IMPROVING NUTRITIONAL QUALITY OF HOT PEPPER (*CAPSICUM ANNUUM* L.) PLANT VIA FOLIAR APPLICATION WITH ARGININE OR TRYPTOPHAN OR GLUTATHIONE

Journal

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ABSTRACT

Two field experiments were carried out in the newly reclaimed sandy soil at Nubaria region, Egypt, during two successive seasons (2007 and 2008) to study the effect of foliar application with (50 or 100 mg/l) arginine, tryptophan or glutathione on hot pepper (*Capsicum annuum* L. cv. Albasso) growth parameters; yield; endogenous growth regulators (IAA, GA_3, ABA) as well as nutritive components in the yielded fruits such as ascorbic acid, anthocyanins, tannins, phenolic compounds, carbohydrate content, protein content and amino acids composition. Application of the previously mentioned substances resulted in significant increases in plant growth parameters and yield concomitantly with an increase in the level of IAA, GA_3 and decrease in ABA content as well as increase in all nutritive value parameters as ascorbic acid, anthocyanins, tannins, phenolic compounds, carbohydrate content, protein content and amino acids composition. Generally, promoting effect of glutathione and arginine treatments especially at 100mg/l were more pronounced than tryptophan treatments.

Key words: hot pepper, arginine, tryptophan, glutathione, yield, chemical composition.

INTRODUCTION

Hot pepper is a high valuable vegetable crop that commercially cultivated in Egypt and many countries of the world for its importance in human nutrition as it is excellent source of antioxidants content.

The growth of pepper plants under sandy soil cultivation is suffering from several kinds of stresses such as the lack of soil nutrients and the unfavourable environmental conditions.

The regulation of plant growth, development and biosynthesis of important economic chemical constituents could be achieved through the use of different growth regulating substances, since there is a recent trend to use naturally occurring substances as amino acids and antioxidants.

The application of amino acids before, during and after the stress conditions supplies the plants with amino acids which can directly or indirectly influence the physiological activities of the plant and has a preventing and recovering effect. Supplying the plant cells with hydrolyzed amino acids through foliar spray provides plant with ready made building blocks for protein synthesis. The addition of amino acid or amino acids mixture may be used to stimulate cell growth and facilitate plant regeneration as well as increase fenugreek yield and overall crop quality (Mohammed, 1996). Foliar application of amino acids is based on its requirement by plants especially at critical stages of growth. Amino acids are required by plant for synthesis of proteins, amines, purines, pyrimidines, alkaloids, vitamins and terpenoids as well as important enzymes and hormones which are needed for completing metabolic activities (Rashed et al.,2003).

Amino acid arginine is considered the main precursor of polyamines mainly putrescine. Via putrescine and methionine, the other polyamines are synthesized. Paschalidis and Roubelakis – Angelakis (2005) reported that polyamines, their precursor arginine and their biosynthetic enzymes are involved in the stimulation of cell division, expansion and differentiation as well as vascular development in tobacco plant. Furthermore, polyamines regulate the enzyme activities of plants, these regulations may be attributed to the potential effect of polyamines that acts as free radical scavenger (Todorov et al., 1998). Moreover, polyamines act as antioxidants by inhibiting lipid peroxidation of wheat plants (Hui Guo et al., 2006); as well as retard RNase and DNase action, so it can retard senescence (Papadakis and Roubelakis – Angelakis 2005).

Tryptophan is considered an efficient physiological precursor of auxins in higher plant, low cost and non toxic substance that can be exogenously applied to plants to elicit an auxin response, thus has indirect role on plant growth. Attoa et al., (2002) reported that spraying *Iberis amara* L. plants with tryptophan increased plant growth; total carbohydrates; nitrogen and phosphorous contents.

Glutathione (γ-L glutamyl – L – cystinyl – glycine) is a predominant and most important non protein thiol present in plant cells and an important pool of reduced sulphur. Glutathione is a powerful antioxidant which plays a crucial role in maintaining the normal balance between oxidation and antioxidation; regulates many of the cell vital functions such as synthesis and repair of DNA, synthesis of proteins as well as activation and regulation of enzymes in plants. Also, glutathione protects cells from free radicals and peroxides (Pompella et al., 2003). In addition, glutathione is a crucial for biotic and abiotic stress management. It is a pivotal component of the glutathione – ascorbate cycle, a system that reduces poisonous hydrogen peroxide (Noctor and Foyer, 1998). It is a precursor of phytochelatins, glutathione oligomeres which chelates heavy metals such as cadmium (Suk – Bong Ha et al., 1999) and involved in flower development and plant defence signaling (Rouhier et al., 2008).

