World Journal of Agricultural Sciences 2 (1): 75-81, 2006
ISSN 1817-3047

Physiological Effect of Diphenylamin and Tryptophan on the Growth and Chemical Constituents of *Philodendron erubescens* Plants

[1]*T.A.M. Abou Dahab and* [2]*Nahed G. Abd El-Aziz*

[1]Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Egypt
[2]Department of Ornamental Plants and Woody Trees, National Research Center, Dokki, Cairo, Egypt

Abstract: A pot experiment was carried out in the nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, during the two successive seasons of 2003/2004 and 2004/2005, with the aim of studying the effect of foliar application of the amino acids diphenylamin and tryptophan (each at the rates of 50 or 100 ppm), applied separately or in combinations of the different concentrations (plus untreated control plants), on the growth and chemical constituents of *Philodendron erubescens* plants. The most important results can be summarized as: 1) Both diphenylamin and tryptophan significantly increased plant growth (in terms of plant height, number of leaves/plant, stem diameter, root length, leaf area, as well as fresh and dry weights of the different plant parts) and the contents of carotenoids, total soluble sugars and total free amino acids in the leaves. 2) The effect of diphenylamin was superior to that of tryptophan on increasing plant growth and chemical constituents. 3) In both seasons, the maximum plant growth (as determined by all the recorded parameters) was obtained from plants treated with diphenylamin at the rate of 100 ppm, followed by tryptophan at 100 ppm. 4) Amino acids treatments had no significant effect on the chlorophyll A and B contents in both seasons. However, the total chlorophyll content was significantly increased in the second seasons as a result of the amino acid treatments. 5) Plant treated with diphenylamin at 100 ppm had the highest contents of caroteniodes, total soluble sugars and total free amino acids in the leaves.

Key words: Diphenylamin · Tryptophan · *Philodendron erubescens* · amino acids

INTRODUCTION

The regulation of plant growth and biosynthesis of important economic chemical constituents could be achieved through the use of different growth regulating substances. There has been a recent trend to use naturally-occurring compounds (including amino acids) to achieve such regulation. Davies [1] reported that amino acids as organic nitrogenous compounds are the building blocks in the synthesis of proteins, which are formed by a process in which ribosomes catalyze the polymerization of amino acids.

Several hypotheses have been proposed to explain the role of amino acids in plant growth. Available evidence suggests several alternative routes of IAA synthesis in plants, all starting from amino acids [2]. On the other hand, Waller and Nowaki [3] suggested that the regulatory effects of certain amino acids, like phenylalanine and ornithine, on plant development is through their influence on gibberellins.

The role of tryptophan is well known: it has an indirect role on the growth via its influence on auxin synthesis. Phillips [4] reported that alternative routes of IAA synthesis exist in plants, all starting from tryptophan. Thus, when tryptophan was supplied to some plant tissues IAA was formed. Moursy *et al.*, [5] established callus lines of *Datura stramonium* L. and found that phenylalanine and ornithine increased both fresh and dry weights of callus compared with the control. Moreover, there have been reports that foliar application of amino acids (Lysine, ornithine, salicylic acid and tryptophan) enhanced the vegetative growth and chemical constituents [Talaat and Youssef [6] on basil plants, Talaat [7] on *Pelargonium graveolens* L. and Talaat *et al.,* [8] on *Catharanthus roseus* L.].

Philodendron erubescens 'Red Emerald' plants (Family: Araceae) is one of the most important house plants. It has waxy arrow-shaped leaves, up to 25 cm in length, bronzy green in colour, with red edges and wine-red beneath. The petioles are green with red and are occasionally winged.

The aim of this work was to study the effect of the amino acids diphenylamine and tryptophan, as well as and their combinations, on growth and chemical

Corresponding Author: Dr. T.A.M. Abou Dahab, Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Egypt

constituents of *Philodendron erubescens* plants and the feasibility of using these chemicals to improve plant quality.

MATERIALS AND METHODS

A pot experiment was carried out during two seasons (2003/2004 and 2004/2005) at the nursery of the Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, with the aim of studying the effect of foliar applications of the amino acids diphenylamin and tryptophan on the growth and chemical constituents of *Philodendron erubescens* 'Red Emerald' plants.

