



## TEFFEC OF AMINO ACIDS ON GROWTH AND FLOWERING OF *Rosa hybrid* 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., Zagazig University, Egypt, during the two seasons of 2017 and 2018. In order to estimate 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 designed 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

Rose (*Rosa hybrida* L.) is the most important member of the Family Rosacea, 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 a remarkable role in interior decoration and add charm to different social and cultural ceremonies. Millions of rose shrubs are planted in garden or pots and billions of rose cut flowers are sold annually all 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. NFT had an enormous latent potential for agriculture production areas where soil has a disease and pest problems (Burrage, 1992). 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 in the plant cell, since they include both acid and basic groups. The regulatory effect of amino acids on growth could be explained by the theory that some amino acids like 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). Phenylalanine and proline are a proteogenic amino acids and accumulates under stress and non-stress conditions as a beneficial solute in plants. Recent discoveries point out that proline plays an important role in plant growth and differentiation across life cycle (Paciorek *et al.*, 2005). Proline may also act as a signaling molecule or regulatory to activate a variety of responses (Maggio *et al.*, 2002). L-methionine considered as a precursor of a significant number of essential biomolecules such as cofactors, vitamins and polyamine (Paciorek *et al.*, 2005). 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).

The aim of the present study is to evaluate the performance of different amino acids 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 seedlings, 15 month old were planted in the nutrient film technique (NFT) or solid substrate culture (SSC) on 17<sup>th</sup> 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 <sup>-1</sup> )						
N	P	K	Ca	Mg	S	
6.1	0.5	2.6	2.0	1.6	1.3	
Micronutrients (µmol l <sup>-1</sup> )						
Fe	Cu	Mn	Zn	B	Mo	Cl
45.0	20.0	25.0	38.0	12.0	1.0	1.0

The nutrient solution used was GHE Floragro (ProGrow Co, UK); pH and electrical conductivity (EC) were adjusted to 7 and 2.5 S·m<sup>-1</sup>, respectively. The solution was pumped continuously at a flow rate of 120 l hr<sup>-1</sup>. The nutrient solution reservoir was a 100 l black plastic tank, connected directly to the pipes feeding the plants. A pump (MaxiJet, Mj1000, Aqua culture, UK) with plastic coatings was used to avoid metal contamination due to salt corrosion. The nutrient solution was collected in a 50 l black plastic tank and re-cycled by the pump. Nutrient solution was replaced at 14-day intervals. The system was maintained under glasshouse conditions. Seedlings were planted without any substrates around root system.

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 consist 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<sup>-1</sup>) 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 established 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 Package (Analytical Software, 2008). Differences between means were compared by using the least significant difference (LSD) test at  $P \leq 0.05$  as reported by Gomez and Gomez (1984).

## 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.

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.

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.

**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		Means (A)	2018 season		Means (A)
	NFT *	SSC**		NFT *	SSC**	
<b>Plant height (cm)</b>						
Control	58.00	64.33	<b>61.17</b>	59.67	67.00	<b>63.33</b>
Glutamine	66.33	68.67	<b>67.50</b>	67.67	69.67	<b>68.67</b>
Methionine	63.00	68.00	<b>65.50</b>	64.67	67.67	<b>66.17</b>
Phenylalanine	71.00	76.33	<b>73.67</b>	74.00	79.00	<b>76.50</b>
Proline	67.67	70.33	<b>69.00</b>	70.33	71.17	<b>71.17</b>
<b>Means (S)</b>	<b>65.20</b>	<b>69.53</b>		<b>67.27</b>	<b>71.07</b>	
<b>LSD at 5%</b>	<b>S=1.60</b>	<b>A=1.61</b>	<b>AS=2.48</b>	<b>S=1.49</b>	<b>A=1.37</b>	<b>AS=2.18</b>
<b>Number of leaves/ plants</b>						
Control	6.33	7.67	<b>7.00</b>	7.00	7.33	<b>7.17</b>
Glutamine	7.00	9.00	<b>8.00</b>	7.67	9.67	<b>8.67</b>
Methionine	7.33	8.33	<b>7.83</b>	7.67	9.00	<b>8.33</b>
Phenylalanine	9.33	13.00	<b>11.17</b>	10.67	13.33	<b>12.00</b>
Proline	8.67	11.00	<b>9.83</b>	9.33	11.67	<b>10.50</b>
<b>Means (S)</b>	<b>7.73</b>	<b>9.80</b>		<b>8.47</b>	<b>10.20</b>	
<b>LSD at 5%</b>	<b>S=0.29</b>	<b>A=0.60</b>	<b>AS=0.80</b>	<b>S=1.08</b>	<b>A=1.15</b>	<b>AS=1.70</b>
<b>Fresh weight of leaves/ plant (g)</b>						
Control	6.54	7.49	<b>7.02</b>	6.54	7.85	<b>7.19</b>
Glutamine	8.23	9.08	<b>8.66</b>	8.21	8.73	<b>8.47</b>
Methionine	7.41	7.43	<b>7.42</b>	7.27	7.93	<b>7.60</b>
Phenylalanine	10.72	12.40	<b>11.56</b>	11.10	13.81	<b>12.46</b>
Proline	10.36	10.74	<b>10.55</b>	10.70	12.12	<b>11.41</b>
<b>Means (S)</b>	<b>8.65</b>	<b>9.43</b>		<b>8.76</b>	<b>10.09</b>	
<b>LSD at 5%</b>	<b>S=0.71</b>	<b>A=0.61</b>	<b>AS=1.00</b>	<b>S=0.46</b>	<b>A=0.50</b>	<b>AS=0.75</b>