Generally, many investigators have concluded that when amino acids are sprayed on potato(commercial amino acid at 200 ppm) (Abd-Elmalek et al., 2005) and on tomato(two commercial amino acids products from plant and animal origin sprayed at two different concentrations (1 and 2 ml l^1) (Cerdan et al., 2009), a marked increase in yield was recorded.

This study is an attempt to improve the limited growth of hot pepper plant under newly reclaimed sandy soil conditions at Nubaria region, Egypt, through improving growth, yield quantity and quality by using naturally occurring substances arginine (precursor of polyamines), tryptophan (precursor of auxins) and glutathione (powerful antioxidant).

MATERIALS AND METHODS

Experimental conditions

Two field experiments were conducted at the experimental station of National Research Centre at Nubaria region North Egypt – during 2007and 2008. The experimental site had a sandy soil texture with pH 7.6, EC 0.19 (Ds/m in soil paste) and the organic matter was 0.21% with 14.00, 8.9, 15.60 mg/100g soil of N, P and K respectively. At soil preparation composts supplemented with full dose of P_2O_5 (90 kg/feddan(fed)) as calcium superphosphate, a half dose of K_2O (60 kg /fed) as potassium sulphate and N (120 kg / fed) as ammonium nitrate were incorporated into the top 15 cm of the soil with a roto – tiller. Whereas, remaining N and K doses were applied 30 days after transplanting. Normal agricultural practices common in the area were followed. A drip irrigation system was designed for the experiment. Laterals were laid in each plant row and inline emitters with discharge rate of 2 L/h were spaced at 30 cm intervals. Hot pepper seedlings (cv. Albasso) 4 weeks old were transplanted on Feb. 25/2007 and Feb. 27/2008 into two rows on 70 cm beds with a 30 cm spacing in the row. The experimental design was a randomized complete block design with four replicates. After one week of transplanting, dead seedlings (~5%) were replaced by planting fresh seedlings to obtain uniform stand.

After 30 days from transplanting, plants were sprayed twice at 15 days intervals with the following treatments:

1- Control
2- L-arginine 50 mg/l
3- L-arginine 100 mg/l
4- L- tryptophan 50 mg/l
5- L- tryptophan 100 mg/l
6- glutathione 50 mg/l
7- glutathione 100 mg/l

Plant sampling

Four plant samples / plot were harvested 75 days after transplanting for determination of the vegetative growth parameters (plant height, number of leaves and branches/ plant as well as plant fresh and dry weight).

Endogenous growth regulators

The endogenous growth regulators, indole acetic acid (IAA), gibberellic acid (GA_3) and abscisic acid (ABA) were estimated in the fresh shoot. Hormone extraction was done using the method adapted by Wasfy and Orrin (1975) and methylation processes was carried out according to the method described by Vogel (1975). Identification and determination were carried out by Helwett Packered gas liquid chromatography (5890) with a flame ionization detector. Standards of IAA, GA_3 and ABA were used.

Total yield measurement

The days when hot pepper plants first flowered were noted down as well when the fruits reached their physiological maturity, ripe fruits were harvested two times weekly. Yield was determined by counting and weighing all fruits on each plant and total yield (ton/fed) was calculated. Fruit length and diameter as well as fresh and dry weight were measured.

Chemical compositions of fruits

Ascorbic acid content of hot pepper fruit was determined according to the method described by Nielsen (1998). Anthocyanins were extracted and measured as the method described by Tibor and Francis (1967). Tannins were determined using the modified hydrochloric acid (MV - HCl) as reported by Maxson and Rooney (1972). Phenolic compounds were estimated according to Snell and Snell (1953) by using Folin and Ciocalteu phenol reagent. Bradford (1976) method was used to determine protein content. Total carbohydrates were estimated colorimeterically according to Dubois et al., (1956). For amino acids determination, hydrolysis was carried out according to the method of Gehrke et al., (1985) and analysis was performed on an Eppdrof LC 3000 amino acid analyzer.

