EFFECT OF AMINO ACIDS ON GROWTH AND FLOWERING OF 
*Rosa hybrida* L. PLANT GROWING IN NUTRIENT FILM TECHNIQUE 
AND SOLID SUBSTRATE SOILLESS CULTURE

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ABSTRACT: *Rosa hybrida* (cv. Red Dino) was grown at the experimental site of the Hort. Dept., Fac. Agric., University of Zagazig, Egypt, during the two consecutive seasons of 2017 and 2018. Aiming to evaluate the effect of different amino acid types (glutamine, methionine, phenylalanine and proline), soilless culture methods (nutrient film technique and solid substrate culture) and their combination treatments on growth and flowering of rose plant. These experiments were performed as a split-plot in complete randomized block design with three replicates. The results showed that in most cases phenylalanine acid gave the highest values of growth parameters (plant height, number and weight of leaves, leaf length and width as well as root length) compared to the other amino acid types under study. The same trend was obtained concerning flowering parameters (flowers number, weight and diameter per plant, flower stalk length as well as vase life of cut flowers) during both seasons. The solid substrate culture (SSC) in most cases gave correspondingly higher values of above mentioned parameters (except that of flowering date and flowers vase life) than the nutrient film technique (NFT). Total chlorophyll content (SPAD) was significantly increased with SSC compared to NFT. The best combination treatment, from the productive point of view, was treating plants with phenylalanine acid at 200 ppm and culturing in solid substrate soilless culture (mixture of granulated sand and peat).

Key words: Rose, Soilless culture, Amino acids, Growth, Flowering, Chlorophyll

INTRODUCTION

*Rosa* (*Rosa hybrida* L.) is the most important member of the Family *Rosaceae*, which contains 200 species and more than 18,000 cultivars (*Gudin, 2000*), grown as ornamental plant around the world. It is one of the leading cut flowers and ranks among the top ten cut flowers of the world. Cut rose flowers play an important role in interior decoration and add charm to different social and cultural ceremonies. Millions of rose bushes are planted in garden or pots and billions of rose cut flowers are sold annually over the world (*Khosh-Khui and Teixeira da Silva, 2006*).

Soilless culture system represents a valid alternative to conventional cultivation techniques due to the full control of the inputs that provides and it is a good technique to grow rose offering guarantees of quality to the market (*Nicola et al., 2005*). It allows to produce clean material at harvest, and consequently to reduce many washing treatments. Nutrient film technique (NFT) can be utilized to overcome soil problems where, plants grow in the solution of nutrient directly, so it does not need any disinfection. Also, it had an enormous latent potential for agriculture production in areas where soil has a disease and pest problems (*Burrage, 1992*), especially in near future when the methyl bromide will be band. *Abou-Hadid et al. (1989)* indicated that under Egyptian conditions, NFT produced higher yield in shorter time when compared with traditional cultivation. In addition, the cost of production by the NFT is similarly to the soil grown plants.

*Davies* (1982) reported that amino acids as organic nitrogenous compounds are the building blocks in the synthesis of protein components. Amino acids (AA) are particularly important for cell growth stimulation. They act as buffers which help to maintain favorable pH value within the plant cell,
since they contain both acid and basic groups; they remove the ammonia from the cell. The regulatory effect of amino acids on growth could be explained by the notion that some amino acids e.g. phenylalanine (Phe) can affect development through their influence on gibberellins biosynthesis and plant growth (Walter and Nawacke, 1978).

Evidently, the glutamate absorb by the cells faster than it is metabolized, as the glutamate eventually is found in glutamine (Gln), protein and glutathione (El-Ghamry et al., 2009). Proline (Pro) may also act as a signaling molecule or regulatory to activate a variety of responses (Maggio et al., 2002). Its storage is also beneficial for several plants as a source of nitrogen element. However, previous studies have showed an association of L-methionine with the biosynthesis of growth regulating substances such as brassinosteroids, cytokinins and auxins in plants (El-Awadi et al., 2011 and Yong et al., 2014). L-methionine functions as a precursor of a significant number of essential bio-molecules such as cofactors, vitamins and polyamine (Paciorek et al., 2014). Therefore, the target of the present study was to evaluate the performance of amino acid type on the growth and flowering of rose plants in different soilless culture systems.

