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MILK THISTLE GROWTH, PRODUCTIVITY AND CHEMICAL CONSTITUENTS AS AFFECTED BY FOLIAR APPLICATION OF PHENYLALANINE AND TRYPTOPHAN

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ABSTRACT: The present work was done at the Experimental Farm of Faculty of Agriculture, Zagazig University (Al-Khattara), Sharkia Governorate, Egypt during two consecutive seasons of 2012-2013 and 2013-2014. Different concentrations (0, 100, 200 or 300 mg/l) of L-phenylalanine or L-tryptophan each alone were foliar applied to milk thistle (*Silybum marianum* L.) plants to assess their effects on growth, productivity and chemical constituents. Obtained results demonstrated that the maximum values of plant growth characters (plant height, number of main branches, number of leaves /plant and herb fresh weight), yield components (number of fruits/plant, fruit weight, weight of 1000 seeds, seed weight/plant and seed yield/faddan) and chemical constituents (total nitrogen, phosphorus, potassium and total carbohydrates percentages in leaves as well as total phenolic compounds content of seeds) were recorded by spraying the plants with the highest concentration (300 mg/l) of each compound alone.

Key words: *Silybum marianum* L., foliar application, phenylalanine and tryptophan.

INTRODUCTION

Milk thistle (*Silybum marianum* L., family Astereaceae) is grown commercially for seed in Europe, Egypt, China, and Argentina (Anonymous, 1995). Extracts from variegated thistle seed are amongst the top selling phytomedicine preparations in Germany and the United States (American Botanical Council, 1998). These extracts have been used for at least 2000 years for the treatment of liver disorders (Bissett, 1994; Morazzoni and Bombardelli, 1995). This traditional use has been fully supported by clinical trials and mechanism of action studies, so that the extract, silymarin, is now an important hepatoprotective agent (Sonnenbichler *et al*., 1998; Mahady *et al.,* 2001), and is used in the treatment of most forms of liver disease, including cirrhosis, hepatitis, necroses, and liver damage as a result of alcohol and drug abuse (Morazzoni and Bombardelli, 1995; Flora *et al*., 1998). More recent research indicates that silymarin is also effective against skin and prostate cancer (Zi and Agarwal, 1999 ; Katiyar, 2005).

Variegated thistle seeds contain 1.5–3% silymarin, which is a mixture of flavonolignans including isomers of silychristin, silydiadin, silybin, and silybinin (Bissett, 1994 ; Smith *et al*., 2005).

The aromatic amino acids, phenylalanine and tryptophan are central molecules in plant metabolism. These aromatic amino acids in plants are not only essential components of protein synthesis, but also serve as precursors for a wide range of secondary metabolites that are important for plant growth as well as for human nutrition and health (Tzin and Galili, 2010). Phenylalanine and tryptophan are serve as precursors for many natural (secondary) products such as flavonoids, phenolic acids, coumarins, alkaloids, glucosinolates and cyanogenic glycosides (Wink, 2010).

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To the best of our knowledge there is no report on the effect of foliar application of phenylalanine and tryptophan on *Silybum marianum* L. Therefore, the present paper was designed to evaluate the influence of foliar application with different concentrations of both amino acids on *Silybum marianum* L. growth, productivity and chemical constituents.

MATERIALS AND METHODS

The aim of this study was to investigate growth, yield components and chemical composition of milk thistle (*Silybum marianum* L.) as influenced by foliar application of different concentrations (0, 100, 200 or 300 mg/l) of L-phenylalanine or L-tryptophan.

Seeds of milk thistle (*Silybum marianum* L.) plants were obtained from Department of Medicinal and Aromatic Plants Research, Ministry of Agriculture, Egypt. Seeds were sown on 7th of October during both seasons in sandy soil. Five seeds were sown per hill. The seedlings were thinned to one plant per hill after one month from sowing date. The irrigation system was drip irrigation. Physical and chemical properties of the experimental farm soil are presented in Table 1.

The experimental plot area was 4 m^2 (2×2 m) which contained four rows at 50 cm between rows and 50 cm between plants within the row. Each plot contained 16 plants.

