to the effects of the studied mineral nutrients which supplying the plant with the required nutrients necessary for healthy growth.

The aforementioned results of amino acids are in agreement with El-Sherbeny and Hassan (1987) on *Datura stramonium*, Gamal El-Din *et al.* (1997) on lemongrass plants, El-Khayat (2001) on *Hibiscus sabdariffa* plant, Wahabe *et al.* (2002) on *Antholyza aethiopica* plants, Youssef *et al.* (2004) on Datura plants and Balbaa and Talaat (2007) on rosemary plants, they stated that foliar spray with amino acids (phenylalanine and ornithine) at the concentrations of 50, 100 and 150 mg/L. increased plant height, number of branches/ plant fresh and dry weights of herb/plant. The abovementioned results of mineral nutrients are in conformity with those obtained by Gomaa and Mady (2008) they reported that spraying *Matricaria chamomilla* plants with boron at 50 and 75 ppm succeded in increasing vegetative growth parameters such as plant height, stem diameter, number, fresh and dry weights of branches and leaves/ plant.

I-4- Leaf volatile oil percentage:

Data in Table (4) show that the two amino acids treatments i.e., glutamic or tryptophan significantly succeeded in increasing leaves volatile oil percentage of rosemary plants and the superiority was for glutamic treatment in the first and second seasons. Also, all tested applications of mineral nutrients caused highly significant increment in this parameter, especialy Zn treatment, followed descendingly by Fe treatment in both seasons. Regarding the interaction effect between amino acids and mineral nutrients, it was noticed that all combinations of them increased leaves volatile oil content percentage as compared with control in both seasons. However, the highest leaves volatile oil content percentage was recorded by using the combined treatment between glutamic acid and Zn treatments in both seasons. This trend was true only in the first cut, while in the seconed one, the picture was completely changed, where tryptophan treatment surpased glutamic acid in this concern. Likewise, all studied treatments of mineral nutrients statisticaly increased leaves volatile oil content percentage, particularly Fe treatment, followed in descending order by Zn treatment in both seasons. In general the greatest leaves volatile oil content percentage in the second cut was obtained by using the combined treatment between tryptophan and Fe treatments in both seasons.

This may be due to the combined effects of both tryptophan as a precursor of indole acetic acid which induces cell division and enlargement and glutamic as a growth promoters, in addition to the effects of the studied mineral nutrients which supplying the plant with the required nutrients necessary for healthy growth.

The abovementioned results of amino acids are nearly similar to those obtained by Mohamed and Wahba (1993) they stated that tryptophan at 100 ppm gave the highest oil content of *Rosmarinus officinalis* plants, and Balbaa and Talaat (2007) they stated that, foliar spray with phenylalanine and ornithine at the concentrations of 50, 100 and 150 mg/L. on rosemary plants increased leaves volatile oil percentage. The aforementioned results of mineral nutrients are in parallel with those obtained by Gomaa and Mady (2008) they reported that spraying *Matricaria chamomilla* plants with boron at 50 and 75 ppm succeded in increasing oil % and oil yield/plant.

II- Gas chromatograms of rosemary leaves volatile oil distilled as affected by different amino acids and mineral nutrients treatments.

Data in Table (5) as illustrated in Figs (1 to 5) clearly indicat that GLC analysis of the volatile oil of rosemary revealed the presence of α –Pinene, Camphene, β- Pinene, Limonene, Y-Terpinene, 1,8 – Cineole, Linalool, Borneol, Bornyl acetate and Eugenol in all treatments. However, as shown in Table (5) all treatments increased the total components of volatile oil, especially the combined treatment between tryptophan and Zn followed in descending order by the combined treatment between glutamic and Fe. Anway, the highest main components of rosemary leaves volatile oil were Camphene, 1,8-Cineole and Borneol, respectively . The highest value of 1,8-Cineole was observed in the combined treatment between glutamic and Zn as well as the highest recored of Borneol was obtained by the combined treatment between glutamic and Fe.