MATERIALS AND METHOD

This study was carried out in the experimental site of the Horticulture Department, Faculty of Agriculture, Zagazig University, Egypt, during the two consecutive seasons of 2017 and 2018 aiming to evaluate the effect of different amino acid types (control, glutamine, methionine, phenylalanine and proline), soilless culture methods (nutrient film technique and solid substrate culture) and their combination treatments on growth and flowering of rose (Rosa hybrida) plant.

Plant material and Growth conditions

Rose (cv. Red Dino) rooted cuttings were planted in the nutrient film technique (NFT) or solid substrate culture (SSC) on 17th February each season under polyethylene greenhouse conditions. The composition of the nutrient solution was recorded in Table 1.

Table 1. Chemical composition of the nutrient solution

| Macronutrients (mol l⁻¹) | Manganese (mol l⁻¹) |
|--------------------------|---------------------|
| N | Fe | Cu | Mn | Zn | B | Mo | Cl |
| 6.1 | 45.0 | 0.5 | 20.0 | 2.6 | 25.0 | Ca | 12.0 | 1.0 | Mg | 38.0 | 1.0 | S | 1.3 | 1.0 |

Plants were grown under a temperature-controlled polyethylene greenhouse. Greenhouse temperature was 22° C; humidity was adjusted to be 70%; and day light was 12 h in spring and 8 hours in autumn. The NFT equipment consisted of rigid PVC gullies (each 12 cm width, 10 cm deep and 300 cm long), with 1% slope. The gullies were at 70 cm above ground level and each gully was fed by a separate 22 l plastic reservoir tank containing the nutrient solution (NS). Continuous circulation (3 l min⁻¹) of the NS was provided by a submerged pump into each reservoir tank. The volume of NS in each tank was constantly monitored and it was completely replaced at weekly. No aeration system was used in this experiment. The solid substrate culture (SSC) was stabilized by mixing of granulated sand (size 3-7 mm) with peat (80: 20 v/v), respectively, in plastic pots (30 cm diameter and 5 l volume). The plants were maintained on concrete benches with a drip irrigation system in open system soilless culture.

Four water soluble amino acids viz., Glutamine (Gln), Methionine (Met), Phenylalanine (Phe) and Proline (Pro) at 200 ppm concentration of each one, which were obtained as Special Grade Chemical form Sigma, USA as well as distilled water as control were applied as a foliar spray (leaves and stem) of rose seedlings two times a week on both soilless culture methods.

Experimental design

These treatments were distributed in a-split plot design with three replications. The soilless culture methods were randomly distributed in the main plots, while amino acid types were randomly distributed in the sub plots. All rose plants in each soilless culture methods received normal agricultural practices whenever they needed.

Data recorded

After 10 weeks (70 days) of amino acids applications the plant height (cm), number and fresh weight (g) of leaves, leaf length and width (mm) as well as root length (cm) of Rosa hybrida were measured. The days till flowering were recorded. Total number of produced flowers from the beginning of harvest period till the end of season for each treatment was determined. Also, average fresh weight of flower/plant (g), flower stalk length (cm) and flower diameter (cm) were recorded. Three cut flowers from each treatment were placed in jar (500 ml) containing 250 ml of distilled water to determine the vase life (days). In addition, total chlorophyll content of leaf was determined by using SPAD- 502 meter (Markwell et al., 1995).

Statistical Analysis

All collected data were subjected to analysis of variance by using MSTAT-C Statistical Software.
RESULTS AND DISCUSSION

Plant growth parameters

Data presented in Tables 2 and 3 reveal that, the application of different amino acid types significantly increased vegetative growth parameters of *Rosa hybrida* compared to control (sprayed with distilled water) in the first and second seasons. Moreover, the tallest plant was observed when plants were treated with phenylalanine at 200 ppm compared to the other ones under study. Phenylalanine acid followed by proline acid significantly increased leaf number/plant, leaf fresh weight/plant, leaf length and width as well as root length compared to the other amino acids under study during both seasons.