Statistical analysis

The data obtained were statistically analyzed using ANOVA and means of separation was done using LSD test at 5% probability according to the method described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Growth parameters

Changes in growth parameters of hot pepper plant as a result of foliar application with 50 or 100 mg/l arginine or tryptophan or glutathione are illustrated in Fig. (1). It is obvious, that all treatments increased plant height ; number of branches and leaves as well as fresh and dry weight / plant relative to control plants. The increments in fresh weight / plant ranged between (25.75% - 87.71%) and in dry weight / plant (31.47% - 74.13%) compared to control plant.

Generally, the magnitude of increase in growth parameters increased as the concentration of the previously mentioned treatments increased. Furthermore, the magnitude of increase was more pronounced by applying either arginine or glutathione than tryptophan. With superiority of arginine when compared with glutathione

These results are in agreement with those obtained by Mohammed (1996) who mentioned that addition of amino acid or amino acids mixture could be used to stimulate cell growth and facilitate plant regeneration. Moreover, Neeraja et al., (2005) and El - Tantawy (2009) reported that application of amino acids (aminofort) at 150 ppm enhanced plant growth expressed in vegetative growth, fresh and dry weight of plant as well as increased the chlorophyll concentration of tomato leaves.

The promoting effect of arginine was proved earlier by Zhong-Xiao Hong et al., (2004) on strawberry; El – Bassiouny et al., (2008) on wheat and Hozayn et al.,(2008) on faba bean.

Regarding the promoting effect of tryptophan, our results are in agreement with those reported by Attoa et al., (2002) on *Iberis amara* ; Dawood and Sadak (2007) on canola.

In respect to glutathione promoting effect, Tallat and Aziz (2005) found that application of glutathione significantly increased plant height, number of branches, fresh and dry weight of *Matricaria chamomilla.* Moreover, glutathione treatments induced an increase in growth parameters of canola even under saline conditions (Khattab, 2007).

Generally, such increases in growth parameters could be attributed to the promoting effect of applied treatments on cell division and / or cell enlargement and differentiation.

