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EFFECT OF FOLIAR SPRAYING WITH ARGININE AND CYSTEINE AND THE NUMBER OF STEMS ON THE GROWTH AND YIELD OF CHERRY TOMATOES GROWN IN PROTECTED CULTURE

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Abstract

Experiment was carried out in experimental field of Faculty of Horticulture from Bucharest in 2018, in a polyethylene tunnel. Biological material used was Romanian tomato cherry variety, named Ema de Buzau. Two amino acids were used, arginine and cysteine, in 2 concentrations, 200 ppm and 400 ppm, which were applied by spraying on plants once a week for 4 consecutive weeks, and the plants were conducted with 1 and 2 strains. Research results showed that most parameters were influenced by use of amino acids. Thus, stem diameter in the lower part was higher in plants treated with cysteine 200 ppm (1.11 cm) and cysteine 400 ppm (1.23 cm) compared to control 0.94 cm. Plant height was more influenced by arginine, being of 246.85 cm (at 400 ppm) and 241.5 cm (at 200 ppm) and by cysteine at 400 ppm (243.45 cm) than cysteine at 200 ppm. Photosynthesis and chlorophyll content were positively influenced by application of amino acids at all 4 concentrations compared to control. Number of stems didn't influence significantly these parameters. Average fruit weight was insignificantly influenced by the use of amino acids and poorly influenced by the number of stems. Plants with 2 stems had fruits of 5.8 g compared to 5.89 g at plants with 1 stem. Production per plant was higher due to application of amino acids arginine and cysteine at doses of 400 and 200 ppm, compared to control. Stems number had a great influence on total production, ranging from 2099.28 g/pl. at plants conducted with 2 stems compared to 864.23 g/pl. at those conducted with 1 stem.

Key words*: arginine, cysteine, average fruit, fructification, tomatoes.*

INTRODUCTION

Tomato consumption has grown both on Romanian and international markets, due to beneficial compounds of fruits for the human body. Cherry tomatoes (*Lycopersicon esculentum* Mill. Var. *cerasiforme*) are particularly appreciated by consumers compared to large fruit tomatoes, due to fruit appearance, high yields of cultivated varieties and hybrids, and superior organoleptic qualities of fruits (Cobryń and Hallmann, 2005; Menezes et al., 2012). Cherry tomatoes represent a commercial attraction in supermarkets (Menezes et al., 2012) Fruits are characterized by high lycopene content, carotene, vitamins, calcium, magnesium, phosphorus and other elements (Filgueira, 2013), antioxidants (Kalogeropoulos et al., 2012), contributing to prevention of cardiovascular diseases and cancer (Gong et al., 2006). Cherry tomatoes can be grown in different crop systems, namely in greenhouses, solariums and in the field. It is also an attraction for utilitarian gardens, plants having a particular ornamental appearance being put to good use by plant height, large dark green leaves, and especially large number of fruits, with colorful and attractive shapes. Tomatoes react very well to various technological interventions, more stems being a yield-enhancing solution, but fruits have a slightly

lower weight and firmness (Cándido et al, 2018, Hoza et al., 2012, 2013 and 2018). Amino acids are organic substances that play a role in protein formation, with a role in plant growth, increasing their resistance to various stress factors, and improving the organoleptic quality of edible parts. In plants, 20 essential or non-essential amino acids are commonly found. Arginine is an essential amino acid present in structural proteins and important for plant growth and development (Thabet, 1991; Yang and Gao, 2007), a precursor for amines with a role in plant growth, cell division and slowing of aging improves thermal stress (Barand et al., 2015, Zhang et al., 2010) and oxidative stress (Nasibi et al., 2013). Cherry tomatoes treatment with arginine and stored at 2° C for 28 days, lowers cold disturbances, increases the concentration of nitric oxide and accumulation of polyamines by increasing the activity of specific catabolic enzymes (Zhang et al., 2013)
Cysteine acid is the metabolic precursor of essential biomolecules, such as vitamins, antioxidants and many defense compounds (Consolacio'n et al, 2012). Cysteine acid is almost exclusively a metabolic input for reducing sulfur in cellular metabolism when biosynthesis of essential compounds is nedeed, including methionine, thiamine, biotin, coenzyme A and Fe/S (Wada and Takagi, 2006; Wirtz et al., 2004). Cysteinic acid plays a role in protein stability by forming disulfide bonds (Wirtz et al., 2004; Wada and Takagi, 2006), as well as in cellular processes such as redox cycles, detoxification of heavy metals and xenobiotics, and metabolism of byproducts, Saito, 2000). Cysteine has antioxidant properties in fruits and vegetables (Demirkol et al., 2004). Although the role of amino acids on plants is clearly accepted, there is little information about isolated effect of some amino acids on plants, as most studies were made with products that had more amino acids in composition (Khan et al., 2009; Colla et al., 2014), which is why this study has been carried out and will continue.

