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Research Article

Response of Carnation (*Dianthus chinensis x barbatus*) to Different Levels of Foliar Spraying of Amino Acid and Chemical Fertilizers

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Abstract

The objective of this investigation was to measure the growth and flower response of carnation plants to the application of various levels (0, 2, 4 $g.l^{-1}$) of amino acid (Terra-Sorb and Triamin) and chemical fertilization (Turo-fort and Nami), three times during the growing period, as a possible program for the production of quality plants through fertilization. Carnations (*Dianthus chinensis x barbatus*) were pot-grown in an unheated green-net greenhouse. The results showed that plants sprayed with fertilizer solutions showed a significant increase in the growth parameters. The results also showed that the treatments stimulated the flowering parameters (number of inflorescences per plant, inflorescences diameter, flowering date, and inflorescences dry mass) and increased the number, diameter, and dry mass of inflorescences per plant, when compared to the untreated plants (control). The a, b, and total chlorophyll (a+b), carotenoid and anthocyanin content, gas exchange measurements and leaf mineral content (P, N, K, and Total carbohydrates) were significantly increased compared to the control, as a result of the application of different levels of the chemical foliar fertilizer spraying solutions (Turo-fort and Nami). Carnations plants with foliar fertilizer solution application had higher leaf gas exchange (stomatal conductance (g_s), transpiration rate (E), photosynthetic rate (P_N) and plant intercellular CO_2 concentration (C_i)).

Keywords: *Flowering Parameters; Gas Exchange; Growth Parameters; Mineral Contents; Photosynthetic Pigments*

Abbreviations

C_i: Plant Intercellular CO_2 Concentration; E: Transpiration Rate; g_s: Stomatal Conductance; P_N: Photosynthetic Rate

Introduction

Increased quality of flowers and perfection within the sort of plants are important purposes in flower and bedding production [1] mentions that quality is a purpose of nutrient level. Phosphorus, potassium, and nitrogen greatly affect the quality and production of flowers. Fertilizer recommendations are excessive, which reflects on the cost of production. In many countries, foliar applications of fertilizer solutions are a more important method of fertilization of many floricultural crops. The advantages of foliar fertilizer solutions are clearer under growing conditions that restrict the absorption of elements from the soil, as mentioned by [2,3]. The nutrients supplied by macro and micro-elements are necessary for the various biochemical processes that occur within the plant and are essential for normal plant growth and development [4]. Since sandy desert soil is characterized by high pH value, foliar fertilization may be useful under these conditions to avoid the soil fixation of some micronutrients such as Fe, Mn, Zn and Cu. Moreover, foliar fertilization technique may also be a good alternative to the conventional soil application to avoid the loss of fertilizers by leaching and thereby minimizing the ground water pollution [5,6]. Foliar fertilizer solutions are suggested by many studies as an alternative fertilization technique to increase the flowering and growth of rose [7], chrysanthemum [8], tuberose [9] and iris plants [10]. Similar findings were also reported with anemone [11], gladiolus [12] carnation [13].

The amino acid is a well-known biostimulant which has positive effects on plant growth, yield and significantly mitigates the injuries caused by abiotic stresses [14,15] stated that the application of amino acid treatment resulted in a significant increase in chlorophyll a and b in Datura leaves while, carotenoids significantly decreased. The effect of amino acids on decreasing nitrate concentrations in cabbage has been reported by [16,17] on carnation found that treatments of amino acids significantly improved growth parameters of shoots and fresh weight as well as flowers yield. [18] on radish found that spraying of amino acids significantly increased vegetative growth expressed as plant height and dry weight of the plant. [19] revealed that spraying strawberry plants with amino acids (peptone) at 0.5 and 1.0 g/L significantly increased total nitrogen, phosphorus and potassium in plant foliage as well as total yield, weight, TSS, vitamin C and total sugars content of fruits compared to control treatment.

The current carnation (Family: Caryophyllaceae; *Dianthus chinensis* L.) cultivars proposal a variety of colours, sizes, and shapes not obtainable in other flowering plants. Carnations are cultivated on an enormous scale within the Mediterranean zone [2]. Though it is native to the Mediterranean area, carnation is often grown in nearly each climate; in temperate areas and sub-tropic zones, it is mostly grown in greenhouses as well as in open fields, and in tropic zones, they are grown under more shaded conditions. Carnations could also be planted at any time of the year but planning peak production for times of peak demand is vital [20]. A carnation grown as a pot plant is a more recent development, although it is cultivated as cut flowers in many areas [21].