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

**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		Means (A)	2018 season		Means (A)
	NFT *	SSC**		NFT *	SSC**	
<b>Leaf length (mm)</b>						
Control	61.67	63.00	<b>62.33</b>	59.67	63.67	<b>61.67</b>
Glutamine	63.67	67.67	<b>65.67</b>	67.00	69.00	<b>68.00</b>
Methionine	62.67	64.67	<b>63.67</b>	64.33	65.67	<b>65.00</b>
Phenylalanine	69.00	72.00	<b>70.50</b>	70.33	73.33	<b>71.67</b>
Proline	66.67	70.33	<b>68.50</b>	69.33	71.67	<b>70.50</b>
<b>Means (S)</b>	<b>64.73</b>	<b>67.53</b>		<b>66.07</b>	<b>68.67</b>	
<b>LSD at 5%</b>	<b>S=0.99</b>	<b>A=0.95</b>	<b>AS=1.48</b>	<b>S=1.31</b>	<b>A=0.86</b>	<b>AS=1.61</b>
<b>Leaf width (mm)</b>						
Control	26.67	28.67	<b>27.67</b>	25.67	29.67	<b>27.67</b>
Glutamine	28.67	30.67	<b>29.67</b>	27.00	32.00	<b>29.50</b>
Methionine	27.67	31.00	<b>29.33</b>	28.67	32.67	<b>30.67</b>
Phenylalanine	33.00	37.00	<b>35.00</b>	32.00	43.00	<b>37.50</b>
Proline	30.33	32.33	<b>31.33</b>	29.67	34.33	<b>32.00</b>
<b>Means (S)</b>	<b>29.27</b>	<b>31.93</b>		<b>28.60</b>	<b>34.33</b>	
<b>LSD at 5%</b>	<b>S=1.15</b>	<b>A=0.91</b>	<b>AS=1.54</b>	<b>S=1.03</b>	<b>A=0.86</b>	<b>AS=1.42</b>
<b>Root length (cm)</b>						
Control	14.90	14.17	<b>14.53</b>	15.67	13.90	<b>14.78</b>
Glutamine	16.63	15.00	<b>15.82</b>	17.33	15.20	<b>16.27</b>
Methionine	17.13	14.63	<b>15.88</b>	16.33	15.20	<b>15.77</b>
Phenylalanine	26.83	18.50	<b>22.67</b>	28.50	20.00	<b>24.25</b>
Proline	23.00	17.27	<b>20.13</b>	23.83	18.07	<b>20.95</b>
<b>Means (S)</b>	<b>19.70</b>	<b>15.91</b>		<b>20.33</b>	<b>16.47</b>	
<b>LSD at 5%</b>	<b>S=0.63</b>	<b>A=0.57</b>	<b>AS=0.91</b>	<b>S=1.02</b>	<b>A=0.47</b>	<b>AS=1.11</b>

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

**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<sup>-1</sup> 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)	Soilless culture method (S)					
	2017 season		Means (A)	2018 season		Means (A)
	NFT *	SSC**		NFT *	SSC**	
<b>Flowering date (days)</b>						
Control	76.67	80.33	<b>78.50</b>	77.33	77.67	<b>77.50</b>
Glutamine	67.00	64.33	<b>65.67</b>	65.33	66.33	<b>65.83</b>
Methionine	71.67	67.67	<b>69.67</b>	70.33	66.67	<b>68.50</b>
Phenylalanine	61.33	60.33	<b>60.83</b>	62.33	61.00	<b>61.67</b>
Proline	62.33	63.00	<b>62.67</b>	64.67	65.33	<b>65.00</b>
<b>Means (S)</b>	<b>67.80</b>	<b>67.13</b>		<b>68.00</b>	<b>67.40</b>	
<b>LSD at 5%</b>	<b>S=N.S</b>	<b>A=1.04</b>	<b>AS=1.47</b>	<b>S=N.S</b>	<b>A=1.19</b>	<b>AS=1.68</b>
<b>Number of flowers/plants</b>						
Control	7.33	7.33	<b>7.33</b>	6.67	7.67	<b>7.17</b>
Glutamine	7.33	8.33	<b>7.83</b>	7.67	8.33	<b>8.00</b>
Methionine	8.33	8.33	<b>8.33</b>	8.67	8.67	<b>8.67</b>
Phenylalanine	9.33	10.33	<b>9.83</b>	9.67	10.67	<b>10.17</b>
Proline	8.67	9.33	<b>9.00</b>	7.67	9.67	<b>9.33</b>
<b>Means (S)</b>	<b>8.20</b>	<b>8.73</b>		<b>8.33</b>	<b>9.00</b>	
<b>LSD at 5%</b>	<b>S=0.29</b>	<b>A=0.45</b>	<b>AS=0.62</b>	<b>S=0.76</b>	<b>A=0.69</b>	<b>AS=1.10</b>
<b>Flower fresh weight/plant (g)</b>						
Control	14.70	15.53	<b>15.12</b>	14.60	15.83	<b>15.22</b>
Glutamine	15.10	17.73	<b>16.42</b>	15.77	18.22	<b>16.99</b>
Methionine	15.47	16.47	<b>15.97</b>	16.03	17.30	<b>16.67</b>
Phenylalanine	17.27	20.87	<b>19.07</b>	18.03	21.37	<b>19.70</b>
Proline	15.87	19.27	<b>17.57</b>	16.20	18.80	<b>17.50</b>
<b>Means (S)</b>	<b>15.68</b>	<b>17.97</b>		<b>16.13</b>	<b>18.30</b>	
<b>LSD at 5%</b>	<b>S=0.45</b>	<b>A=0.62</b>	<b>AS=0.88</b>	<b>S=0.45</b>	<b>A=0.41</b>	<b>AS=0.66</b>