III- Chemical composition determinations:

Data in Tables (4,6 and 7) declare that all tested treatments of amino acids and mineral nutrients increased some bioconstituents and NPK in leaves in both seasons. In this respect, the richest leaves total carbohydrates percentage and total chlorophylls contents were recorded by using the treatments of glutamic and Zn as well as their combination in both seasons as compared with control and the rest treatments. Such trend was true only in the first cut, whereas in the second cut, the picture was completely reversed, where the treatments of tryptophan, Fe and their combination showed to be the most effective treatments for inducing the highest values of leaves total carbohydrates percentage and total chlorophylls content in both seasons. As for leaves N, P, and K contents, data in Tables (6 and 7) revealed that leaves N, P, and K contents were greatly influenced by using all treatments of amino acids and mineral nutrients in both seasons. However, spraying rosemary plants with glutamic and Fe treatments as well as their combination approved to be the most pronounced treatments for producing the highest leaves N, P, and K contents in both seasons. This trend was true in the first and second cuts of this study.

This may be due to the combined effects of both tryptophan as a precursor of indole acetic acid which induces cell division and enlargement and glutamic as a growth promoters, in addition to the effects of the studied mineral nutrients which supplying the plant with the required nutrients necessary for healthy growth.

The effects of the studied mineral nutrients may be due to the role of iron as it incorporated directly into the cytochromes, into compounds necessary to the electron transport system in mitochondria and into ferredaxin. Ferredaxin is indispensable to the light reactions of photosynthesis. Iron is essential for the synthesis of chlorophyll and it plays an essential chemical role in both the synthesis and degradation of chlorophyll (Nason and Mc-Elory, 1963). Iron is required in the synthesis of chloroplast proteins. Protoporphyrinin-9 is one of the intermediates in chlorophyll biosynthesis and may represent a branch point in the biosynthesis of either cytochromes or chlorophyll. The synthetic path is dependent on which metal, magnesium or iron, is incorporated into the porphyrin structure (Granick, 1950).

Moreover, Zinc is one of the essential microelements for growth and flowering of plants (Chandler, 1982). It is recorded that zinc is essential at a specific concentration for sucrose synthesis (Takaki and Kusizaki, 1987) and production of auxin in plants. Zinc also is a part of enzymes participate in starch and protein synthesis (Amberger, 1974).

Table (3): Effect of some amino acids and mineral nutrients treatments on fresh and dry weights of leaves/plant of *Rosmarinus officinalis* plant during 2006 and 2007 seasons.

Parameters	First season (2006)															
	Fresh weight of leaves/plant (g)								Dry weight of leaves/plant (g)							
Amino acids / Mineral nutrients	First cut				Second cut				First cut				Second cut			
	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean
Control (0.0)	92.75	94.50	98.00	**95.08**	116.00	124.00	128.00	**122.66**	15.51	16.06	16.66	**16.08**	18.56	19.84	20.48	**19.62**
Fe at 150 PPm	110.25	112.00	117.25	**113.16**	134.00	134.50	154.00	**140.83**	18.71	19.02	19.92	**19.21**	21.44	22.69	24.64	**22.92**
Zn at 150 PPm	106.75	110.25	113.75	**110.25**	130.00	140.00	148.00	**139.33**	18.13	18.71	19.30	**18.71**	20.80	22.43	23.71	**22.31**
Mn at 150 PPm	103.25	106.75	110.25	**106.75**	124.00	134.00	146.00	**134.66**	17.55	18.13	18.71	**18.13**	19.84	21.44	23.40	**21.56**
B at 150 PPm	98.00	101.50	103.25	**100.91**	120.00	130.00	144.00	**131.33**	16.66	17.25	17.55	**17.15**	19.20	20.80	23.07	**21.02**
Mean	102.20	105.00	108.50		124.80	132.50	144.00		17.31	17.83	18.43		19.96	21.44	23.06	
LSD at 5% for	Amino acids = 2.54				4.43				0.43				0.56			
	Mineral nutrients = 2.93				5.12				0.50				0.64			
	Interactions = 3.96				5.18				0.72				0.76			
	Second season (2007)															
Control (0.0)	98.00	103.25	108.50	**103.25**	114.00	118.00	123.50	**118.50**	16.66	17.55	18.42	**17.54**	18.24	18.88	19.52	**18.88**
Fe at 150 PPm	110.25	126.00	131.25	**122.50**	132.00	144.00	150.00	**142.00**	18.71	21.42	22.31	**20.81**	21.12	23.02	23.99	**22.71**
Zn at 150 PPm	108.50	124.50	129.50	**120.83**	128.00	140.00	144.00	**137.33**	18.42	20.82	22.01	**20.42**	20.48	22.38	23.02	**21.96**
Mn at 150 PPm	106.75	120.75	126.00	**117.83**	126.00	132.00	130.00	**129.33**	18.12	20.52	21.42	**20.02**	20.16	21.12	21.44	**20.90**
B at 150 PPm	103.25	115.50	120.75	**113.16**	118.50	122.00	126.00	**122.16**	17.54	19.63	20.51	**19.23**	19.38	19.52	20.16	**19.68**
Mean	105.35	118.00	123.20		123.70	131.20	134.70		17.89	19.99	20.93		19.87	20.98	21.62	
LSD at 5% for	Amino acids = 7.47				3.13				0.57				0.49			
	Mineral nutrients = 8.44				3.44				0.65				0.56			
	Interactions = 8.62				3.97				0.80				0.61			