All plants were fertilized with nitrogen, phosphorus and potassium fertilizers at the rate of 250 kg/fad., of ammonium sulphate (20.5% N), 200 kg/fad., of calcium super phosphate (15.5% P_2O_5) and 100 kg/fad., of potassium sulphate (50% K_2O), respectively. Phosphorus, potassium and chicken manure (10 m^3/fad.) fertilizers were added to the soil before planting. Nitrogen fertilizer was provided in small doses throughout the growing season. All plants were received normal agricultural practices whenever they needed.

Foliar application of the above mentioned treatments was applied at 60, 90 and 120 days after sowing. Untreated plants (control) were sprayed with tap water. Each treatment was replicated three times.

At full flowering stage vegetative growth parameters *i.e.,* plant height (cm), number of main branches/plant, number of leaves/plant and herb fresh weight (kg) were recorded.

Milk thistle fruits were harvested after ripening when approximately 50% of seeds (achene) had developed pappus and prior to seed dispersion. At harvest (from the first of April until the first of May), random sample of four guarded plants from each experimental unit was taken and number of fruits/plant, fruit weight (g), weight of 1000 seeds (g), seed weight/plant (g) and seed yield/faddan (Kg) were determined. Also, samples from leaves were collected and dried for chemical analyses. Total nitrogen (Naguib, 1969), Phosphorus (Hucker and Catroux, 1980), Potassium (Brown and Lilleland, 1964) and total carbohydrates (Herbert *et al.*, 1971) percentages were determined. Also, Total phenolic compounds content (mg gallic acid/g extract) was estimated in seeds according to the method described by Škerget *et al.* (2005).

The statistical layout of both above mentioned experiments were simple completely randomized block design. Each treatment included three replicates (plots). Each replicate contained 16 plants. All collected data were analyzed with analysis of variance (ANOVA) procedure using the MSTAT-C Statistical Software Package (Michigan State University, 1983). Differences between means were compared by using Duncan multiple range test (Gomez and Gomez. 1984).

RESULTS AND DISCUSSION

Effect of Foliar Application of Phenylalanine

Vegetative growth characters

From the results presented in Table 2 it was observed that plant height was significantly enhanced by spraying plants with any concentration of phenylalanine except with the lowest concentration in the first season. The highest concentration (300 mg/l) was the most pronounced concentration in this regard since it gave the tallest plants (146.25 and 145.17 cm) during both seasons. Concerning number of main branches/plant, it could be concluded that low concentration of phenylalanine

Table 1. Physical and chemical properties of experimental farm soil

Parameter	1 st season	2 nd season
	Soluble cations (meq./l)	
Mg^{++}	0.2	0.1
Ca^{++}	0.4	0.6
K^{+}	0.2	0.3
Na^{+}	0.7	0.5
	Soluble anions (meq./l)	
Cl^{-}	0.4	0.83
HCO_3^{-}	0.15	0.1
SO_4^{--}	0.77	0.3
pH	7.91	7.87
E C m.mohs/cm	1.2	1.0
	Mechanical analysis	
Clay (%)	8.05 %	4.65 %
Silt (%)	1.00 %	4.83 %
Sand (%)	90.95 %	90.25 %
Soil texture	Sandy soil	Sandy soil

Table 2. Effect of foliar application of phenylalanine on some vegetative growth characters of *Silybum marianum* during both seasons

Phenylalanine (mg/l)	Plant height (cm)		No. of main branches / plant		No. of leaves / plant		Herb fresh weight (Kg)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
0	112.50 c	110.42 c	5.83 c	5.83 c	60.00 d	78.83 c	1.451 c	1.436 c
100	121.67 bc	120.42 b	7.16 bc	8.00 bc	82.00 c	84.67 bc	2.134 b	2.150 b
200	130.00 b	128.17 b	8.50 b	10.00 b	100.00 b	103.00 b	2.523 b	2.650 b
300	146.25 a	145.17 a	12.66 a	13.66 a	130.33 a	132.67 a	4.313 a	4.339 a

had no significant effect on this character while increasing of concentration was concomitant with significant increase in number of main branches/plant. The highest numbers of main branches/plant (12.66 and 13.66) were recorded with the highest concentration (300 mg/l) during 1st and 2nd seasons, respectively. Number of leaves /plant was enhanced as phenylalanine concentration increased especially in the first season. The maximum numbers of leaves/plant (130.33 and 132.67) were obtained by spraying plants with the highest concentration (300 mg/l) of phenylalanine during 1st and 2nd seasons, respectively. Herb fresh weight was significantly improved by spraying plants with any concentration of phenylalanine. The highest concentration was the best treatment in this regard since it produced the heaviest (4.313 and 4.339 Kg) herb plant fresh during first and second seasons, respectively.