Aim of the Study

The aim of this investigation was to monitor the growth and flower response of the carnation plants to different levels of amino acid and chemical fertilization and to evaluate the commercial foliar fertilizers as a useful technique in the production of carnation plants.

Materials and Methods

Plant materials and soil

The research was carried out at the nursery and grown under the net greenhouse conditions of the Plant Production Dep., College of Food and Agriculture Sciences, King Saud University, Riyadh, Saudi Arabia. The experiment was conducted during 2017/2018 (first season) and during 2018/2019 (second season), using a decorative Carnation (*Dianthus chinensis x barbatus* cv. Dianthus Interspecific Pink) (Floranova, Pierceton, USA).

The soil consisted of sand (83.6%), silt (8.5%), and clay (7.9%). Seeds were planted in plastic trays 50 × 50 cm2 filled with sand on November 19, 2017, for the first season and November 21, 2018, for the second season. When the carnation had 4-5 true leaves, seedlings with similar heights were collected from the nursery and transplanted into 15 cm-diameter plastic pots (one seedling per pot). After transplantation, plants were carefully watered three times per week with municipal water to establish a soil moisture content close to the field capacity of around (85%, v/w).

Foliar application of amino acid and chemical fertilizers

The treatments included foliar application of solutions with commercial formulations, two amino acids, and two chemical fertilizers at two levels 2 and 4 g·L^{-1} Terra-Sorb and Triamin (amino acid); Turo-fort and Nami (chemical fertilizer), and also a control treatment (without any application of amino acid and chemical fertilizers). Four commercial formulations of amino acid and chemical fertilizers were supplied, and the details of the formulations are mentioned in table 1. One month after planting, foliar applications of the fertilizers were applied to the carnation plants using a pump pressure sprayer (Pompa A Pressicne, Vicenza, Italy) until runoff, with the solutions applied three times at intervals of seven days. The first spray application was conducted seven days after the carnation was transplanted from the nursery into plastic pots filled with sand (Dec 21, 2017 and 2018, respectively). The second and third applications were conducted on Dec 28 and Jun 5, 2018 and 2019, respectively.

Data collection

Data collection included recording the plant height (cm), number of leaves, number of branches, stem diameter (cm), leaf area (cm^2) and were recorded using LI-COR 3000 A, a portable area meter, root length (cm), shoot dry weight, root dry weight, time to first

	Formulation of compounds			
	Amino acid		Chemical fertilizar	
Componentes	Terra-Sorb	Triamin	Turo-Fort	Nami
Nitrogen (N) total	2,1%	2.5%	20%	20%
Phosphorus P_2O_5	-	-	20%	20%
Potassium K_2O	0.064%	-	20%	20%
MgO	-	-	-	1.5%
Amino acid	9,3%	10.2	-	-
Nitrogen (N) organic	2,1%	-	-	-
Boron (B)	0,019%	0.06%	100 ppm	0.03%
Manganese (Mn)	0,046%	0.59%	250 ppm	0.073%
Zinc (Zn)	0,067%	0.116%	250 ppm	0.073%
Materia organic	14,8%	-	-	28%
Iron (Fe) - EDTA	-	1.16%	400 ppm	0.146%
Copper (Cu)	-	0.064%	150 ppm	0.073%
Molybdenum (Mo)	-	0.017%	10 ppm	0.00012%
Cobalt (Co)	-		-	0.0012%
Company	Arvensis agro, Zaragoza (SPAIN).	Arvensis agro, Zaragoza (SPAIN).	Abu Dhabi Fertilizer Industries Co. W.L.L. (UEA) (AD-FERT)	OMEX Agriculture Ltd. UK.

Table 1: Formulation of stimulators used in the experimental treatments.

flower (days), number of flowers plant^{-1}, flower diameter (cm), and flower dry weight (24 h at a temperature of 80°C).