G= Glutamic T= Tryptophan

Table (4): Effect of some amino acids and mineral nutrients treatments on leaves volatile oil percentage and total carbohydrates percentage of *Rosmarinus officinalis* plant during 2006 and 2007 seasons.

Parameters	First season (2006)															
	Leaves volatile oil percentage								Total carbohydrates percentage							
Amino acids / Mineral nutrients	First cut				Second cut				First cut				Second cut			
	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean
Control (0.0)	0.242	0.252	0.245	**0.247**	0.250	0.257	0.263	**0.257**	17.00	18.00	17.50	**17.50**	17.75	18.75	19.75	**18.75**
Fe at 150 PPm	0.255	0.275	0.268	**0.266**	0.270	0.287	0.290	**0.282**	18.50	20.25	18.75	**19.16**	20.25	21.50	22.00	**21.25**
Zn at 150 PPm	0.262	0.280	0.275	**0.273**	0.265	0.285	0.285	**0.278**	18.75	20.75	19.25	**19.58**	19.75	20.75	21.50	**20.66**
Mn at 150 PPm	0.250	0.268	0.258	**0.258**	0.265	0.280	0.282	**0.276**	17.75	19.75	18.50	**18.66**	19.00	20.50	21.50	**20.33**
B at 150 PPm	0.245	0.257	0.250	**0.251**	0.255	0.275	0.282	**0.271**	17.25	19.25	18.00	**18.16**	18.25	19.50	20.75	**19.50**
Mean	0.251	0.267	0.259		0.261	0.277	0.280		17.85	19.60	18.40		19.00	20.20	21.10	
LSD at 5% for	**Amino acids = 0.0019**				**0.0026**				**0.427**				**0.336**			
	Mineral nutrients = 0.0027				**0.0029**				**0.494**				**0.388**			
	Interactions = 0.0054				**0.0033**				**0.538**				**0.674**			
	Second season (2007)															
Control (0.0)	0.238	0.260	0.250	**0.249**	0.257	0.263	0.267	**0.262**	17.50	19.50	18.25	**18.41**	18.25	19.50	19.75	**19.16**
Fe at 150 PPm	0.252	0.278	0.270	**0.267**	0.278	0.287	0.310	**0.292**	20.25	22.50	20.75	**21.16**	21.00	22.50	23.75	**22.41**
Zn at 150 PPm	0.257	0.282	0.273	**0.271**	0.273	0.285	0.308	**0.288**	20.75	22.75	21.50	**21.66**	20.50	22.00	23.50	**22.00**
Mn at 150 PPm	0.247	0.278	0.265	**0.263**	0.268	0.280	0.298	**0.282**	18.50	22.25	20.25	**20.33**	19.75	21.75	22.75	**21.41**
B at 150 PPm	0.245	0.268	0.255	**0.256**	0.260	0.267	0.287	**0.272**	18.00	21.25	19.25	**19.50**	19.25	20.75	21.25	**20.41**
Mean	0.248	0.273	0.262		0.267	0.276	0.294		19.00	21.65	20.00		19.75	21.30	22.20	
LSD at 5% for	**Amino acids = 0.0024**				**0.0021**				**0.350**				**0.456**			
	Mineral nutrients = 0.0054				**0.0029**				**0.368**				**0.527**			
	Interactions = 0.0092				**0.0083**				**0.404**				**0.706**			

G= Glutamic T= Tryptophan

Table (5): Effect of some amino acids and mineral nutrients treatments on leaves volatile oil (second cut) of *Rosmarinus officinalis* plant calculated as a percentages during 2007 season.