Solid substrate culture was more effective in terms of overall vegetative studied parameters compared to nutrient film technique (Tables 2 and 3). In the other words, plant height, number and fresh weight of leaves as well as leaf length and width of *Rosa hybrida* were significantly increased by using solid substrate culture compared to the other one under study during both seasons. While, longer roots were observed with NFT compared to SSC soilless culture during both seasons (Table 3).

In both seasons, plant height, number and fresh weight of leaves, leaf length and width as well as root length of *Rosa hybrida* were higher with all combination treatments between SSC and different amino acids compared to the combination between NFT and with or without amino acids foliar spray in both seasons (Tables 2 and 3). Also, the combination between solid substrate culture and phenylalanine acid (200 ppm) significantly increased all vegetative growth characters of rose plant (except in the case of root length) comparing with the other ones under study, in most cases, during the two seasons.

### Table 2. Effect of amino acid type (A), soilless culture method (S) and their combination treatments (A×S) on plant height (cm), number of leaves/plant and leaves fresh weight/plant (g) of *Rosa hybrida* during 2017 and 2018 seasons

| Amino acid type (A) | Soilless culture method (S) | 2017 season | 2018 season |
|---------------------|---------------------------|-------------|-------------|
|                     |                           | NFT*        | SSC**       | NFT*        | SSC**       |
|                     |                           | Means (A)   | Means (A)   |
|                     |                           | Plant height (cm) |           | Plant height (cm) |          |
| Control             |                           | 58.00       | 64.33       | 61.17       | 59.67       |
| Glutamine           |                           | 66.33       | 68.67       | 67.50       | 67.67       |
| Methionine          |                           | 63.00       | 68.00       | 65.50       | 64.67       |
| Phenylalanine       |                           | 71.00       | 76.33       | 73.67       | 74.00       |
| Proline             |                           | 67.67       | 70.33       | 69.00       | 70.33       |
| **Means (S)**       |                           | **65.20**   | **69.53**   | **67.27**   | **71.07**   |
| LSD at 5%           |                           | S=1.60      | A=1.61      | AS=2.48     | S=1.49      | A=1.37      | AS=2.18     |
| Control             |                           | 6.33        | 7.67        | 7.00        | 7.00        |
| Glutamine           |                           | 7.00        | 9.00        | 8.00        | 7.67        |
| Methionine          |                           | 7.33        | 8.33        | 7.83        | 7.67        |
| Phenylalanine       |                           | 9.33        | 13.00       | 11.17       | 10.67       |
| Proline             |                           | 8.67        | 11.00       | 9.83        | 9.33        |
| **Means (S)**       |                           | **7.73**    | **9.80**    | **8.47**    | **10.20**   |
| LSD at 5%           |                           | S=0.29      | A=0.60      | AS=0.80     | S=1.08      | A=1.15      | AS=1.70     |
| Fresh weight of leaves/plant (g) |
| Control             |                           | 6.54        | 7.49        | 7.02        | 6.54        |
| Glutamine           |                           | 8.23        | 9.08        | 8.66        | 8.21        |
| Methionine          |                           | 7.41        | 7.43        | 7.42        | 7.27        |
| Phenylalanine       |                           | 10.72       | 12.40       | 11.56       | 11.10       |
| Proline             |                           | 10.36       | 10.74       | 10.55       | 10.70       |
| **Means (S)**       |                           | **8.65**    | **9.43**    | **8.76**    | **10.09**   |
| LSD at 5%           |                           | S=0.71      | A=0.61      | AS=1.00     | S=0.46      | A=0.50      | AS=0.75     |

* NFT = Nutrient film technique and ** SSC = Solid substrate culture
Consulting the above mentioned results (Tables 2 and 3), foliar application of different amino acids types under study resulted in significant increases in growth parameters compared with distilled water foliar application (control). This result is in line with those obtained on gerbera (Mahdi and Saeed, 2019). Also, Khan et al. (2019) indicated that plant growth of lettuce significantly improved by applying amino acids, which can, therefore, improves hydroponic production of lettuce plants. The increase in the growth parameters due to spraying phenylalanine may be related to its role in protein building and will perform a number of additional functions in storage of nitrogen, transport and regulating metabolism (Davies, 1982). In addition, Nicola et al. (2005) found that rocket (Eruca sativa) grown in traditional culture had 36.5% more of dry weight and 41.5% more of dry matter content than plants grown in soilless culture one, respectively.