This enhancing effect of foliar application of phenylalanine especially at high concentration on growth characters was earlier confirmed on some plants such as lemongrass (Gamal *et al*., 1997), *Antirrhinum majus* plant (Abdel Aziz *et al*., 2009), *Foeniculum vulgare* var. Azoricum (Hendawy and Ezz El-Din, 2010) and *Ocimum basilicum* L. var. Genoveser (Reham *et al*., 2016). Waller and Nawacki (1978) reported that the regulatory effects of the amino acids could indirectly be explained since certain amino acids were suggested to affect plant development through their influence on gibberellins biosynthesis. Thon *et al*. (1981) pointed out that amino acids provide plant cells with an immediately available source of nitrogen, which generally can be taken by the cells more rapidly than inorganic nitrogen.

Yield and its components

Number of fruits/plant did not affect by foliar application of phenylalanine at low (during both seasons) and medium (during first season) concentrations, while high concentration (300 mg/l) significantly improved the number of produced fruits (14.33 and 14.16 during both seasons, respectively) compared with control and other concentrations (Table 3). Fruit weight followed the similar trend of number of fruits/plant but without significant difference between medium (200 mg/l) and high (300 mg/l) concentrations of phenylalanine. In most cases, weight of 1000 seeds did not significantly affect by foliar application of phenylalanine at any concentration. A gradual increase in seed weight/ plant was observed as a result of increasing the concentration of phenylalanine, especially in the second season. The maximum plant seed yields (83.00 and 96.83 g) were detected as a result of spraying plants with the highest concentration (300 mg/l) of phenylalanine during both seasons, respectively. Also, seed yield/faddan followed similar trend of seed weight/plant since the highest seed yields (1394.4 and 1626.7 Kg) were produced by plants sprayed with the highest concentration (300 mg/l) of phenylalanine during both seasons, respectively.

In this study foliar application of phenylalanine especially at high concentration (300 mg/l) had enhancing effect on yield components. This result seems to be in harmony with those obtained by Hendawy and Ezz El-Din (2010) since they stated that spraying *Foeniculum vulgare* var. azoricum plants with the highest concentration (300 ppm) of phenylalanine gave the maximum seed yield.

This may be due to the fact that phenylalanine is a substrate for phenylalanine ammonia lyase (Davies, 2010). Phenylalanine ammonia-lyase catalyzes the deamination of L-phenylalanine to trans-cinnamic acid, which is the first step in the biosynthesis of a large class of plant natural products based on the phenylpropane skeleton. Phenylpropanoids play key roles in plant development and in protection against environmental stresses (Dixon *et al*., 1983 ; Jones, 1984).

Chemical constituents

As shown in Table 4, total nitrogen percentage in plant leaves was gradually enhanced by increasing of phenylalanine concentration. The highest total nitrogen percentages (2.31 and 2.33%) were recorded when plants were sprayed with the highest concentration (300 mg/l) of phenylalanine. Treating plants with low and medium concentrations of phenylalanine significantly enhanced phosphorus percentage during first season but not in second season. During both seasons high concentration (300 mg/l) significantly surpassed control treatment since it produced the maximum percentages

Table 3. Effect of foliar application of phenylalanine on yield components of *Silybum marianum* during both seasons

Phenylalanine (mg/l)	No. of fruits/plant		Fruit weight (g)		Weight of 1000 seeds (g)		Seed weight/plant (g)		Seed yield/faddan (Kg)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
0	8.00 b	7.50 c	73.00 b	73.00 c	20.980 a	20.607 b	41.30 c	46.50 d	693.8 c	781.2 d
100	9.33 b	9.13 c	86.50 b	104.00 b	21.570 a	22.030 ab	52.25 bc	64.00 c	877.8 bc	1075.2 c
200	9.50 b	11.83 b	108.83 ab	116.67 ab	21.917 a	22.303 a	61.16 b	76.33 b	1027.4 b	1282.3 b
300	14.33 a	14.16 a	135.33 a	131.67 a	22.137 a	22.463a	83.00 a	96.83 a	1394.4 a	1626.7 a