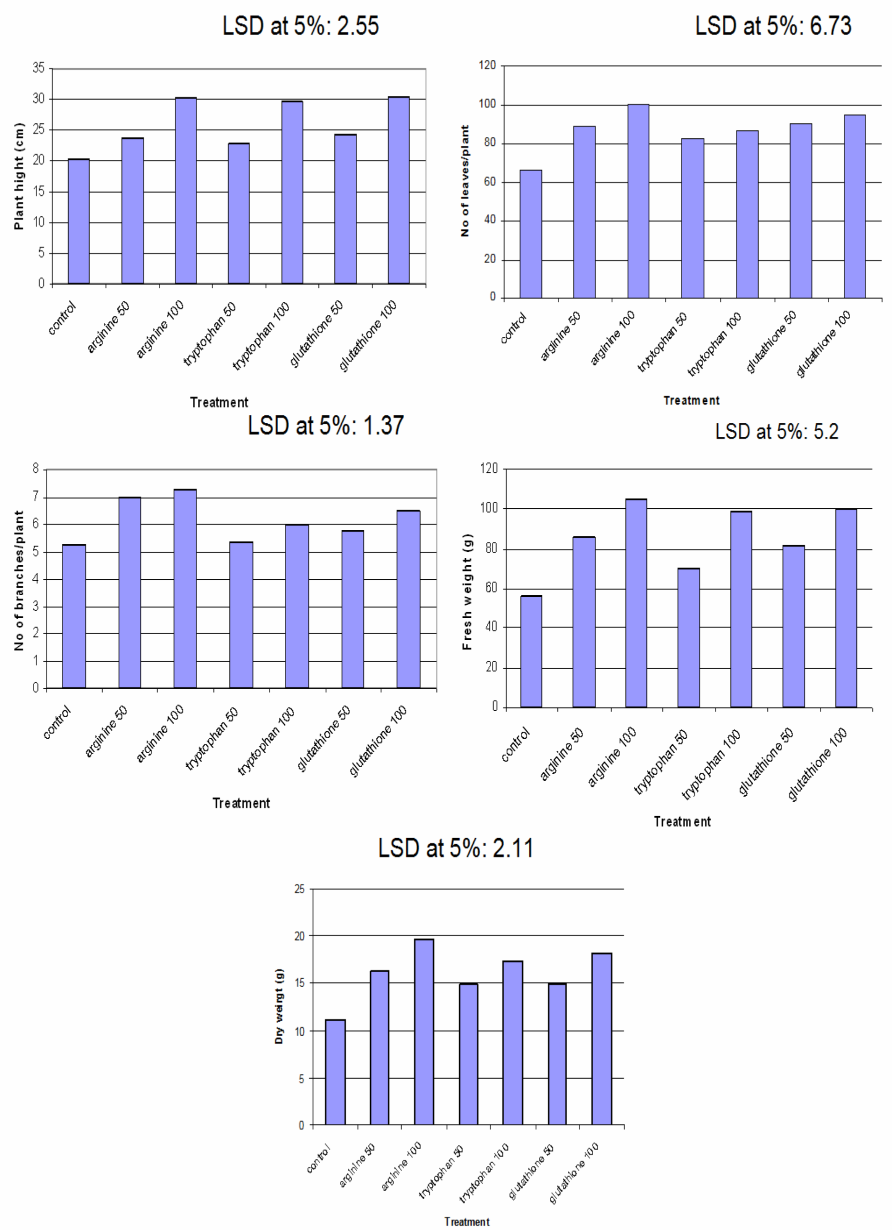

Fig. (1): Effect of foliar application with arginine, tryptophan or glutathione on growth parameters of hot pepper plant (combined analysis of two seasons)

Endogenous growth regulators

Data presented in Table (1) show that foliar application with (50 or 100 mg/l) arginine, tryptophan or glutathione effectively increased the amounts of endogenous growth promoters (IAA and GA_3) concomitant with a decrease in the inhibitor (ABA) in the treated plants. The maximum increase in IAA resulted from tryptophan treatments followed by glutathione and arginine treatments. On the other hand, glutathione treatments resulted in maximum increase in GA_3 and maximum decrease in ABA. Arginine effect is intermediate between glutathione and tryptophan effect.

Table (1): Effect of foliar application with arginine, tryptophan or glutathione on endogenous acidic growth regulators (µg/100g fresh weight) of hot pepper (combined analysis of two seasons).

Treatments		IAA	GA_3	ABA
Control		6.83	42.34	12.5
Arginine mg/l	50	8.00	57.99	8.21
	100	8.24	60.41	7.06
Tryptophan mg/l	50	11.21	51.34	9.41
	100	14.45	53.50	8.34
Glutathione mg/l	50	9.24	71.32	6.80
	100	10.39	75.24	6.19

These results are coinciding with those obtained by Harridy (1986) who mentioned that tryptophan treatment on periwinkle (*Catharanthus roseus)* plant increased IAA concentration. The increase of indoles may be attributed to the conversion of tryptophan to IAA. El-Bassiouny (2005); Dawood and Sadak (2007) reported that IAA and GA_3 increased and ABA decreased as a result of tryptophan treatments application to wheat plants under saline condition and canola respectively.

It was mentioned by El-Bassiouny (2004) and Hussein et al., (2006) on pea plants that putrescine treatments have promoting effect on IAA and GA_3 and suppressing effect on ABA. Moreover, Bekheta and El-Bassiouny (2005) demonstrated that putrescine increased the auxin content in treated wheat plants due to retarding the destruction of endogenous auxins through decreasing the activity of IAA- oxidase.

The increases in the endogenous growth promoting substances in response to arginine might be attributed to its effect on increasing the biosynthesis of the endogenous growth promoters and/ or decreasing their inactivation. The increase in the different growth promoters could be occurred through retarding the biosynthesis of hormone degradative enzymes and / or repressing their activities or through preventing the transformation of these active substances into inactive forms (El-Bassiouny et al., 2008). On the other hand, the reduction in ABA could be attributed to the antagonistic effect of polyamines to ABA synthesis and / or action. Smith (1985) mentioned that the application of polyamines stimulate α amylase synthesis in aleurone layer which is inhibited by ABA. This means that polyamines acting antagonistically to ABA action. In addition, amino acids can affect plant growth and development through their influence on gibberellin biosynthesis (Abd El-Aziz and Balbaa, 2007).