### Table 3. Effect of amino acid type (A), soilless culture method (S) and their combination treatments (A×S) on leaf length (mm), leaf width (mm) and root length (cm) of Rosa hybrida during 2017 and 2018 seasons

| Amino acid type (A) | Soilless culture method (S) | 2017 season | 2018 season | 2017 season | 2018 season |
|---------------------|-----------------------------|-------------|-------------|-------------|-------------|
|                     | NFT * | SSC** | Means (A) | NFT * | SSC** | Means (A) | NFT * | SSC** | Means (A) |
| Leaf length (mm)    |       |       |           |       |       |           |       |       |           |
| Control             | 61.67 | 63.00 | 62.33     | 59.67 | 63.67 | 61.67     |
| Glutamine           | 63.67 | 67.67 | 65.67     | 64.33 | 65.67 | 65.00     |
| Methionine          | 62.67 | 64.67 | 63.67     | 64.33 | 65.67 | 65.00     |
| Phenylalanine       | 60.00 | 70.00 | 70.50     | 70.33 | 73.33 | 71.67     |
| Proline             | 66.67 | 70.33 | 68.50     | 69.33 | 71.67 | 70.50     |
| Means (S)           | 64.73 | 67.53 | 66.07     | 69.00 | 71.67 | 70.50     |
| LSD at 5%           | S=0.99 | A=0.95 | AS=1.48    | S=1.31 | A=0.86 | AS=1.61    |
| Leaf width (mm)     |       |       |           |       |       |           |       |       |           |
| Control             | 26.67 | 28.67 | 27.67     | 25.67 | 29.67 | 27.67     |
| Glutamine           | 28.67 | 30.67 | 29.67     | 27.00 | 32.00 | 29.50     |
| Methionine          | 27.67 | 31.00 | 29.33     | 28.67 | 32.67 | 30.67     |
| Phenylalanine       | 30.00 | 37.00 | 35.00     | 32.00 | 43.00 | 37.50     |
| Proline             | 30.33 | 32.33 | 31.33     | 29.67 | 43.33 | 32.00     |
| Means (S)           | 29.27 | 31.93 | 28.60     | 34.33 | 34.33 | 32.00     |
| LSD at 5%           | S=1.15 | A=0.91 | AS=1.54    | S=1.03 | A=0.86 | AS=1.42    |
| Root length (cm)    |       |       |           |       |       |           |       |       |           |
| Control             | 14.90 | 14.17 | 14.53     | 15.67 | 13.90 | 14.78     |
| Glutamine           | 16.63 | 15.00 | 15.82     | 17.33 | 15.20 | 16.27     |
| Methionine          | 17.13 | 14.63 | 15.88     | 16.33 | 15.20 | 15.77     |
| Phenylalanine       | 26.83 | 18.50 | 22.67     | 28.50 | 20.00 | 24.25     |
| Proline             | 23.00 | 17.27 | 20.13     | 23.83 | 18.07 | 20.95     |
| Means (S)           | 19.70 | 15.91 | 20.33     | 20.00 | 16.47 | AS=1.11   |
| LSD at 5%           | S=0.69 | A=0.57 | AS=0.91    | S=1.02 | A=0.47 | AS=1.11   |

* NFT = Nutrient film technique and ** SSC = Solid substrate culture

Moreover, as mentioned above, both soilless culture methods and all amino acid types (each alone) increased rose growth parameters, in turn; they together might maximize their effects leading to taller plants as well as more and heaviest leaves.