Table 4. Effect of foliar application of phenylalanine on nitrogen, phosphorus, potassium and total carbohydrates percentages in leaves and total phenolic compounds content (TPC) as mg gallic acid/g extract of *Silybum marianum* seeds during both seasons

Phenylalanine (mg/l)	Total nitrogen (%)		Phosphorus (%)		Potassium (%)		Total carbohydrates		TPC (mg gallic acid/g extract)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
0	0.88 c	0.90 d	0.20 c	0.24 b	1.77 c	1.55 c	9.33 b	9.75 b	9.01 d	8.71 d
100	1.65 b	1.53 c	0.28 b	0.28 b	2.25 bc	2.10 bc	21.32 a	20.52 a	13.29 c	12.30 c
200	1.99 ab	1.99 b	0.32 b	0.32 ab	2.57 b	2.56 b	21.51a	21.51 a	20.82 b	21.71 b
300	2.31 a	2.33 a	0.33 a	0.38 a	3.39 a	3.39 a	25.23 a	24.28 a	25.45 a	26.23 a

(0.33 and 0.38%) during both seasons, respectively. High and medium concentrations of phenylalanine could significantly increase potassium percentage. High concentration was more effective than medium one in this regard. The highest potassium percent (3.39%) was observed during both seasons in the leaves of plants sprayed with high concentration (300 mg/l) of phenylalanine. Spraying plants with any concentration of phenylalanine significantly enhanced total carbohydrates percentage compared with untreated plants without significant differences among all applied phenylalanine concentrations.

This promotive effect of foliar application of phenylalanine on chemical constituents which observed in this study was previously demonstrated by El-Sherbiny and Hassan (1987) on *Datura stramanium* L. and Abdel Aziz *et al.* (2009) on *Antirrhinum majus* plant**.** This is consistent with the knowledge that phenylalanine serves as protein building block as well as precursor of numerous plant-derived metabolites, which play crucial roles in plant growth, development, reproduction and environmental responses. In vascular plants, about 30% of photosynthetically fixed carbon is channeled through phenylalanine toward the biosynthesis of lignin, a key structural component of plant cell walls and a major obstacle in cellulosic biofuel production (Boerjan *et al*., 2003).

It could be observed that as the concentration of phenylalanine increased, the total phenolic compounds content of seeds increased throughout the range examined. The maximum total phenolic compounds contents (25.45 and 26.23 mg gallic acid /g extract) were detected when plants were sprayed with the highest phenylalanine concentration (300 mg/l) during both seasons, respectively. In this regard, Ellis and Towers (1970) found that addition of phenylalanine to *Salvia officinalis* cell suspension cultures stimulated the production of phenolic acid (rosmarinic). This is consistent with the knowledge that phenylalanine serves as precursor for phenolic acids (Wink, 2010).

Effect of Foliar Application of Tryptophan

Vegetative growth characters

With the reference to Table 5, low concentration (100 mg/l) of tryptophan had no effect on plant height and number of main branches/plant. On the other side, medium and high concentrations (200 and 300 mg/l) significantly improved both characters compared with control and low concentration without significant difference between both concentrations (200 and 300 mg/l). Number of leaves/plant was significantly enhanced as a result for spraying plants with any concentration of tryptophan. There was no significant difference between low and medium concentrations in this regard, while high concentration (300 mg/l) could significantly surpass all other treatments. Herb fresh weight did not influence by foliar application of tryptophan at low concentration, while increasing of tryptophan concentration was concomitant with gradual significant increase in this character. Generally, the maximum values of all recorded growth characters were belonging to the highest concentration (300 mg/l) of tryptophan.

The above mentioned stimulatory effect of foliar application of tryptophan on growth characters especially at high concentration was earlier reported with many plants such as *Iberis amara* L. (Attoa *et al*., 2002), periwinkle (Talaat *et al*., 2005), *Thuja orientalis* (Abdel Aziz *et al*., 2010), thyme plant (Orabi *et al*., 2014) and *Urtica pilulifera* L. (Wahba *et al*., 2015).