Chemical composition

The a, b, and total chlorophyll content Chla = 13.43$A^{663.8}$- 3.47$A^{646.8}$; Chlb = 22.90 $A^{663.8}$ - 5.38 $A^{646.8}$; Chl total = 19.43 $A^{663.8}$ - 8.05 $A^{646.8}$ were determined as described by [22]. Carotenoid = (1000 A^{470}– 0.89 (Chla) – 52.02 (Chlb)/245 [23,24] and anthocyanin = A^{530}– 0.25A^{657} [25]. Leaf nitrogen percentage was determined by Kjeldahl method [26]. The potassium percentage (K%) was measured by method a Flame Photometer consistent with [27], while available the phosphorus percentage (P%) of the dried leaves was measured consistent with using by [28]. Total carbohydrate contents in the dried leaves were measured consistent with methods described by [29].

Gas exchange measurements

Stomatal conductance to H_2O (g_s), photosynthesis rate (P_N), transpiration rate (E), and intercellular CO_2 concentration (C_i) of leaves were measured between 9:50 and 11:10 am from fully expanded fourth blades of Carnations, by a transportable open flow gas exchange system LI-COR-6400 (Lincoln, NE, USA) at light saturating intensity on a sunny day when photosynthetically active radiation was ~630 μmol $m^{-2}s^{1}$, air temperature was~22°C and relative humidity was ~41% on a fully expanded top leaves (number three) of the main axis of the plant. Measurements were repeated four times for (third blades of each plant pot^{-1}) and the averages were recorded.

Statistical analysis and experimental design

The data were analyzed using Statistical Analysis System (SAS) software v. 9.2, (SAS Institute, Cary, NC). Data was subjected to analysis of variance (ANOVA) according to a split-plot in a completely randomized block design (RCBD), with three replicates per treatment, following the procedure outlined by [30]. Means of treatments were compared based on least significant difference (L.S.D) in order to evaluate the differences among fertilizer concentrations, and the level of significance was set at $P \leq 0.05$. The four foliar applications of solutions containing Terra-Sorb, Triamin, Turo-fort and Nami were arranged in the main plots, and the three treatment concentrations were randomly allocated to the sub-plots. Each plot included six potted carnation plants in each replicate. The fertilizers were applied to the leaves of the carnation plants in the three treatments at the different concentrations. In addition, the experiment included a control treatment (foliar application of water), resulting in a total of 108 plants [4 fertilizers (Terra-Sorb, Triamin, Turo-fort and Nami) × 3 concentrations (0, 2, and 4 g·L^{-1}) × 3 replicates × 6 plants].

Results and Discussion

Effect of foliar application solutions of fertilizers on vegetative growth

The data recorded within the two seasons and presented in table 2 and 3 showed that spraying "*Dianthus chinensis x barbatus* *cv*. Dianthus Interspecific Pink" carnation plants with different levels of foliar fertilizer solutions containing Terra-Sorb, Triamin (amino acid), and Turo-fort, Nami (chemical fertilizer) significantly increased the different vegetative growth characteristics; plant height, number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}, stem diameter, as well as the dry masses of shoot and root, root length compared to the control plants. A decrease in growth characteristics was more within the control treatments.