Plant material: Plantlets of *Philodendron erubescens* (6 months old, with 2 leaves/plantlet and an average height of 13-15 cm) were transplanted in pots (16 cm in diameter) filled with a mixture of sand and peat moss (1:1, v/v) on September 20th, 2003 and 2004, in the first and second seasons, respectively.

The seedlings were placed in an uncontrolled glasshouse. Each pot was supplied with 2 g of an NPK (15:15:15) fertilizer. The fertilizers were repeated with a total of 6 applications, at one-month intervals, starting after 21 days from transplanting. Other common cultural practices were preformed as needed. The plants were sprayed with the amino acids diphenylamin and tryptophan, (each at concentrations of 50 or 100 ppm) applied either separately, or in combinations (at concentrations of 50:50, 50:100, 100:50 or 100:100 ppm of diphenylamin and tryptophan, respectively), in addition to the untreated control plants. The amino acids foliar spray treatments were applied one month after transplanting (on October 20th in both seasons) and were repeated 4 times at one-month intervals.

The pots were arranged in a randomized complete blocks design, with 9 treatments (control plus eight amino acid treatments), replicated three times, with each replicate (block) consisting of 10 plants/treatment.

At the termination of the experiment (on April 20th in both seasons), the following data were recorded:

Measurements of growth parameters:

- Plant height (cm).
- Number of leaves/plant.
- Stem diameter (mm) at a height of 5 cm from soil surface.
- Root length (cm).
- Leaf area (cm^2) of 4th leaf from soil surface.
- Fresh and dry weights of leaves, stems and roots (g/plant).

Chemical analysis:

- Fresh leaf samples were collected from plants receiving the different treatments and were chemically analyzed to determine their content of photosynthetic pigments (chlorophyll A, chlorophyll B and carotenoids) using the method described by Von Wettstein [9].
- Leaf samples were dried and their contents of total soluble sugars were determined according to Dubois *et al.,* [10].
- The content of total free amino acids in leaves was determined according to Rosein [11].

Statistical analysis: Data obtained were subjected to analysis of variance and the means were compared using the Duncan's Multiple Range Test (at the 0.05 level), as recommended by Snedecor and Cochran [12].

RESULTS AND DISCUSSION

Effect of amino acids on plant growth:

Plant height (cm): Treatment of *Philodendron erubescens* plants with the amino acids diphenylamin and tryptophan had a significant effect on plant height (Table 1). In the first season, the plant height ranged from 25.60 to 46.30 cm, whereas in the second season, the recorded values ranged from 27.30 cm to 47.30 cm. In both seasons, the shortest plants were those that were untreated (control). Treatment of the plants with any of the tested amino acid treatments caused a significant increase in plant height and the percentages of increases (compared to the control plants) ranged from 31.25 to 80.86% in the first season and from 12.09 to 73.26% in the second season. The highest percentage of increase was found in plants which were treated by diphenylamin at 100 ppm, which gave the highest values in both seasons (46.30 and 47.30 cm in the first and second seasons, respectively).

The comparison between diphenylamin and tryptophan revealed the superior effect of diphenylamine, especially at the rate of 100 ppm, over tryptophan in the two seasons.

The role of the amino acids in stimulating growth of several plant species was studied by Phillips [4], who indicated that several alternative routes of IAA synthesis exist in plants, all starting from amino acids. Russell [13] reported that the increase in growth as a result of

Table 1: Effect of diphenylamin (Dip) and tryptophan (Try) on growth of *Philodendron erubescens* plants