Components / Treatments	Area %										
	α -Pinene	Camphene	β-Pinene	Limonene	Y-Terpinene	1,8 - Cineole	Linalool	Borneol	Bornyl acetate	Eugenol	Total components
Control (0.0)	0.79272	24.18030	3.75975	4.57586	2.36542	23.02603	3.63584	8.80297	5.10298	2.31987	78.56174
Glutamic x Fe	0.93868	19.34915	4.93051	8.02493	5.81264	16.66808	4.71961	10.62459	7.99542	8.30331	82.43641
Glutamic x Zn	0.59725	22.32989	3.35431	4.11917	0.64104	28.41746	3.80911	9.90480	5.59320	3.22977	81.996
Tryptophan x Fe	0.15460	23.87109	3.25470	4.33463	0.60090	26.83022	3.48772	9.75425	5.02628	3.02034	81.19333
Tryptophan x Zn	0.24332	24.07667	3.67626	5.26207	9.54583	21.58000	2.44448	8.82016	5.01207	3.89315	84.55401

Table (6): Effect of some amino acids and mineral nutrients treatments on total chlorophylls (mg/g. f.w.) and N percentage of *Rosmarinus officinalis* plant during 2006 and 2007 seasons.

Parameters	First season (2006)															
	Total chlorophylls (mg/g. f.w.)								N %							
Amino acids / Mineral nutrients	First cut				Second cut				First cut				Second cut			
	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean
Control (0.0)	2.241	2.420	2.392	**2.351**	2.394	2.508	2.609	**2.504**	1.307	1.323	1.312	**1.314**	1.328	1.350	1.340	**1.339**
Fe at 150 PPm	2.534	2.637	2.495	**2.556**	2.756	2.930	2.986	**2.891**	1.343	1.392	1.360	**1.365**	1.370	1.433	1.392	**1.398**
Zn at 150 PPm	2.736	2.830	2.603	**2.723**	2.682	2.841	2.806	**2.776**	1.333	1.377	1.353	**1.354**	1.363	1.417	1.377	**1.386**
Mn at 150 PPm	2.610	2.735	2.593	**2.646**	2.644	2.733	2.781	**2.719**	1.323	1.368	1.345	**1.345**	1.353	1.402	1.368	**1.374**
B at 150 PPm	2.593	2.609	2.483	**2.561**	2.575	2.690	2.704	**2.656**	1.317	1.348	1.335	**1.333**	1.338	1.380	1.355	**1.358**
Mean	2.542	2.646	2.513		2.610	2.740	2.777		1.325	1.362	1.341		1.350	1.396	1.367	
LSD at 5% for	**Amino acids = 0.083**				**0.079**				**0.0021**				**0.0023**			
	Mineral nutrients = 0.181				**0.195**				**0.0022**				**0.0026**			
	Interactions = 0.241				**0.311**				**0.0029**				**0.0033**			
	Second season (2007)															
Control (0.0)	2.197	2.346	2.398	**2.314**	2.307	2.406	2.531	**2.415**	1.312	1.348	1.338	**1.333**	1.338	1.365	1.358	**1.353**
Fe at 150 PPm	2.341	2.533	2.632	**2.502**	2.490	2.630	2.839	**2.653**	1.430	1.495	1.463	**1.463**	1.380	1.465	1.428	**1.424**
Zn at 150 PPm	2.390	2.739	2.700	**2.610**	2.406	2.594	2.736	**2.579**	1.417	1.468	1.438	**1.441**	1.373	1.443	1.417	**1.411**
Mn at 150 PPm	2.384	2.699	2.593	**2.560**	2.535	2.583	2.705	**2.608**	1.355	1.448	1.410	**1.404**	1.358	1.415	1.392	**1.388**
B at 150 PPm	2.295	2.630	2.551	**2.492**	2.436	2.501	2.694	**2.544**	1.335	1.407	1.375	**1.373**	1.348	1.397	1.382	**1.376**
Mean	2.321	2.589	2.575		2.435	2.543	2.701		1.370	1.433	1.405		1.359	1.417	1.395	
LSD at 5% for	**Amino acids = 0.149**				**0.108**				**0.0018**				**0.0017**			
	Mineral nutrients = 0.196				**0.132**				**0.0020**				**0.0025**			
	Interactions = 0.321				**0.275**				**0.0023**				**0.0035**			