MATERIALS AND METHODS

Experiment was carried out in the experimental field from the Faculty of Horticulture Bucharest, in a polyethylene tunnel, in 2018. Research aim was to evaluate and analyze the effect of foliar application of two amino acids, on cherry tomatoes growth and fructification, conducted with one and two stems. Biological material used was the Romanian cherry tomato variety, Ema de Buzau, a very productive variety, with spherical, red fruits. Seedlings were produced greenhouse, seeds being sowed on March 12th. Seedlings were planted on May 2nd, in equidistant rows at a distance of 80 cm between rows and 40 cm between plants per row, at plants with one stem resulting in 3.1 pl/m^2 and at 1m/0.4 m at plants conducted with 2 stems, resulting in 2.5 pl/m^2.

Soil in the experiment had a pH of 6.5, EC 0.180 dSm^{-1}, N-NO_3-34.33 ppm, N-NH_4-112.54 ppm, phosphorus and potassium 21.0 ppm and 177.72 ppm respectively. Prior to planting, soil was fertilized with Dix 10 N 300 g/m^2. Plants were conducted with one and two stems. Those with 2 stems were obtained by cutting the stem over cotyledon leaves, when the first pair of true leaves was well formed (Figure 1 and 2).

Figure 1 Cutting of tomato plants

Foliar treatments with arginine and cysteine amino acids were applied in two concentrations, 200 and 400 ppm by spraying, first application being on 1.06.2018, then repeated once a week for 3 weeks, both in plants with a stem and plants with 2 stems. During vegetation period, all sprouts were removed from plants and specific care recommended for tomatoes was applied, namely repeatedly dripping irrigation, phytosanitary treatments for diseases and pests and foliar fertilization with Kristalon 0.5%, 2 times in 3 weeks, the first being on 29.06.2018.

Figure 2 The growth of the stems

Experience diagram

Experience had 2 factors, organized by randomized block method with 3 replications and 5 plants per replication, using a cherry tomato cultivar conducted on 1 and 2 stems, applying 2 amino acids in two concentrations. Control was also conducted on 1 and 2 stems, without application of amino acids.

Following measurements were made: plant height, from the soil to top of the plant, once a week until 8^{th} inflorescence; stem diameter at beginning of harvest using the Vernier Caliper apparatus, chlorophyll content of leaves (mg/m^2) with CCM_200PLUS chlorophyll-meter, determining the photosynthesis (µmol CO_2 m^{-2} s^{-1}) 4 weeks after planting and one week after application of amino acids using portable LCI apparatus (ADC Bioscientific Ltd.), determining percentage of fruit formation according to the number of flowers formed, determining average fruit harvest by counting and weighing the fruits on variants at 4 harvests and calculating production/plant. Statistical interpretation was made by ANOVA and Tukey's Multiple Comparison Test using the SPSS 18.0 statistic software by LSD at the 5% level of significance.

RESULTS AND DISCUSSIONS

Effect of amino acids and number of stems on plant growth parameters

Arginine and cysteine amino acids in concentration of 200 ppm and 400 ppm and the way plants were conducted, with 1 and 2 stems, have more or less influenced plant growth processes.

Analyzing data from Table 1, it was observed that plants conducted on 1 stem and treated with arginine 200 ppm and 400 ppm and cysteine 400 ppm had the highest height respectively 251.2 cm and 252.5 cm comparative with cysteine 200 ppm, 231.2 cm. Control obtained lowest height, respectively 208.4 cm. In plants run with 2 stems, at all variants, plant height was smaller than those with 1 stem, but larger than control that had 184.7 cm. This is explained by the fact that amino acids, especially arginine, stimulate growth of potassium and phosphorus content of plants and the synthesis of proteins and enzymes with a role in growth, division and expansion of cells (Ahmad et al, 2010, Faraj and Abbdul Wahab, 2011, Ibrahim, 2013).

Table 1. Effect the amino acids and number of stems on some growth parameters of cherry tomato

Treatments		Plant height (cm)	Stem diameter (cm)	Chloro-phyll content mg/m^2	Photosynthesis µmol CO_2 m^{-2} s^{-1}
Control	Single stem	208.4d	0.98c	19.07d	15.29b
	Double stems	184.7e	0.90d	18.12d	15.74b
Arginine 200ppm	Single stem	251.2ab	1.15b	26ab	19.18a
	Double stems	242.5b	1.22b	20.45cd	19.91a
Arginine 400ppm	Single stem	252.5a	1.02c	28.25a	20.53a
	Double stems	230.5c	1.30a	21.43cd	19.68a
Cysteine 200ppm	Single stem	231.2c	1.02c	29.35a	20.26a
	Double stems	213.1d	1.2b	23.04bc	16.47b
Cysteine 400ppm	Single stem	251.2ab	1.16b	27.08ab	19.62a
	Double stems	235.7b	1.30a	23.93b	16.48b
S.E		9.76	0.07	3.97	2.11