Fruit yield and its characteristics

Regarding to the yielded fruit characteristics (Fig. 2), all applied treatments induced significant increase in number of fruits, fresh and dry weight of fruits/plant as well as fruit yield (ton/fed) relative to control except at 50 mg/l either arginine or tryptophan that showed non significant increase in fruit fresh weight/plant. The increments in fruit yield (ton/fed) are significant and ranged between (16.04 – 92.59%) relative to control plants. It is worthy to mention that these results are in harmony with the vegetative growth parameters that illustrated in Fig. (1) since the enhancing effect of either arginine or glutathione is more pronounced than tryptophan. The increments in fruit length are non significant due to all applied treatments whereas treatments at higher concentrations (100 mg/l) showed significant increases in fruit diameter.

El-Tantawy, (2009) reported that tomato marketable yield was increased as a result of amino acid application and this may be attributed to the increase in leaves chlorophyll content leading to increment in carbohydrate synthesis and consequently increment in plant production. Also, application of amino acids increased pollen germination and the length of pollinic tube leading to increment in fruit set percentage, average fruit weight, and yield/plant

The increase in yield of hot pepper fruits as a result of arginine treatments (Fig. 2) are in agreement with those reported by El – Bassiouny et al., (2008) on wheat and Hozayen et al., (2008) on faba bean. Since some physiologists use arginine as a precursor of polyamines, Davis (1995) reported that polyamines play a critical role in different biological processes including cell division, growth and floral initiation.

Concerning the role of tryptophan, our results are supported by Zhong – Xiao Hong et al., (2004) on strawberry; Dawood and Sadak (2007) on canola plant. Furthermore, Frankenberger and Arshad (1991) revealed that 60 ppm L-tryptophan applied as foliage spray resulted in pronounced increase in fresh pepper fruit weight / plant.

Moreover, Mostafa (1998) reported that glutathione significantly induced positive effects on pomegranate fruit weight as well as fruit maturity. Glutathione enhances the photosynthetic activities and chlorophyll biosynthesis or retard chlorophyll degradation and integrated into primary metabolism as well as it can influence the functioning of signal transduction pathway by modulating cellular redox state (Khattab, 2007) thus return in increasing crop yield.

It is worthy to mention that there is a close relationship between the enhancement effect of different treatments on acidic growth regulators (IAA and GA_3) (Table,1) which appeared in enhancement growth parameters (Fig.1) that reflect the increase in yield (Fig.2). These increments could be partially or totally attributed to the physiological roles of such substances as growth regulators and antioxidants as well as having the power to increase the amount of assimilates and increasing their translocations from leaves to fruits.