G= Glutamic T= Tryptophan

Table (7): Effect of some amino acids and mineral nutrients treatments on P and K percentages of *Rosmarinus officinalis* plant during 2006 and 2007 seasons

Parameters	First season (2006)															
	P %								K %							
Amino acids	First cut				Second cut				First cut				Second cut			
Mineral nutrients	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 200 ppm	T. at 200 ppm	Mean	Control	G. at 150 ppm	T. at 150 ppm	Mean
Control (0.0)	0.135	0.157	0.137	**0.143**	0.147	0.185	0.172	**0.168**	1.050	1.150	1.130	**1.110**	1.098	1.145	1.130	**1.124**
Fe at 150 PPm	0.175	0.218	0.195	**0.196**	0.203	0.228	0.220	**0.217**	1.188	1.213	1.198	**1.199**	1.178	1.18	1.208	**1.201**
Zn at 150 PPm	0.167	0.208	0.185	**0.187**	0.193	0.215	0.200	**0.203**	1.175	1.198	1.190	**1.188**	1.173	1.213	1.198	**1.194**
Mn at 150 PPm	0.160	0.198	0.172	**0.177**	0.183	0.200	0.193	**0.192**	1.157	1.193	1.165	**1.172**	1.162	1.195	1.183	**1.180**
B at 150 PPm	0.142	0.188	0.152	**0.161**	0.157	0.190	0.165	**0.171**	1.118	1.180	1.450	**1.147**	1.145	1.167	1.157	**1.157**
Mean	0.156	0.194	0.168		0.177	0.204	0.190		1.137	1.187	1.166		1.151	1.188	1.175	
LSD at 5% for	**Amino acids = 0.0034**				**0.0057**				**0.0069**				**0.0077**			
	Mineral nutrients = 0.0042				**0.0074**				**0.0071**				**0.0096**			
	Interactions = 0.018				**0.0119**				**0.0113**				**0.0188**			
	Second season (2007)															
Control (0.0)	0.142	0.177	0.160	**0.160**	0.162	0.188	0.170	**0.173**	1.075	1.150	1.132	**1.119**	1.167	1.198	1.183	**1.183**
Fe at 150 PPm	0.198	0.225	0.200	**0.208**	0.215	0.238	0.225	**0.226**	1.180	1.240	1.218	**1.212**	1.238	1.265	1.250	**1.251**
Zn at 150 PPm	0.190	0.210	0.195	**0.198**	0.208	0.233	0.223	**0.221**	1.167	1.228	1.203	**1.199**	1.220	1.257	1.248	**1.242**
Mn at 150 PPm	0.172	0.203	0.190	**0.188**	0.188	0.228	0.198	**0.204**	1.152	1.218	1.188	**1.186**	1.203	1.245	1.228	**1.225**
B at 150 PPm	0.170	0.195	0.182	**0.182**	0.177	0.205	0.193	**0.192**	1.130	1.182	1.155	**1.156**	1.170	1.233	1.208	**1.203**
Mean	0.174	0.202	0.186		0.190	0.218	0.202		1.141	1.204	1.179		1.200	1.240	1.223	
LSD at 5% for	**Amino acids = 0.013**				**0.0078**				**0.057**				**0.0066**			
	Mineral nutrients = 0.021				**0.0093**				**0.0068**				**0.0073**			
	Interactions = 0.031				**0.0155**				**0.0112**				**0.0123**			

G= Glutamic T= Tryptophan

Gas chromatograms of rosemary (*Rosmarinus officinalis, L.*) leaves distilled volatile oil (second cut) as influenced by some amino acids and mineral nutrients treatments (2007, season).