Stem diameter was very little influenced by studied factors. However, it is noteworthy that arginine and cysteine amino acids at 400 ppm concentration, at plants with 2 stems, determined the increase of stem diameter more than in other variants, value being 1.3 cm. Chlorophyll content from leaves was higher in plants with 1 stem, treated with cysteine 200 ppm, 29.35 mg/m^2, followed by: arginine 400 ppm, 28.25 mg/m^2, cysteine 400 ppm 27.08 mg/m^2 and arginine 200 ppm 26.0 mg/m^2 compared to control 19.07 mg/m^2. In plants with 2 stems, chlorophyll content was lower than in those with 1 stem, but higher than control, which recorded 18.12 mg/m^2. By combining the number of stems with the use of amino acids it was found that photosynthesis recorded higher values for arginine 400 ppm and cysteine 200 ppm with 1 stem, respectively 20.53 µmol CO_2 m^{-2} s^{-1} and 20.26 µmol CO_2 m^{-2} s^{-1}. Lowest values were in cysteine with both concentrations in plants with 2 stems.

Effect of amino acids on plant growth parameters

Application of arginine and cysteine amino acids has significantly influenced some growth parameters in cherry tomatoes (Table 2).

Table 2. The effect of the amino acids on some growth parameters of cherry tomato

Treatments	Plant height (cm)	Stem diameter (cm)	Chloro-phyll content mg/m^2	Photo-synthesis µmolCO_2 m^{-2} s^{-1}
Control	196.55d	0.94b	18.59c	15.51c
Arginine 200ppm	246.85a	1.18a	23.22b	19.54ab
Arginine 400ppm	241.5b	1.16a	24.84ab	20.10a
Cysteine 200ppm	222.15c	1.11a	26.19a	18.36ab
Cysteine 400ppm	243.45ab	1.23a	25.50a	18.05b
S.E	5.32	0.14	1.65	2.02

Average plant height was between 222.15 cm (cysteine 200 ppm) and 246.85 cm (arginine 200 ppm) versus 196.55 cm in the untreated control. Stem diameter was slightly influenced by application of amino acids, stem thickness being over 1 cm in all variants compared to control at which it was 0.94 cm. Regarding to leaves chlorophyll content, amino acid cysteine at 200 ppm and 400 ppm reached the highest values, an accumulation of 26.19 mg/m^2 and 25.5 mg/m^2, respectively. Also, arginine amino acid 200 ppm and 400 ppm determined higher chlorophyll content compared to control, but slightly lower than after cysteine amino acid application with the two concentrations. Intensity of photosynthesis increased after application of amino acids in the two concentrations. Highest intensity was recorded for arginine 400 ppm, 20.10 µmol $CO_2m^{-2}s^{-1}$, followed by arginine 400 ppm, 19.54 µmol $CO_2m^{-2}s^{-1}$ and values over 18 µmol $CO_2m^{-2}s^{-1}$ were obtained at cysteine 200 ppm and 400 ppm. Control recorded lowest values, 15.51 µmol CO_2m^{-2} s^{-1}, which demonstrates the role of amino acids in this plant growth process. At all analyzed parameters, results were statistically assured.

Number of stems effect on plant growth parameters

Number of stems with which plants were conducted significantly influenced their growth and chlorophyll content. Plants with 1 stem recorded the highest height (238.90 cm) and highest content in chlorophyll 25.95 mg/m^2. Stem diameter and photosynthesis were not influenced by stems number (Table 3). This can be explained by the fact that between single stem plants competition for water, nutrients and light is lower than between two-stemmed plants, at which consumption is higher.

Table 3. The effect of the number stem on some growth parameters of cherry tomato

Treatments	Plant height (cm)	Stem diame-ter (cm)	Chloro-phyll content mg/m^2	Photosyn-thesis µmolCO_2m^{-2} s^{-1}
Single stem	238.90a	1.06	25.95a	18.97
Double stems	221.30b	1.18	21.39b	17.65
SE	5.42	NS	2.44	NS

Effect of amino acids and stem number on some production parameters for cherry tomatoes

Data presented in Table 4 shows that fruit set percentage was influenced by application of amino acids for both concentrations, to plants conducted on 1 and 2 stems. Fruit set percentage was 68.64% for arginine 200 ppm in plants with 1 stem and 69.32% for plants with 2 stems, followed by cysteine 400 ppm in both modes (65.87% and 67.49%). Cysteine 200 ppm treatment had a higher effect on fruit formation in 2-stem plants than in 1 stem (65.78% and 60.05%). Lowest percentage of fruit set was obtained at control in both conduction ways (55.68% and 54.31%). Regarding fruits average weight, application of amino acids determined its increase compared to control. Largest fruits were obtained after application of arginine and cysteine 400 ppm to plants with 1 stem (6.7g and 6.71g). On plants with 2 stems, at all studied variants, average fruit weight was lower than those with 1 stem. Same results were obtained in other experiments (Cándido et al., 2018, Hoza et al, 2012, 2013 and 2018). Fruit weight at the control was below 5 g.