Treatments	Plant height (cm)	Number of leaves/plant	Stem diameter (mm)	Root length (cm)	Leaf area (cm^2)
	First season (2003/2004)				
Control	25.60F	7.00E	7.60F	14.30F	913.0G
Dip.50 ppm	44.00B	10.60BC	9.20B	19.30E	1324.0C
Dip.100 ppm	46.30A	13.30A	10.30A	35.00A	1765.0A
Try.50 ppm	37.60D	10.00B-D	9.10B	19.30E	1232.0DE
Try.100 ppm	37.60D	11.00B	10.20A	24.30D	1223.0E
Dip+Try (50:50 ppm)	44.30B	9.00CD	8.30D	19.60E	936.0G
Dip+Try (50:100 ppm)	39.00C	10.00B-D	8.60C	19.00E	1386.0B
Dip+Try (100:50 ppm)	38.00CD	8.90DE	8.10E	32.30B	1281.0CD
Dip+Try (100:100 ppm)	33.60E	10.00B-D	8.60C	30.60C	1119.0F
LSD 0.5%	1.249	1.683	0.172	1.521	50.220
	Second season (2004/2005)				
Control	27.30G	8.00F	7.90I	15.60G	943.0G
Dip.50 ppm	45.60B	11.30CD	10.30C	21.30E	1369.0C
Dip.100 ppm	47.30A	14.60A	11.00A	36.10A	1820.0A
Try.50 ppm	40.30D	11.00D	10.00D	20.60E	1330.0CD
Try.100 ppm	36.60E	13.30B	10.90B	26.60D	1320.0CD
Dip+Try (50:50)	46.60AB	10.60D	9.30F	18.30F	1001.0F
Dip+Try (50:100)	41.60C	12.30BC	9.60E	17.60F	1405.0B
Dip+Try (100:50)	39.60D	9.30E	8.60H	34.60B	1311.0D
Dip+Try(100:100)	30.60F	11.60CD	9.00G	31.60C	1190.0E
LSD 0.5%	1.108	1.241	0.079	1.239	49.59

Within each column, values followed by the same alphabetical letter(s) are not significantly different according to Duncan's multiple range test (at the 0.05 level)

application of amino acids may be due to their conversion into IAA. Attoa *et al.*, [14] reported that spraying *Iberis amara* L. plants with the amino acid tryptophan increased plant growth. Regarding the effect of amino acids on plant height, the results of this study are in agreement with those obtained by Salonen [15] on *Atropa belladomna*, Moursy *et al.*, [5] on *Datura stramonium*, El-Bahar *et al.*, [16] on *Datura metel*, Gamal El-Din [17] on *Hyoscyamus muticus* and Talaat and Youssef [6] on *Ocimum basilicum*, who reported that foliar applications of amino acids significantly promoted plant growth.

In conclusion, it can be stated that diphenylamin (100 ppm) was the most effective treatment in causing a significant increase in the length of *Philodendron* plants.

Number of leaves/plant: The data recorded in this study (Table 1) indicated that the effect of the different treatments on the number of leaves/plant was generally similar to their effect on plant height. In both seasons, all the diphenylamin or tryptophan treatments that were used in this study significantly increased the number of leaves/plant, compared to the control. The percentage of increase recorded with the different treatments varied from 27.14 to 90.00% in the first season and from 16.25 to 82.50% in the second season, over the untreated plants. The data in Table 1 also show that the effect of diphenylamin (especially at the rate of 100 ppm) on the number of leaves/plant was superior to that of tryptophan. In fact, the highest percentage of increase in both seasons was recorded on plants that were treated with diphenylamin at 100 ppm. This means that this treatment was the most effective one for causing the greatest significant increase in the production of leaves by the plants (i.e. giving the highest number of leaves/plant), compared to the other treatments. In contrast, the shortest plants were those that received no treatment (control).

From the above results, it can be concluded that the amino acids diphenylamin and tryptophan had a stimulating effect on the production of leaves (i.e. they increased the number of leaves/plant), with diphenylamine (especially at 100 ppm) being more effective in this respect than tryptophan. The number of leaves/plants is one of the most important criteria in the foliage plants, by which plant quality is determined.