It is well known that L-tryptophan is a physiological precursor of auxins in higher plants. It is investigated that L-tryptophan has more positive effect on plant growth and yield as compared to pure auxins (Zahir *et al*., 1999). L-tryptophan is an amazing amino acid. It may act as an osmolyte, ion transport regulator, modulates stomatal opening and detoxify harmful effects of heavy metals (Rai, 2002). Also, Talaat *et al.* (2005) stated that spraying periwinkle plants with low concentrations (10^{-5} M) of tryptophan decreased endogenous levels of gibberellic acid, IAA and cytokinins, while high concentration (10^{-3} M) increased their contents.

Yield and its components

The results in Table 6 indicate that there was a linear relationship between number of fruits/plant and tryptophan concentration. The maximum numbers of fruits (14.83 and 14.16) were recorded with the highest concentration (300 mg/l) of tryptophan during both seasons, respectively. Fruit weight was significantly improved by spraying plants with tryptophan except with low concentration in the first season since this increase did not reach to significant level. The heaviest fruit (127.50 and 170.41 g) were produced when plants were sprayed with the highest concentration (300 mg/l) of tryptophan during both seasons, respectively. In most cases, weight of 1000 seeds did not significantly affect by spraying plants with low and medium concentrations of tryptophan, while high concentration could significantly surpass control in this regard. Seed weight/plant and seed yield/ faddan were elevated by foliar application of tryptophan at any concentration, but these increases did not reach to significant level during first season. The ultimate seed weight/ plant (79.91 and 102.00 g) and seed yield/faddan (1342.4 and 1713.6 Kg) were produced with the highest concentration (300 mg/l) of tryptophan during both seasons, respectively.

This beneficial effect of spraying plants with tryptophan especially at high concentration on yield components was earlier confirmed by El-Awadi *et al.* (2011) on snap bean and Wahba *et al*. (2015) on *Urtica pilulifera* L. plant. This

Table 5. Effect of foliar application of tryptophan on some vegetative growth characters of *Silybum marianum* during both seasons

Tryptophan (mg/l)	Plant height (cm)		No. of main branches/plant		No. of leaves /plant		Herb fresh weight (Kg)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
0	112.75 b	107.67 b	6.00 b	6.50 b	73.83 c	75.00 c	1.430 c	1.434 c
100	120.92 b	117.67 b	7.00 b	7.50 b	103.67 b	107.17 b	1.932 c	1.776 c
200	145.33 a	142.33 a	9.53 a	11.00 a	116.67 b	122.00 b	2.998 b	3.006 b
300	143.33 a	142.00 a	11.33 a	11.66 a	162.17 a	166.17a	3.903 a	3.920 a

Table 6. Effect of foliar application of tryptophan on yield components of *Silybum marianum* during both seasons

Tryptophan (mg/l)	No. of fruits/plant		Fruit weight (g)		Weight of 1000 seeds (g)		Seed weight/plant (g)		Seed yield/faddan	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
0	7.33 d	7.00 c	57.50 c	73.08c	20.62 b	20.49 b	36.41 c	43.50 c	611.6 c	730.8 c
100	9.50 c	9.50 b	76.42bc	105.19b	21.54ab	21.26 ab	46.66 c	63.00 b	783.8 c	1058.4 b
200	11.66 b	10.33 b	94.33 b	109.76b	22.51 a	22.28 ab	64.66 b	65.33 b	1086.2 b	1097.5 b
300	14.83 a	14.16 a	127.50 a	170.41a	23.23 a	22.64 a	79.91 a	102.00 a	1342.4 a	1713.6 a

effect can be interpreted in the light of fact that tryptophan is a physiological precursor of auxins in higher plants. Auxin influences aspects of cell division, cell elongation and cell differentiation. The physiological responses that auxin governs are central to a plant's structure and functioning (Teale *et al*., 2006). It is investigated that tryptophan has more positive effect on plant growth and yield as compared to pure auxins (Zahir *et al*., 1999).