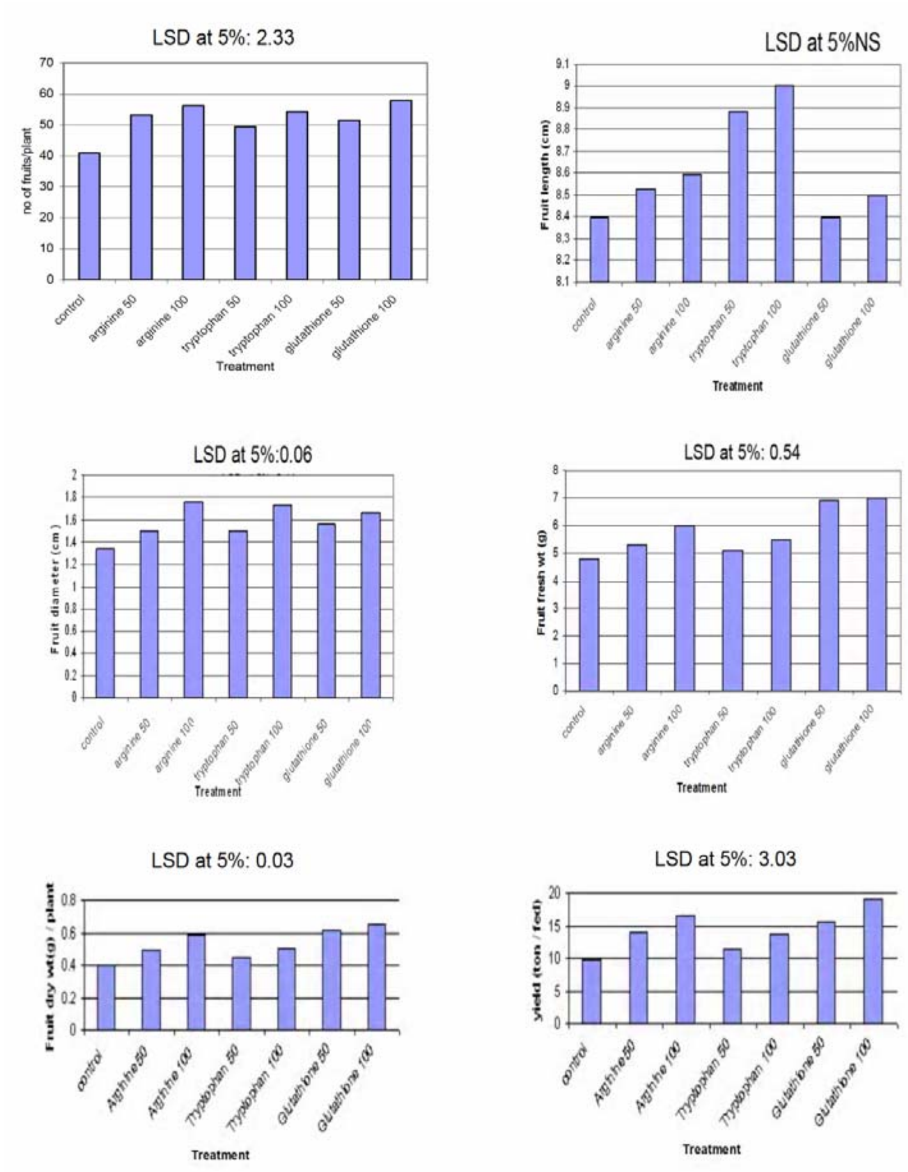

Fig.(2): Effect of foliar application with arginine, tryptophan or glutathione on the yield of hot pepper fruit and its characteristics (combined analysis of two seasons)

Chemical composition of the yielded fruits

Special attention was paid to the chemical composition of hot pepper fruits that eaten by human and considered as best source of antioxidants. Data in Table (2) show that ascorbic acid (vitamin C) increased significantly as a result of all applied treatments except at 50 mg/l tryptophan that showed non significant change. Moreover, glutathione treatments were the most effective followed by arginine treatments.

Parvez et al., (2000) stated that L – tryptophan enhanced ascorbic acid of tomato. Moreover, Khattab, (2007) reported the marked increase in ascorbic acid in canola plants pretreated with exogenous glutathione and the increase in ascorbic acid was 3 folds compared to stressed control (under salinity stress).

Anthocyanins, tannins and phenolic compounds (Table 2) of the yielded fruits increased significantly due to all treatments. The increase in anthocyanins was more pronounced by arginine followed by glutathione and lastly by tryptophan. Whereas, the increase in tannins due to tryptophan treatments > arginine treatments > glutathione treatments. However, the increases in phenolic contents similar to that of ascorbic acid, where glutathione effect >arginine effect > trypyophan effect.

These results are supported by Abd - El Aziz et al., (2009) who reported that putrescine treatments increased total phenols of gladiolus plants. In addition, spraying auxin at the beginning of flowering of potatoes increased phenols (Chandra and Mondy, 2006). The increase in total phenolic content was concur with the increase in IAA contents in shoots which reflected in stimulating the growth and yield of plant. Moreover, Graham and Graham (1996) found that applying glutathione led to increase the phenolic polymers content in soybean plant. Khattab, (2007) reported that priming of canola seeds by soaking in glutathione stimulates the accumulation of phenols under stress condition. Phenols protect the cells from potential oxidative damage and increase stability of cell membrane.