Stem diameter (mm): The data (Table 1) revealed that the response of stem diameter to the amino acid treatments followed the same trend as in plant height and number of leaves/plant. In both seasons, plants receiving the different treatments had significantly thicker stems than the untreated control plants. Here also, the application of diphenylamin at the rate of 100 ppm was the most effective treatment in increasing stem thickness, giving the greatest mean stem diameters in both seasons (10.30 and 11.0 mm in the first and second seasons,

Table 2: Effect of diphenylamin (Dip) and tryptophan (Try) on the fresh and dry weights (g/plant) of different parts of *Philodendron erubescens* plants

	Fresh weight (g/plant)				Dry weight (g/plant)			
Treatments	Leaves	Stems	Roots	Total	Leaves	Stems	Roots	Total
				First season (2003/2004)				
Control	25.4F	21.8G	7.4E	54.6G	3.5C	2.9G	2.2F	8.6F
Dip.50 ppm	44.7C	36.2C	8.7E	89.6D	5.5AB	4.3CE	2.6EF	12.4CD
Dip.100 ppm	66.8A	51.8A	16.3A	134.0A	7.2A	5.7A	4.9A	17.8A
Try.50 ppm	46.7B	36.7C	10.4D	93.8C	4.8BC	4.0DF	2.6EF	11.4DE
Try.100 ppm	45.1C	38.4B	12.6BC	96.1B	6.2AB	5.3AB	2.9DE	14.4B
Dip+Try (50:50)	36.6E	28.9F	10.7D	76.2F	4.6BC	3.4FG	2.4EF	9.9EF
Dip+Try (50:100)	40.7D	33.9E	11.7CD	86.3E	5.7AB	4.5BD	3.6C	13.8BC
Dip+Try (100:50)	45.5BC	38.1B	13.4B	97.0B	5.9AB	5.0AC	3.4CD	14.3B
Dip+Try (100:100)	45.7BC	35.0D	15.4A	96.1B	5.0BC	3.6FG	4.4B	13.0BC
LSD 0.5%	1.521	0.538	1.472	1.600	1.717	0.832	0.576	1.608
				Second season (2004/2005)				
Control	22.9H	26.4E	9.2F	58.5H	3.5C	4.2D	3.0B	10.7F
Dip.50 ppm	38.1DE	34.1D	10.1EF	82.3F	5.1AB	6.2BC	3.1B	14.4DE
Dip.100 ppm	53.8A	69.9A	19.2B	142.9A	6.2A	8.1A	5.2A	19.5A
Try.50 ppm	38.7CD	48.7B	11.6DE	99.0D	4.9AC	5.3B	3.1B	13.3E
Try.100 ppm	40.3B	47.3B	13.9C	101.5C	6.1A	6.9BC	3.8B	16.8B
Dip+Try (50:50)	31.3G	35.1D	12.1D	78.5G	4.2BC	5.8BC	3.3B	13.3E
Dip+Try (50:100)	35.0F	42.9C	13.9C	91.8E	5.2AB	6.2BC	4.4B	15.8BC
Dip+Try (100:50)	40.0BC	47.5B	14.9C	102.4C	5.9A	6.4BC	4.2AB	16.5B
Dip+Try (100:100)	36.7E	48.1B	16.9B	101.7B	4.1BC	5.9BC	5.1A	15.1CD
LSD 0.5%	1.588	2.335	1.588	1.087	1.549	1.126	1.548	1.083

Within each column, values followed by the same alphabetical letter(s) are not significantly different according to Duncan's multiple range test (at the 0.05 level)

respectively). These values reflect increases of 35.5 and 39.2% in stem diameter in the first and second season, respectively, compared to the control.

Root length (cm): The data (Table 1) showed that the effect of the amino acid treatments on root length followed the same trend as that detected for plant height, number of leaves/plant and stem diameter. Using diphenylamin at 100 ppm gave significantly longer roots than those of plants receiving any other treatment. The percentages of increase in root length as a result of this treatment (over the control) reached 144.8% and 131.4% in first and second seasons, respectively.

It has been reported that the amino acid lysine is converted into the diamine cadaverine by decarbotylation. Its synthesis is catalyzed by lysine decarboxylase. Cadaverine may play an important role in root development [18].