Chemical constituents

Tabulated data in Table 7 indicate that foliar application of tryptophan at any concentration had a stimulatory effect on nitrogen accumulation in leaves. High concentration (300 mg/l) of tryptophan recorded the maximum total nitrogen percentages (2.33 and 2.30 %) in leaves during both seasons, respectively. Spraying plants with low or medium concentrations of tryptophan had no effect on phosphorus percentage in leaves. On the other side, high concentration could significantly elevates this percentage, since it was reached to 0.39 and 0.38 % with this concentration during both seasons, respectively. Treating plants with tryptophan significantly enhanced potassium percentage in leaves except with low concentration during second season since this increase did not reach to the significant level. High concentration of

Table 7. Effect of foliar application of tryptophan on nitrogen, phosphorus, potassium and total carbohydrates percentages in leaves and total phenolic compounds content (TPC) as mg gallic acid/g extract of *Silybum marianum* seeds during both seasons

Tryptophan (mg/l)	Total nitrogen (%)		Phosphorus (%)		Potassium (%)		Total carbohydrates %		TPC (mg gallic acid/g extract)	
	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season	1 st season	2 nd season
0	0.86 d	0.87 c	0.24 b	0.24 b	1.76 c	1.79 c	10.38 b	9.85 b	9.69 d	9.59 d
100	1.51 c	1.61 b	0.28 b	0.28 b	2.32 b	2.12 bc	20.37 a	20.00 a	12.78 c	13.32 c
200	1.90 b	1.99 ab	0.32 ab	0.33 ab	2.67 b	2.52 b	21.70 a	21.70 a	21.41 b	24.43 b
300	2.33 a	2.30 a	0.39 a	0.38 a	3.26 a	3.39 a	25.25 a	25.70 a	25.30 a	25.97 a

tryptophan was the most effective treatment in this regard since it produced the maximum values (3.26 and 3.39%) during both seasons, respectively. Total carbohydrates percentage was significantly raised by spraying plants with any concentration of tryptophan without significant differences among these concentrations (100, 200 and 300 mg/l).

These advantages of spraying plants with tryptophan especially at high concentration for enhancing some major chemical constituents of plant was previously demonstrated on some species such as; *Iberis amara* L. (Attoa *et al*., 2002), *Thuja orientalis* (Abdel Aziz *et al*., 2010), *Thymus vulgaris* L. (Orabi *et al*., 2014) and *Urtica pilulifera* L. (Wahba *et al*., 2015). This may be due to the dual effect of tryptophan as essential component of protein synthesis and as precursor of auxins in higher plants. Auxin influences cell division, cell elongation and cell differentiation, and has great impact on the final shape and function of cells and tissues in all higher plants (Ljung, 2013). Also, it was suggested that IAA-directed transport of metabolites (Tamas *et al*., 1989).

Also, there was a linear relationship between total phenolic compounds content of seeds and tryptophan concentration. The maximum total phenolic compounds contents (25.30 and 25.97 mg gallic acid/g extract) were obtained by spraying plants with the highest tryptophan concentration (300 mg/l) during both seasons, respectively. This result seems to be in harmony with those obtained by El-Awadi *et al*. (2011) on snap bean. This result was supported by Ishihara *et al*. (2008) who postulated that tryptophan biosynthetic pathway can potentially provide phenolic compounds.

REFERENCES

Abdel Aziz, N.G., A.A.M. Mazher and M.M. Farahat (2010). Response of vegetative growth and chemical constituents of *Thuja orientalis* L. plant to foliar application of different amino acids at Nubaria. J. Ame. Sci., 6 (3): 295-301.

Abdel Aziz, N.G., M.H. Mahgoub and A.A.M. Mazher (2009). Physiological effect of phenylalanine and tryptophan on the growth and chemical constituents of *Antirrhinum majus* plants. Ozean J. Appl. Sci., 2 (4): 399-407.

American Botanical Council (1998). The Complete German Commission E Monographs. Therapeutic guide to herbal medicines. Austin, American Botanical Council.

Anonymous (1995). Market Report (1995). Herbalgram, 39: 68.

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. plant. Egypt J. Hort., 29: 17-37.

Bissett, N.G. (1994). Herbal Drugs and Phytopharmaceuticals. London, CRC Press.

Boerjan, W., J. Ralph and M. Baucher (2003). Lignin biosynthesis. Annu. Rev. Plant Biol., 54: 519–546.

Brown, J.D. and O. Lilleland (1964). Rapid determination of potassium and sodium in plant material and soil extracts by flame photometry. Proc. Ame. Soc. Hort. Sci., 48: 341-46.

Davies, P.J. (2010). Plant Hormones: Biosynthesis, Signal Transduction, Action. Springer Sci. + Business Media, USA.

Dixon, R.A., P.M. Dey and C.J. Lamb (1983). Phytoalexins: Enzymology and molecular biology. Adv. Enzymol. Relat. Areas MOI. Biol., 55: 1-135.