**Flowering parameters and chlorophyll content**

Regarding flowering parameters, it is clear from data in Tables 4 and 5 that plants treated with all amino acids reflect significant effect on flowering date, number and fresh weights of flowers/plant, flower stalk length and flower diameter as well as vase life (Table 6) compared to control. The best treatment in this connection was phenylalanine at 200 ppm compared to the other three ones under study during both seasons. It is clear that phenylalanine acid foliar spray significantly decreased the number of days till flowering compared to control and the other amino acid during the two seasons. Total chlorophyll content was significantly increased with phenylalanine treatment compared to control (Table 6).
Generally, fresh weight of flowers/plant, flower stalk length and total chlorophyll content (SPAD unit) of *Rosa hybrida* were significantly increased by using solid substrate culture compared to NFT during both seasons (Tables 4, 5 and 6). While, least number of days till flowering was observed with plants cultured in SSC compared to NFT soilless culture during both seasons (Table 4).

The combination between both soilless culture methods and spraying with amino acids revealed that the combination which consist of SSC culture and phenylalanine acid gave the highest values of number and fresh weight of flowers/plant, flower stalk length, flower diameter and flowers vase life as well as total chlorophyll content in leaves, while, the lowest values in this regard were noted with NFT culture and without amino acids application (Tables 4, 5 and 6).

Similar results were also found by Mahdi and Saeed (2019) who reported that foliar spray with phenylalanine at 150 mg.l⁻¹ was superior in number of inflorescences, inflorescence diameter, inflorescences stalk length and total chlorophyll content of gerbera plants. Increment in length of flower stalk may be due to the biological effect of these amino acids in stimulating cell division and elongation (Pareek et al., 2000). Increment in floral parameters due to foliar spray with amino acids are in agreement with those obtained by Abd El-Aziz and Balbaa (2007) on *Salvia farinacea*, Sewedan and Osman (2014) on *Dendranthema grandiflorum* and Khattab et al. (2016) on *Gladiolus grandiflorum*. Furthermore, as mentioned above, both soilless culture methods and different amino acid types (each alone) increased rose flowering traits, in turn; they together might maximize their effects leading to early flowering date as well as more and heaviest flowers.

### Table 4. Effect of amino acid type (A), soilless culture method (S) and their combination treatments (A×S) on flowering date (days), number of flowers /plant and flower fresh weight/plant (g) of *Rosa hybrida* during 2017 and 2018 seasons

| Amino acid type (A) | 2017 season |               | 2018 season |               |
|--------------------|-------------|---------------|-------------|---------------|
|                    | NFT * | SSC** | Means (A) | NFT * | SSC** | Means (A) |
| Flowering date (days) |     |     |         |     |     |         |
| Control            | 76.67 | 80.33 | 78.50 | 77.33 | 77.67 | 77.50 |
| Glutamine          | 67.00 | 64.33 | 65.67 | 65.33 | 66.33 | 65.83 |
| Methionine         | 71.67 | 67.67 | 69.67 | 70.33 | 66.67 | 68.50 |
| Phenylalanine      | 61.33 | 60.33 | 60.83 | 62.33 | 61.00 | 61.67 |
| Proline            | 62.33 | 63.00 | 62.67 | 64.67 | 65.33 | 65.00 |
| Means (S)          | 67.80 | 67.13 | 68.00 | 67.40 |        |         |
| LSD at 5%          | S=N.S   | A=1.04 | S=1.47 | S=N.S   | A=1.19 | AS=1.68 |
| Number of flowers/plant |     |     |         |     |     |         |
| Control            | 7.33  | 7.33  | 7.33  | 6.67  | 7.67  | 7.17  |
| Glutamine          | 7.33  | 8.33  | 7.83  | 7.67  | 8.33  | 8.00  |
| Methionine         | 8.33  | 8.33  | 8.33  | 8.67  | 8.67  | 8.67  |
| Phenylalanine      | 9.33  | 10.33 | 9.83  | 9.67  | 10.67 | 10.17 |
| Proline            | 8.67  | 9.33  | 9.00  | 7.67  | 9.67  | 9.33  |
| Means (S)          | 8.20  | 8.73  | 8.33  | 9.00  |        |         |
| LSD at 5%          | S=0.29 | A=0.45 | AS=0.62 | S=0.76 | A=0.69 | AS=1.10 |
| Flower fresh weight/plant (g) |     |     |         |     |     |         |
| Control            | 14.70 | 15.53 | 15.12 | 14.60 | 15.83 | 15.22 |
| Glutamine          | 15.10 | 17.73 | 16.42 | 15.77 | 18.22 | 16.99 |
| Methionine         | 15.47 | 16.47 | 15.97 | 16.03 | 17.30 | 16.67 |
| Phenylalanine      | 17.27 | 20.87 | 19.07 | 18.03 | 21.37 | 19.70 |
| Proline            | 15.87 | 19.27 | 17.57 | 16.20 | 18.80 | 17.50 |
| Means (S)          | 15.68 | 17.97 | 16.13 | 18.30 |        |         |
| LSD at 5%          | S=0.45 | A=0.62 | AS=0.88 | S=0.45 | A=0.41 | AS=0.66 |