Leaf area (cm^2): The data presented in Table 1 showed that treatment of *Philodendron erubescens* plants with the amino acids diphenylamin and tryptophan significantly increased the leaf area. In both seasons, the smallest leaves (913 and 943 cm^2 in the first and second seasons, respectively) were those of the untreated plants. On the other hand, the largest leaves (1765 and 1820 cm^2 in the two seasons, respectively) were found on plants that had been treated with diphenylamin at the concentration of 100 ppm. The percentages of increase in this character as a result of applying diphenylamin at 100 ppm (compared to the control) reached 93.3 and 93.0% in the first and second seasons, respectively. Similar increases in root length as a result of amino acid treatments have been previously observed by several investigators on a number of plant species Gamal El-Din *et al.*, [19] on lemon-grass (*Cymbopogon citratus*) and Talaat and Youssef [6] on *Ocimum basilicum*.

Fresh and dry weights of different plant parts (gm/plant): The data recorded in the two seasons (Table 2) showed that the amino acids diphenylamin and tryptophan significantly increased the fresh and dry weights of the different parts of the plant (leaves, stem, roots and the whole plants), compared to those of the untreated control plants. The most effective treatment was the application of diphenylamin at 100 ppm (in both seasons). This may be attributed to the fact that this treatment gave the longest plants, the greatest number of leaves/plants, the thickest stem diameter and the largest leaf area.

Comparing the effects of diphenylamin and tryptophan on the fresh and dry weights of the different plant parts, one can notice that diphenylamin was generally more effective than tryptophan.

Table 3: Effect of diphenylamin (Dip) and tryptophan (Try) on chemical constituents of *Philodendron erubescens* plants

Treatments	Chlorophyll A (mg/100 g FW)	Chlorophyll B (mg/100 g FW)	Total Chl. A+B (mg/100 g FW)	Caroteniodes (mg/g FW)	Total soluble sugars (mg/100 g DW)	Total free amino acids (mg/g DW)
	First season (2003/2004)					
Control	0.531A	0.257A	0.788A	1.039C	27.71F	8.45D
Dip.50 ppm	0.640A	0.296A	0.936A	1.068C	37.88AB	11.02C
Dip.100 ppm	1.118A	0.471A	1.588A	1.567A	41.17A	15.18A
Try.50 ppm	0.991A	0.369A	1.360A	1.407AB	33.59CD	13.53AB
Try.100 ppm	1.024A	0.451A	1.475A	1.531A	33.27CE	14.16A
Dip+Try (50:50)	1.098A	0.471A	1.569A	1.510A	31.85DE	13.60AB
Dip+Try (50:100)	0.970A	0.449A	1.419A	1.559A	35.65BC	11.76BC
Dip+Try (100:50)	0.911A	0.379A	1.290A	1.279B	30.24FE	11.33BC
Dip+Try (100:100)	0.999A	0.443A	1.442A	1.419AB	38.53AB	13.27AC
LSD 0.5%	0.798	0.612	0.802	1.660	3.303	2.343
	Second season (2004/2005)					
Control	0.542A	0.291A	0.833H	1.091B	29.25G	9.40D
Dip.50 ppm	0.649A	0.301A	0.950G	1.123B	39.90B	12.51C
Dip.100 ppm	1.201A	0.511A	1.712A	1.613A	44.20A	16.22A
Try.50 ppm	1.001A	0.391A	1.392F	1.501A	35.30D	14.67B
Try.100 ppm	1.113A	0.510A	1.623B	1.602A	34.90D	16.17A
Dip+Try (50:50)	1.007A	0.492A	1.499D	1.598A	30.51F	15.63A
Dip+Try (50:100)	0.989A	0.509A	1.498DE	1.610A	37.96C	12.98C
Dip+Try (100:50)	1.102A	0.391A	1.493E	1.495A	33.23E	12.21C
Dip+Try (100:100)	1.009A	0.481A	1.600C	1.502A	40.71B	14.33B
LSD 0.5%	0.804	0.614	0.0055	0.134	1.123	0.948

Within each column, values followed by the same alphabetical letter(s) are not significantly different according to Duncan's multiple range test (at the 0.05 level)

These results are in agreement with previous reports of Russell [13], Harridy [20] on *Catharanthus roseus*, Attoa *et al.*, [14] on *Iberis amara* and Talaat *et al.*, [8] on *Nigellia sativa*.