El-Awadi, M.E., A.M. El-Bassiony, Z.F. Fawzy and M.A. El-Nemr (2011). Response of snap bean (*Phaseolus vulgaris* L.) plants to nitrogen fertilizer and foliar application with methionine and tryptophan. Nat. and Sci., 9 (5): 87-94.

El-Sherbiny, E.S. and A.E. Hassan (1987). Physiological studies on *Datura stramanium* L., The effect of some alkaloid precursors on growth, chemical composition and leaf alkaloid. Bull. Nat. Res. Cent., 12:101-110.

Ellis, B.E. and G.H.N. Towers (1970). Biogenesis of rosamrinic acid in *Mentha*. J. Biochem., 118: 291-297.

Flora, K., M. Hahn, H. Rosen and K. Benner (1998). Milk thistle (*Silybum marianum*) for the therapy of liver disease. Ame. J. Gastroenterol., 93: 139–143.

Gamal, E.K.M., A.S. Tarraf and L. Balbaa (1997). Physiological studies on the effect of some amino acids and micronutrients on growth and essential oil content in lemon grass. J. Agric. Sci. Mansoura Univ., 22: 4229 - 4241.

Gomez, K.A. and A.A. Gomez (1984). Statistical Procedures for Agricultural Research. Wiley, New York, USA.

Hendawy, S.F. and A.A. Ezz El-Din (2010). Growth and yield of *Foeniculum vulgare* var. azoricum as influenced by some vitamins and amino acids. Ozean J. Appl. Sci., 3 (1): 113-123.

Herbert, D., P.J. Philipps and R.E. Strange (1971). Carbohydrate analysis. Methods Enzymol., 5B: 265-277.

Hucker, T.W.G. and G. Catroux (1980). Phosphorus in sewage ridge and animal waster slurries. Proceeding of the EEC Seminar, Haren (Gr); Groningen Netherlands, 12 - 13 June.

Ishihara, A., Y. Hashimoto, C. Tanaka, J.G. Dubouzet, T. Nakao, F. Matsuda, T. Nishioka, H. Miyagawa and K. Wakasa (2008). The tryptophan pathway is involved in the defense responses of rice against pathogenic infection *via* serotonin production. The Plant J., 54: 481–495.

Jones, D.H. (1984). Phenylalanine ammonia-lyase: Regulation of its induction, and its role in plant development. Phytochem., 23:1349-1359.

Katiyar, S.K. (2005). Silymarin and skin cancer prevention: antiinflammatory, antioxidant and immunomodulatory effects. Int. J. Oncol., 26: 169–176.

Ljung, K. (2013). Auxin metabolism and homeostasis during plant development. Develop., 140: 943-950.

Mahady, G.B., H.H.S. Fong, N.R. Farnsworth (2001). Botanical Dietary Supplements: Quality, Safety and Efficacy. Lisse, Swets and Zeitlinger.

Michigan State University (1983). MSTAT-C Micro Computer Statistical Programe, Version 2. Michigan State Univ., East Lansing.

Morazzoni, P. and E. Bombardelli (1995). *Silybum marianum* (*Carduus marianus*). Fitoterapia, 66: 3–42.

Naguib, M.I. (1969). Colorimeter determination of nitrogen components of plant tissues. Bull. Fac. Sci., Cairo Univ., 43 : 1-9.

Orabi, S.A., I.M. Talaat and L.K. Balbaa (2014). Physiological and biochemical responses of thyme plants to some antioxidants. Bioscince., 6 (2): 118-125.

Rai, V.K. (2002). Role of amino acid in plant responses to stresses. Biol. Plantarum J. 45: 481-487.

Reham, M.S., M.E. Khattab, S.S. Ahmed and M.A.M. Kandil (2016). Influence of foliar spray with phenylalanine and nickel on growth, yield quality and chemical composition of genoveser basil plant. Afr. J. Agric. Res.,11 (16): 1398-1410.

Škerget, M., P. Kotnik, M. Hadolin, A. Rižner-Hraš, M. Simonič and Ž. Knez (2005). Phenols, proanthocyanidins, flavones and flavonols in some plant materials and their antioxidant activities. Food Chem., 89: 191–198.