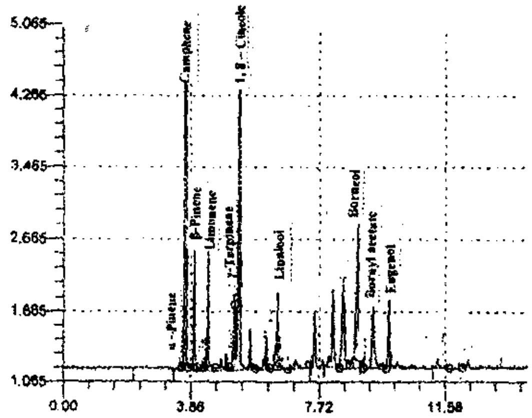

Fig (1): control (without amino acids or mineral nutrients)

1-α -Pinene
2- Camphene
3- β-Pinene
4- Limonene
5-Y-Terpinene
6-1,8 - Cineole
7- Linalool
8- Borneol
9- Bornyl acetate
10- Eugenol

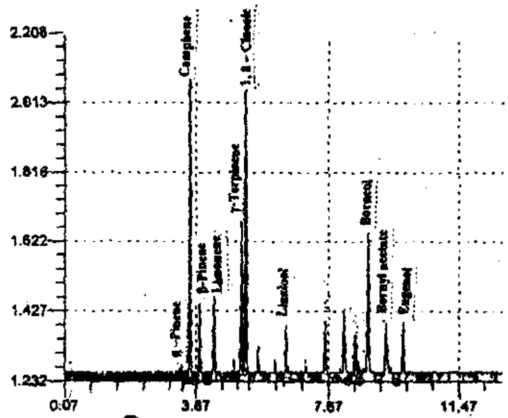

Fig (2): Combined treatment between glutamic and Fe

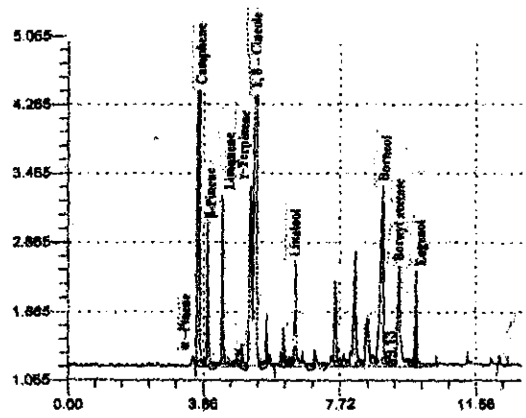

Fig (3): Combined treatment between glutamic and Zn

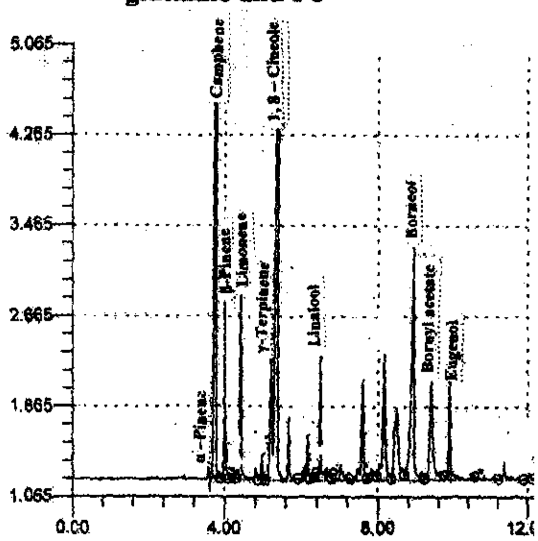

Fig (4): Combined treatment between tryptophan and Fe

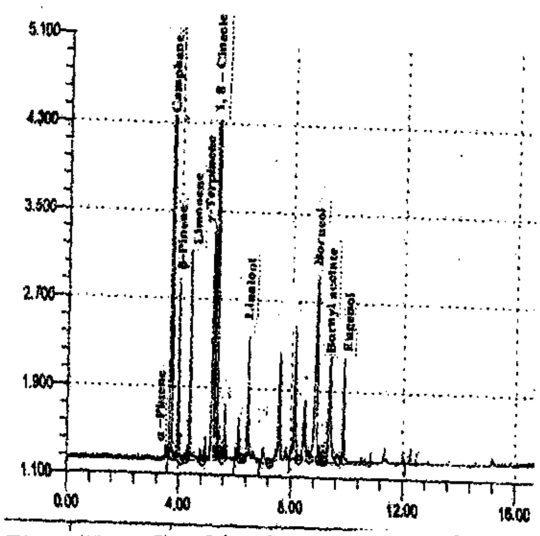

Fig (5): Combined treatment between tryptophan and Zn

Additionally, boron caused a gradual hyperpolarization of the plasma membrane in root tips and stimulate boron secretion and the activity of plasma membrane NADH oxidase. Thus, boron could be directly associated with cell growth (Goldbach *et al.*, 1990).