Table 4. Effect of foliar application with Arginine and Cysteine and number of stems on some yield parameters of cherry tomato

Treatments		Fruit set (%)	Average of Fruit weight/plant (g)	Yield /plant (g)
Control	Single stem	55.68c	4.92d	710.73d
	Double stem	54.31c	4.83d	1653.44d
Arginine 200ppm	Single stem	68.64a	5.45c	726.43d
	Double stem	69.32a	5.36c	1915.36c
Arginine 400ppm	Single stem	61.32b	6.70a	990.33b
	Double stem	58.88b	6.69a	3258.30a
Cysteine 200ppm	Single stem	60.05b	5.71b	803.19c
	Double stem	65.78a	5.53bc	1631.88d
Cysteine 400ppm	Single stem	65.87a	6.71a	1090.49a
	Double stem	67.49a	6.63a	2037.44b
S.E		4.43	0.38	77.56

Production per plant has been greatly influenced by stem number and use of amino acids. Thus, interaction between two stems and 400 ppm arginine application resulted in the highest production per plant, of 3258.3 g compared to 990.33 g at same concentration, but in plants with 1stem. Spray application of arginine causes increased production by stimulating growth processes, synthesis of polyamines, especially amines that play a special role in cell division, flower formation and growth (Konya, 1995, Nassar et al., 2003, Jari et al. 2014).

Effect of applying amino acids on some production parameters for cherry tomatoes

Results presented in Table 5 show that amino acids significantly increased fruit set percentage. Highest percentage of fruit set was recorded for arginine 200 ppm, 68.98% and the lowest for arginine 400 ppm and 60.10% respectively. Control had fruit formation percentage of 54.99%. Fruits had a higher average weight in plants treated with amino acids, ranging from 5.92 g to cysteine 200 ppm and 6.69 g at 400 ppm arginine treated plants. Production on the plant also increased and ranged from 1217.53 g/pl to 1563.96 g/pl, compared to untreated control which had 1182.08 g/pl.

Table.5 Effect the amino acids on some yield parameters of cherry tomato

Treatments	Fruit set (%)	Average of Fruit weight/plant (g)	Yield/plant (g)
Control	54.99c	4.87b	1182.08e
Arginine 200ppm	68.98a	6.40a	1320.89c
Arginine 400ppm	60.10b	6.69a	2128.81a
Cysteine 200ppm	62.91ab	5.92a	1217.53d
Cysteine 400ppm	66.68a	6,67a	1563.96b
SE	4.45	1.02	23.88

Effect of stems number on some production parameters for cherry tomatoes

Stems number did not significantly influence fruit set percentage and average fruit weight (Table 6).

Table 6. Effect the number of stems on some yield parameters of cherry tomato

Treatments	Fruit set (%)	Average of Fruit weight/plant (g)	Yield /plant (g)
Single stem	62.31	5.89	864.23b
Double stems	60.04	5.80	2099.28a
SE	NS	NS	27.32

Instead, plant production has been greatly influenced, this being more than double in plants conducted with 2 stems (2099.28 g/pl). These results are similar to results presented by Maboko and Du Plooy, 2008, which show that yields increase with the increase in the number of stems, but average fruit weight is smaller but does not decrease so much that they can not be marketed.

CONCLUSIONS

Research results regarding treatment of cherry tomatoes with arginine and cysteine amino acids and conducted on 1 and 2 stems showed that this species responded well to both treatments. It was noted the influence of arginine and cysteine, at a concentration of 400 ppm, in plant height increase, especially in plants with 1 stem, followed by 200 ppm arginine in the same plants. Chlorophyll content increased to untreated plants, with larger amounts being accumulated in plants with 1 stem. Also photosynthesis was stimulated by application of amino acids at 2 concentrations, being superior to control, and differences compared to control were statistically assured. Yield was very significantly influenced, especially by number of stems, highest being recorded in plants with 2 stems, following treatment of plants with arginine 400 ppm. Average fruit weight was lower in plants with 2 stems, but did not fall below marketing limit, and fruit set percentage was superior to untreated control in both 1 stem and 2 stem plants.

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