Table (2): Effect of foliar application with arginine , tryptophan or glutathione on the chemical composition of hot pepper fruits (combined analysis of two seasons)

Treatments		Ascorbic acid**	Anthocyanins*	Tannins %	Total phenolic compounds %	Protein content %	Carbohydrate content %
Control		95.96	47.16	0.33	0.64	10.56	20.14
Arg. mg/l	50	121.21	88.20	0.43	0.78	13.60	22.92
	100	124.70	99.72	0.60	0.89	15.42	24.39
Try. mg/l	50	94.17	57.24	0.44	0.76	12.47	22.32
	100	121.17	60.48	0.75	0.77	13.47	23.39
Glu. mg/l	50	128.66	65.04	0.36	0.82	12.85	24.75
	100	147.71	76.31	0.51	0.88	14.39	25.38
LSD 5%		15.65	1.20	0.02	0.03	0.89	1.17

**mg/100g fresh wt. *mg/g dry weight % is on dry weight basis

Protein and carbohydrate content of the yielded fruits (Table, 2) increased significantly, however, tryptophan treatments showed the lowest effect on both parameters, while glutathione was more effective in increasing carbohydrate content than arginine. Vice versa appeared in protein content.

Thus we can detect that glutathione treatments were the most effective in increasing ascorbic acid, total phenolic compounds and carbohydrate content of the fruits whereas arginine treatments were more pronounced in increasing anthocyanins and protein content. On the other hand, tryptophan treatments showed the lowest positive effect on different parameters except on tannins content.

These results of arginine are agreement with those reported by El- Bassiouny et al., (2008) on wheat; Hozayen et al., (2008) on faba bean. It has been reported by Hussein et al., (2006) that putrescine treatments resulted in an increase in the biosynthesis of nucleic acids, macromolecules particularly protein and photosynthetic pigments thus improve nutritive value.

Regarding tryptophan effect, our results are similar to those obtained with Attoa et al., (2002) on *Iberis amara* and with Dawood and Sadak (2007) on canola plant. This may be attributed to enhancing effect of tryptphan on photosynthetic pigments and consequently increased carbohydrates percentage.

In respect to glutathione, May et al., (1998) illustrated the beneficial roles of glutathione in the synthesis of proteins and nucleic acid as well as modulator of enzymes activities. Talaat and Aziz (2005) mentioned that foliar application of glutathione to chamomile plants significantly increased total sugars as well as total nitrogen in the herb.

Generally the increase in protein content resulted from all treatments may be attributed to the translocation of amino acids from shoots to fruits and thus increasing protein synthesis.

It has been found in the present investigation, that the different treatments of arginine or tryptophan or glutathione increased total amino acids relative to control (Table, 3). The highest increase in total amino acids reached (36.35%) followed by (24.43%) resulted from 100 mg/l arginine and glutathione respectively. While, the lowest increase was (12.59%) due to 50 mg/l glutathione. Regarding to the essential amino acids (EAA), 100 mg/l arginine caused the highest increase in EAA by 69.41%. The predominant Non EAA are glutamic acid and proline followed by aspartic acid whereas the predominant EAA are threonine and tyrosine.

Abd El-Aziz and Balbaa (2007) mentioned that amino acids act as buffers which help to maintain favourable pH in the plant cell, since they contain both acid and basic groups. They remove ammonia from the cell, this function is associated with amide formation, so they protect the plants from ammonia toxicity. Moreover, amino acids take part in the synthesis of proteins, amines, purines, pyrimidines, alkaloids, vitamins, enzymes and terpenoids. In addition, Smith and Wood (1992) reported that putrescine application significantly increased proline. The increase in proline content in pea shoots may be refer to catabolic processes of polyamines to pyrroline which can be reduced to proline. Furthermore, proline is a protective agent of enzyme and membrane (Solomon et al.,1994) and as an intracellular structure (Van Rensburg et al., 1993) or as storage compound of carbon and nitrogen for rapid recovery from stress. El-Bassiouny(2004) reported that putrescine was more effective in increasing proline content in pea plants over control. Kesba (2005) found that foliar application of arginine mainly enhanced the levels of proline in grape roots.