The increase in the fresh and dry weights as a result of the tryptophan treatments may be due to its conversion into IAA [13]. The percentages of increase in the total plant fresh weight due to spraying the plants with diphenylamin at 100 ppm (compared to the control) reached 145.2 and 111% in the first and second seasons, respectively. However, for the dry weight these percentages reached 104 and 80%, respectively.

Effect of amino acids on chemical constituents:

Photosynthetic pigments: The data presented in Table 3 showed that the amino acid treatments which were used in this study had no signifricant effect on the chlorophyll A, chlorophyll B and total chlorophyll contents in the first season, whereas in the second season, the foliar applications of all treatments caused a significant increase in the total chlorophyll (A+B) content, compared to that of control plants. Plants treated with 100 ppm diphenylamin had the highest total chlorophyll content (1.712 mg/100 g), while untreated plants gave the lowest value (0.833 mg/100 g).

The recorded data also revealed that plants treated with diphenylamin at 100 ppm had the highest carotenoides content, compared to that found in plants receiving any other treatment. The percentages of increase due to this treatment over the control reached 50.8 and 47.8% in the first and second seasons, respectively.

The comparison between the effects of diphenylamin and tryptophan revealed that the influence of diphenylamin on increasing the photosynthetic pigments (especially at the rate of 100 ppm, which can be considered as the most effective treatment) was superior to that of tryptophan.

The present data are in agreement with the findings of Milad [21] on *Mentha virids*, Shoala [22] on *Lavendula multifida* plants and Hassanein [23] on *Foeniculum vulgare*. They reported that foliar application of amino acids (tryptophan), caused an increase in the contents of photosynthetic pigments.

Total soluble sugars contents: Data in Table 3 indicated that application of the amino acids diphenylamin and tryptophan as a foliar spray caused a significant increase in the contents of total soluble sugars in the leaves. The most effective treatment in this respect was diphenylamin at 100 ppm, followed by diphenylamin plus tryptophan (at 100:100 ppm). Comparing the effects of diphenylamin and tryptophan, the data indicated that diphenylamin was superior to tryptophan. The percentages of increase in the

total soluble sugars content caused by treating the plants with diphenylamin at 100 ppm (compared to the control) were 48.6 and 51.1% in the first and second seasons, respectively.

These results are in agreements with those obtained by Talaat and Youssef [6] on *Ocimum basilicum* L. and Wahba *et al.*, [24] on *Antholyza aethiopica* plants.

Total free amino acids: The results recorded in the two seasons (Table 3) showed that spraying *Philodendron* plants with different amino acid treatments caused a significant increase in the content of total free amino acids in the leaves. In both seasons, application of the high diphenylamin concentration (100 ppm) was the most effective treatment in producing the highest values, followed by tryptophan at the rate of 100 ppm. The increase in the content of total free amino acids as a result of the tryptophan treatments may be attributed to its conversion of to IAA, as stated by Phillips [4].

The percentages of increase in total free amino acid contents as a result of using diphenylamin at 100 ppm (compared to the untreated plants) were 79.6 and 72.6% in the first and second seasons, respectively. Our results are in agreement with the findings of Harridy [20] on *Catharanthus roseus*.

In conclusion, it can be stated that treatment of *Philodendron erubescens* plants with diphenylamin (especially at the concentration of 100 ppm) or tryptophan had a beneficial effect plant growth and chemical constituents.