\* 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		Means (A)	2018 season		Means (A)
	NFT *	SSC**		NFT *	SSC**	
<b>Flower stalk length (cm)</b>						
Control	32.67	34.33	<b>33.50</b>	30.67	35.67	<b>33.17</b>
Glutamine	34.33	36.67	<b>35.50</b>	33.33	39.33	<b>36.33</b>
Methionine	35.67	35.67	<b>35.67</b>	37.00	39.67	<b>38.33</b>
Phenylalanine	41.00	45.67	<b>43.33</b>	42.33	48.33	<b>45.33</b>
Proline	37.67	40.67	<b>39.17</b>	38.67	44.00	<b>41.33</b>
<b>Means (S)</b>	<b>36.27</b>	<b>38.60</b>		<b>36.40</b>	<b>41.40</b>	
<b>LSD at 5%</b>	<b>S=0.57</b>	<b>A=0.96</b>	<b>AS=1.31</b>	<b>S=0.50</b>	<b>A=0.80</b>	<b>AS=1.11</b>
<b>Flower diameter (cm)</b>						
Control	7.27	7.43	<b>7.35</b>	7.07	7.57	<b>7.32</b>
Glutamine	7.63	8.10	<b>7.87</b>	7.53	8.08	<b>7.81</b>
Methionine	7.57	8.17	<b>7.87</b>	7.90	8.07	<b>7.98</b>
Phenylalanine	8.80	9.43	<b>9.17</b>	9.03	9.57	<b>9.30</b>
Proline	8.70	8.42	<b>8.56</b>	8.43	8.73	<b>8.58</b>
<b>Means (S)</b>	<b>7.99</b>	<b>8.31</b>		<b>7.99</b>	<b>8.40</b>	
<b>LSD at 5%</b>	<b>S=0.12</b>	<b>A=0.30</b>	<b>AS=0.40</b>	<b>S=0.69</b>	<b>A=0.38</b>	<b>AS=0.78</b>

\* 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		Means (A)	2018 season		Means (A)
	NFT *	SSC**		NFT *	SSC**	
<b>Vase life (days)</b>						
Control	10.33	9.67	<b>10.00</b>	11.00	10.00	<b>10.50</b>
Glutamine	11.33	10.33	<b>10.83</b>	11.67	10.67	<b>11.17</b>
Methionine	10.67	10.33	<b>10.50</b>	11.33	10.67	<b>11.00</b>
Phenylalanine	12.67	11.67	<b>12.17</b>	12.67	12.33	<b>12.50</b>
Proline	11.67	11.33	<b>11.50</b>	12.33	11.33	<b>11.83</b>
<b>Means (S)</b>	<b>11.33</b>	<b>10.67</b>		<b>11.80</b>	<b>11.00</b>	
<b>LSD at 5%</b>	<b>S=0.57</b>	<b>A=0.55</b>	<b>AS=0.86</b>	<b>S=0.50</b>	<b>A=0.70</b>	<b>AS=0.96</b>
<b>Total chlorophyll content (SPAD unit)</b>						
Control	50.33	51.67	<b>51.00</b>	51.67	52.67	<b>52.17</b>
Glutamine	53.67	54.67	<b>54.17</b>	53.33	56.33	<b>54.83</b>
Methionine	53.00	55.00	<b>54.00</b>	53.33	56.00	<b>54.67</b>
Phenylalanine	55.67	57.67	<b>56.67</b>	54.67	58.67	<b>56.67</b>
Proline	54.33	56.33	<b>55.33</b>	55.33	56.67	<b>56.00</b>
<b>Means (S)</b>	<b>53.40</b>	<b>55.07</b>		<b>53.67</b>	<b>56.07</b>	
<b>LSD at 5%</b>	<b>S=1.03</b>	<b>A=0.82</b>	<b>AS=1.39</b>	<b>S=1.31</b>	<b>A=1.08</b>	<b>AS=1.80</b>

\* 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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