Table(3): Effect of foliar application with arginine , tryptophan or glutathione on the amino acids composition of hot pepper fruits(combined analysis of two seasons)**

	Treatments						
Amino acids	**Control**	**Arg. 50mg/l**	**Arg. 100mg/l**	**Try. 50mg/l**	**Try. 100mg/l**	**Glu. 50mg/l**	**Glu. 100mg/l**
Alanine	0.23	0.36	0.33	0.29	0.29	0.29	0.37
Arginine	0.57	0.78	0.87	0.69	0.70	0.60	0.81
Aspartic acid	0.90	0.98	1.80	0.96	1.13	1.20	1.50
Glutamic acid	1.65	1.79	1.82	1.78	2.04	1.95	2.10
Glycin	0.50	0.50	0.46	0.44	0.41	0.46	0.52
Histidine	0.69	0.72	0.79	0.63	0.59	0.64	0.62
*Isoleucine	0.36	0.46	0.42	0.38	0.39	0.39	0.41
*Leucine	0.61	0.63	0.68	0.62	0.65	0.58	0.60
*Lysine	0.65	0.74	0.76	0.81	0.74	0.75	0.72
*Methionine	0.45	0.42	0.45	0.48	0.69	0.39	0.52
*Phenylalanine	0.42	0.65	0.90	0.64	0.52	0.49	0.60
Proline	1.14	1.25	1.31	1.14	1.31	1.30	1.49
Serine	0.19	0.40	0.41	0.66	0.51	0.33	0.23
*Threonine	0.93	1.07	1.97	1.24	1.19	1.10	1.02
*Tyrosine	0.74	0.88	0.87	0.98	0.77	0.87	0.98
*Valine	0.45	0.55	0.45	0.44	0.57	0.47	0.57
Total EAA*	4.61	5.40	7.81	5.64	5.52	5.04	5.40
Total Non EAA	5.87	6.78	6.48	6.59	6.80	6.76	7.64
Total AA	10.48	12.18	14.29	12.23	12.32	11.80	13.04

** % of fruit dry basis

Finally we can conclude that foliar application of arginine, tryptophan or glutathione at (50 or 100 mg/l) has a positive effect on growth parameters; yield; endogenous growth promoters, ascorbic acid, anthocyanins, tannins, phenolic compounds, carbohydrate, protein and amino acids contents in the yielded fruits and generally, the promoting effect of glutathione and arginine treatments especially at 100 mg/1 were more pronounced than tryptophan treatments.

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تحسين القيمة الغذائية لثمار الفلفل الحار عن طريق الرش الورقي بالارجنيين أو التربتوفان أوالجلوتاثيون

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أجريت تجربتان حقليتان بالأراضي الرملية المستصلحة حديثا في منطقة النوبارية- جمهورية مصر العربية - في موسميين متتاليين (2007 و2008) لدراسة تأثير الرش الورقي بتركيزي 50 أو100 مجم/لتر لكل من الارجنيين أو التربتوفان أو الجلوتاثيون على النمو والمحصول والمحتوى الهرمونى (أندول حمض الخليك وحمض الجبريليك وحمض الابسيسيك) و المحتوى الكيميائي لثمار الفلفل الحار(حمض الاسكوربيك والانثوسييانيين والتانينات والمواد الفينولية والكربوهيدراتية والبروتينية والأحماض الأمينية). وقد أظهرت الدراسة أن استخدام المواد السابق الإشارة لها أدت إلى زيادة معنوية في النمو والمحصول متلازمة مع زيادة فى أندول حمض الخليك وحمض الجبريلييك وانخفاض فى حامض الابسيسيك وكذلك زيادة في كل من حمض الاسكوربيك والانثوسييانيين والتانينات والمواد الفينولية والكربوهيدراتية والبروتينية والأحماض الأمينية. وبصفة عامة كان لكل من معاملات الجلوتاثيون و الارجنيين تأثير أعلى من معاملات التربتوفان.

توصى هذه الدراسة أن معاملات الرش الورقي لنبات الفلفل الحار بالارجنيين أو التربتوفان أو الجلوتاثيون لها تأثير جيد على تحسين إنتاج ثمار الفلفل الحار المنزرع في الأراضي الرملية المستصلحة حديثا بالإضافة إلي تحسين القيمة الغذائية للثمار.