Smith, W.A., D.R. Lauren, E.J. Burgess, N.B. Perry and R.J. Martin (2005). A silychristin isomer and variation of flavonolignan levels in milk thistle (*Silybum marianum*) fruits. Planta Med., 71: 877–880.

Sonnenbichler, J., I. Sonnenbichler and F. Scalera (1998). Influence of the flavonolignan silibinin of milk thistle on hepatocytes and kidney cells. In: Lawson LD, Bauer R ed. Phytomedicines of Europe. Chem. and Biol. Activity. Washington, Ame. Chem. Soc., 118–132.

Talaat, I.M., A. Bekheta and M.H. Mahgoub (2005). Physiological response of periwinkle plants (*Catharanthus roseus* L.) to tryptophan and putrescine. Int. J. Agric. and Biol., 7 (2): 210-213.

Tamas, I.A., J.L. Schlossberg-Jacobs, R. Lim, L.B. Friedman and C.C. Barone (1989). Effect of plant growth substances on the growth of axillary buds in cultured stem segments of *Phaseolus vulgaris* L. Plant Growth Regulation, 8: 165-183.

Teale, W.D., I.A. Paponov and K. Palme (2006). Auxin in action: signalling, transport and the control of plant growth and development. Molec. Cell Biol., 7:847-859.

Thon, M., A. Maretzki, E. Korner and W.S. Sokai (1981). Nutrient uptake and accumulation by sugar cane cell culture in relation to growth cycle. Plant Cell Tissue and Organ Culture, 1: 3-14.

Tzin, V. and G. Galili (2010). New insights into the shikimate and aromatic amino acids biosynthesis pathways in plants. Molec. Plant, 3 (6): 956–972.

Wahba, H.E., H.M. Motawe and A.Y. Ibrahim (2015). Growth and chemical composition of *Urtica pilulifera* L. plant as influenced by foliar application of some amino acids. J. Mater. Environ. Sci., 6 (2): 499-506.

Waller, G.R. and E. Nawacki (1978). Alkaloid Biology and Metabolism in Plants. Phanum, Press, New York.

Wink, M. (2010). Biochemistry, physiology and ecological functions of secondary metabolites. In Biochemistry of Plant Secondary Metabolism (2nd Ed.). M. Wink, 1-17. New York: Wiley–Blackwell Publishing.

Zahir, A.Z., M.A.R. Malik and M. Arshad (1999). Effect of auxins on the growth and yield of rice. Pak. J. Agric. Sci., 36: 3-4.

Zi, X. and R. Agarwal (1999). Silibinin decreases prostate-specific antigen with cell growth inhibition *via* G 1 arrest, leading to differentiation of prostate carcinoma cells: Implications of prostate cancer intervention. Proc. Nat. Acad. Sci. USA, 96: 7490–7495.

تأثير الرش الورقي بالفينيل ألانين والتربتوفان على النمو والإنتاجية والمكونات الكيميائية لنبات شوك الجمل

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أجرى هذا العمل في المزرعة البحثية التابعة لكلية الزراعية – جامعة الزقازيق (مزرعة الخطارة)، محافظة الشرقية، مصر، خلال موسمين متتاليين لأعوام ٢٠١٣/٢٠١٢ و ٢٠١٤/٢٠١٣، حيث رُشت نباتات شوك الجمل بتركيزات مختلفة (صفر، ١٠٠، ٢٠٠، ٣٠٠ ملليجم/لتر) من الفينيل ألانين أو التربتوفان كل على حده بهدف تقدير تأثير ذلك على النمو والإنتاجية و المكونات الكيميائية لهذا النبات، وقد أثبتت النتائج المتحصل عليها أن أعلى القيم لصفات النمو (طول النبات وعدد الأفرع الرئيسية وعدد الأوراق للنبات والوزن الطازج للعشب) ومكونات المحصول (عدد الثمار للنبات ووزن الثمرة ووزن الألف بذرة ووزن البذور للنبات ومحصول البذور للفدان) والمكونات الكيميائية (النسب المئوية لكل من النتروجين الكلي والفوسفور والبوتاسيوم والكربوهيدرات الكلية بالأوراق والمحتوى الكلي للمركبات الفينولية بالبذور) قد سجلت عند رش النباتات بأعلى تركيز (٣٠٠ ملليجم/لتر) من أي من المركبين كلاً على حده.

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