REFERENCES

1. Davies, D.D., 1982. Physiological aspects of protein turnover. Encycl. Plant Physiol. New Series, 14 A (Nucleic acids and proteins: structure, biochemistry and physiology of proteins, Eds., Boulter, D. and B. Partier, Springer Verlag, Berlin, Heidelberg & New York, pp: 190-228.
2. Hashimoto, T. and Y. Yamada, 1994. Alkaloid biogenesis: Molecular Aspects. Ann. Rev. Plant Physiol. Plant Mol. Biol., pp: 245-257.
3. Waller, G.R. and E.K. Nowaki, 1978. Alkaliod, Biology and Metabolism in Plants. Plenum Press, New York, pp: 85-247.
4. Phillips, L.D.J., 1971. Introduction to the Biochemistry and Physiology of Plant Growth Hormones. Mc. Graw-Hill Book Co.
5. Moursy, H.A., S.M. Hussein and K.M. El-Bahar, 1988. Effect of some alkaloid precursors on the growth and alkaliod production of *Datura stramonium* L. cultured *in vitro*. Egypt. J. Bot., 31: 153-165.
6. Talaat, I.M. and A.A. Youssef, 2002. The role of the amino acids lysine and ornithine in growth and chemical constituents of basil plants. Egypt. J. Appl. Sci., 17: 83-95.
7. Talaat, I.M., 2005. Physiological effect of salicylic acid and tryptophan on *Pelargonium graveolens* L. Egypt. J. Appl. Sci., 20: 751-760.
8. Talaat, I.M., M. Karima and K.M. Gamal-El-Din, 2005. Physiological effect of putrescine and heat hardening on *Nigellia sativa* L. plants. Intl. J. Agric. Biol., 3: 358-362.
9. Von Wettstein, D., 1957. Chlorophyll- Lethale und der submik roskopische Formwechset der Plastiden. Exptl. Cell Res., 12: 427-506. [c.f. Intl. J. Agric. Biol., 7: 213].
10. Dubois, M., K.A. Gilles, J.K. Hamilton, P.A. Rebers and F. Smith, 1956. Colorimetric methods for determination of sugars and related substances. Analytical Annal Chem., 28: 350-356.
11. Rosein, H., 1957. A modified ninhydrine colorimetric analysis Fr amino acids. Arch-Biochem. Biophys., 67: 10-15.
12. Snedecor, G.M. and W.G. Cochran, 1980. Statical Methods. 7th Ed., Iowa State College Press, Ames, Iowa, USA.
13. Russell, R.S., 1982. Plant Root Systems, 1st Ed. ELBS, UK., pp: 17-18.
14. Attoa, G.E., H.E. Wahba and A.A. Farahat, 2002. Effect of some amino acids and sulphur fertilization on growth and chemical composition of *Iberis amara* L. plants. Egyption J. Hort., 29: 17-37.
15. Salonen, M.L., 1980. Glutamate and aspartate derived amino acids as nitrogen sources for the callus of *Atropa belladomna* L. Annals, Botan. Fenn., 17: 357-378.
16. El-Bahar, K.M., A.S. Ghanem and E.A. Omer, 1990. Responses of *Datura metel* L. cell cultures to some amino acids. Egypt J. Appl. Sci., 5: 192-199.
17. Gamal El-Din, K.M., 1992. Growth response of *Hyoscyamus muticus* L. to temperature hardening in relation to alkaloidal pattern. Ph.D. Thesis, Fac. Agric., Ain Shams Univ.
18. Gramarnik, A. and R.B. Frydman, 1991. Cadaverine on essential diamine for the normal root development of germinating soybean (*Glycine max*) seeds. Plant Physiol., 97: 778-785.
19. Gamal El-Din, K.M., A.T. Shahira and K.B. Laila, 1997. Physiological studies on the effect of some amino acids and microelements on growth and essential oil content in lemon-grass (*Cymbopogon citratus* Host.). J. Agric. Sci. Mansoura Univ., 22: 4229-4241.

20. Harridy, I.M.A., 1986. Physiological studies on periwinkle plant (*Catharanthus roseus*). Ph.D. Thesis, Fac. Agric., Cairo Univ.
21. Milad, S.M.N., 1998. Effect of tryptophan and methionine on the productivity of two *Mentha* species and American *Ocimum* plants. M.Sc. Thesis, Fac. Agric., Cairo Univ.
22. Shoala, A.W.T., 2000. Physiological studies on Lavender plants (*Lavendula multifida*).Ph.D. Thesis. Fac. Agric., Cairo Univ.
23. Hassanein, R.A.M., 2003. Effect of some amino acids, trace elements and irradiation on fennel (*Foeniculum vulgare* L.). Ph.D. Thesis, Fac. Agric., Cairo Univ.
24. Wahba, H., S.M. Mohamed, G.E. Attoa and A.A. Farahat, 2002. Response of *Antholyza aethiopica* to foliar spray with some amino acids and mineral nutrition with sulphur. Annals Agric. Sci. Ain Shams Univ., 47: 929-944.