* NFT = Nutrient film technique and ** SSC = Solid substrate culture
Table 5. Effect of amino acid type (A), soilless culture method (S) and their combination treatments (A×S) on flower stalk length (cm) and flower diameter (cm) of *Rosa hybrida* during 2017 and 2018 seasons

| Amino acid type (A) | Soilless culture method (S) | 2017 season | 2018 season | 2017 season | 2018 season |
|---------------------|-----------------------------|-------------|-------------|-------------|-------------|
|                     | NFT * | SSC** | Means (A) | NFT * | SSC** | Means (A) | NFT * | SSC** | Means (A) |
| Control             | 32.67 | 34.33 | 33.50 | 30.67 | 35.67 | 33.17 |
| Glutamine           | 34.33 | 36.67 | 35.50 | 33.33 | 39.33 | 36.33 |
| Methionine          | 35.67 | 36.67 | 35.67 | 37.00 | 39.67 | 38.33 |
| Phenylalanine       | 41.00 | 45.67 | 43.33 | 42.33 | 48.33 | 45.33 |
| Proline             | 37.67 | 40.67 | 39.17 | 38.67 | 44.00 | 41.33 |
| **Means (S)**       | 36.27 | 38.60 | 36.40 | 36.40 | 41.40 | 41.40 |

LSD at 5%: S=0.57, A=0.96, AS=1.31, S=0.50, A=0.80, AS=1.11

* NFT = Nutrient film technique and ** SSC = Solid substrate culture

Table 6. Effect of amino acid type (A), soilless culture method (S) and their combination treatments (A×S) on vase life (days) and total chlorophyll content (SPAD unit) of *Rosa hybrida* during 2017 and 2018 seasons

| Amino acid type (A) | Soilless culture method (S) | 2017 season | 2018 season | 2017 season | 2018 season |
|---------------------|-----------------------------|-------------|-------------|-------------|-------------|
|                     | NFT * | SSC** | Means (A) | NFT * | SSC** | Means (A) | NFT * | SSC** | Means (A) |
| Control             | 10.33 | 9.67 | 10.00 | 11.00 | 10.00 | 10.50 |
| Glutamine           | 11.33 | 10.33 | 10.83 | 11.67 | 10.67 | 11.17 |
| Methionine          | 10.67 | 10.33 | 10.50 | 11.33 | 10.67 | 11.00 |
| Phenylalanine       | 12.67 | 11.67 | 12.17 | 12.67 | 12.33 | 12.50 |
| Proline             | 11.67 | 11.33 | 11.50 | 12.33 | 11.33 | 11.83 |
| **Means (S)**       | 11.33 | 10.67 | 11.80 | 11.80 | 11.00 |

LSD at 5%: S=0.57, A=0.55, AS=0.86, S=0.50, A=0.70, AS=0.96

* NFT = Nutrient film technique and ** SSC = Solid substrate culture
CONCLUSION

Considering the effects of amino acids under both soilless culture methods on growth and flowering of rose plant (cv. Red Dino), phenylalanine can be used as foliar application at 200 ppm to enhance the productivity of rose under soilless culture especially solid substrate culture in open system culture.

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