The results of amino acids are in accordance with the findings of El-Sherbeny and Hassan (1987) on *Datura stramonium*, Mohamed (1992) on *Dahlia pinnata* plants, Gamal El-Din *et.al.* (1997) on lemongrass plants, El-Khayat (2001) on *Hibiscus sabdariffa* plant, Wahabe *et al.*, (2002) on *Antholyza aethiopica* plants, Youssef *et al.* (2004) on Datura plants and Balbaa and Talaat (2007) on rosemary plants they stated that, foliar spray with phenylalanine and ornithine at the concentrations of 50, 100 and 150 mg/L. increased leaves N, P and K.% content of herb. The aforementioned results of mineral nutrients are in conformity with those obtained by Gomaa (2008) indicated that foliar application of Fe, Zn and Mn to *Hibiscus sabdariffa,* L plant increased leaves N, P, K and total carbohydrates contents. Gomaa and Mady (2008) mentioned that spraying *Matricaria chamomilla* plants with boron at 50 and 75 ppm increased leaves total chlorophylls, N, P and K contents.

Generally, it could be recommended from the previous results, that foliar application with amino acids (tryptophan and glutamic) or mineral nutrients especially Fe and Zn, as well as their combinations could play an important role in improving growth, yield and volatile oil content of rosemary plants. Therefore, the present study strongly admit the use of such treatments to provide good and high exportation characteristics due to its safety role on human health.

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تأثير بعض معاملات الأحماض الأمينية والعناصر المغذية على نمو وإنتاجية نبات حصالبان

أحمد سعيد محمد يوسف
قسم البساتين – كلية الزراعة بمشتهر – جامعة بنها – مصر

أجريت تجربه حقلية لمدة عامين خلال موسمي ٢٠٠٦ و ٢٠٠٧ وذلك بمزرعة الزينة بقسم البساتين – كلية الزراعة– جامعة بنها. وذلك لدراسة تأثير بعض معاملات الأحماض الأمينيه (التربتوفان والجلوتاميك بتركيز ٢٠٠ جزء في المليون لكل منهما) والعناصر المغذية (حديد– زنك– منجنيز– بورون بتركيز ١٥٠ جزء في المليون لكل منهما) على النمو الخضري ومحتوى النبات من الزيت ومكوناته وكذلك على المحتوى الكيماوي لنبات حصالبان. أوضحت النتائج أن المعاملات المختلفة من الأحماض ألأمينيه أو العناصر المغذية قد أدت إلي زيادة معنوية في قياسات النمو الخضري مثل طول النبات ، عدد الأفرع/ نبات، الوزن الطازج والجاف للأفرع/ نبات والوزن الطازج والجاف للأوراق/ نبات. كذلك أدت جميع معاملات الأحماض ألأمينيه والعناصر المغذية وتفاعلاتهم إلي زيادة واضحة في محتوي الأوراق من الكربوهيدرات الكلية والكلوروفيل الكلى والنيتروجين والبوتاسيوم والفوسفور. كما وجد أن جميع المعاملات التي أعطت زيادة كبيرة في النمو قد صحبها أيضا زيادة في محتوى الأوراق من الزيوت الطيارة كما أعطت جميع معاملات الأحماض ألأمينيه والعناصر المغذية وتفاعلاتهم المختلفة زيادة في محتوي الأوراق من الزيوت الطيارة وخاصة المعاملة المختلطة بين التربتوفان والزنك يليها في ذلك المعاملة المختلطة بين الجلوتاميك والحديد. كما أوضح التحليل الكروماتوجرافي أن المكونات الرئيسية لزيت حصالبان هي camphene يليها 1.8- cineole ثم Borneol على التوالي. وقد كان أكبر محتوى من 1.8-cineole في الزيت قد تم الحصول عليه عن طريق المعاملة المختلطة بين الجلوتاميك والزنك بينما أعطت المعاملة المختلطة بين الجلوتاميك والحديد أعلي محتوي لمادة Borneol في الزيت.

وبناءا على النتائج المتحصل عليها فانه ينصح برش نباتات حصالبان بالمعاملات المختلطة بين كل من التربتوفان والجلوتاميك بتركيز ٢٠٠ جزء في المليون والحديد والزنك بتركيز ١٥٠ جزء في المليون وذلك لتحسين نمو وإنتاجية النبات من الزيت .