Fertilization	Levels	Vegetative growth							
		Plant height (cm)		Number of branches plant^{-1}		Number of leaves plant^{-1}		Leaf area plant^{-1} (cm^2)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Tera-sorb	0	15.26 ± 1.67^{bcd}	14.67 ± 0.87^{e}	7.03 ± 0.75^{g}	7.66 ± 1.15^{efg}	81.67 ± 1.52^{f}	62.64 ± 3.05^{h}	53.31 ± 7.77^{h}	66.43 ± 4.06^{hi}
	2 g/l	15.58 ± 0.81^{bcd}	17.16 ± 1.85^{cd}	8.36 ± 0.63^{efg}	9.07 ± 1.10^{c-f}	105.66 ± 6.14^{d}	127.68 ± 8.14^{c}	70.33 ± 6.29^{fg}	103.99 ± 8.35^{def}
	4 g/l	17.46 ± 2.08^{bc}	17.43 ± 0.50^{cd}	10.40 ± 0.52^{bcd}	10.70 ± 1.21^{bc}	104.04 ± 6.24^{d}	96.32 ± 7.23^{de}	125.79 ± 3.20^{cd}	91.86 ± 1.42^{efg}
Triamin	0	13.16 ± 2.10^{d}	14.31 ± 0.11^{e}	7.03 ± 0.85^{g}	8.36 ± 0.63^{d-g}	77.68 ± 6.11^{f}	80.04 ± 8.54^{fg}	76.75 ± 2.78^{f}	78.32 ± 1.55^{gh}
	2 g/l	15.53 ± 0.35^{bcd}	15.48 ± 1.22^{de}	9.06 ± 1.00^{def}	9.73 ± 0.46^{bcd}	91.66 ± 6.50^{e}	85.00 ± 10.53^{ef}	117.59 ± 7.26^{d}	90.86 ± 6.93^{fg}
	4 g/l	18.10 ± 0.85^{b}	17.36 ± 0.11^{cd}	10.76 ± 1.07^{bcd}	10.02 ± 1.00^{bcd}	98.33 ± 6.42^{de}	92.01 ± 4.35^{def}	134.88 ± 5.77^{bc}	121.79 ± 9.55^{bc}
Turo-fort	0	14.01 ± 1.40^{d}	14.03 ± 0.66^{e}	8.36 ± 0.55^{efg}	7.40 ± 1.21^{fg}	78.65 ± 5.58^{f}	78.69 ± 8.50^{fg}	68.42 ± 1.20^{fg}	65.00 ± 2.26^{hi}
	2 g/l	21.73 ± 1.06^{a}	22.20 ± 2.05^{b}	11.06 ± 1.67^{bc}	11.36 ± 1.09^{b}	121.03 ± 3.46^{bc}	103.01 ± 1.73^{d}	143.74 ± 8.90^{b}	127.58 ± 9.10^{b}
	4 g/l	23.10 ± 2.09^{a}	23.06 ± 2.10^{b}	13.33 ± 1.15^{a}	14.31 ± 1.52^{a}	166.67 ± 4.58^{a}	159.64 ± 5.85^{a}	160.71 ± 9.82^{a}	198.47 ± 10.82^{a}
Nami	0	14.62 ± 0.55^{cd}	14.11 ± 0.43^{e}	7.73 ± 0.64^{fg}	7.13 ± 0.11^{g}	75.64 ± 4.04^{f}	68.29 ± 10.34^{gh}	58.94 ± 5.26^{gh}	60.09 ± 3.14^{i}
	2 g/l	17.26 ± 0.85^{bc}	19.02 ± 1.91^{c}	9.76 ± 0.68^{cde}	9.35 ± 0.57^{cde}	127.02 ± 2.64^{b}	141.65 ± 13.37^{bc}	89.39 ± 2.04^{e}	111.21 ± 8.10^{cd}
	4 g/l	24.43 ± 1.19^{a}	25.63 ± 1.95^{a}	12.03 ± 1.10^{ab}	13.68 ± 1.15^{a}	116.01 ± 4.93^{c}	147.70 ± 12.34^{ab}	140.92 ± 6.83^{b}	106.45 ± 9.76^{de}
Mean		17.52	17.87	9.58	9.89	103.69	103.53	103.39	101.83

Table 2: Effect of different levels of foliar fertilizer solution on the vegetative growth of (Dianthus chinensis x barbatus Cv. Dianthus Interspecific Pink) plant grown on the two seasons (2017/2018 and 2018/2019).

Values in each column followed by the different letter(s) are significantly different at $P \leq 0.05$.

± Standard deviation.

The maximum values for several growth parameters were found in the subgroup with the application of foliar solution fertilizer at the level of 4 g·L^{-1}. Of the two fertilization groups (amino acid and chemical fertilizer) the chemical fertilizer group showed superiority over the amino acid group. The Turo-fort chemical fertilizer also appeared superior to the Nami foliar fertilizer solution for some parameters, such as number of branches plant^{-1}, number of leaves plant^{-1}, leaf area plant^{-1}, as well as stem diameter, dry mass of shoot plant^{-1} (giving values of 13.33, 166.67, 160.71 cm^{-2}, 4.40 mm and 3.56 g, respectively, within the first season, and 14.31, 159.64, 198.47 cm^{-2}, 4.31 mm and 3.85 g, respectively, within the second season. While in the first season, the Nami foliar fertilizer solution showed the greater value in some parameters, such as plant height, root length, and root dry mass per plant(24.43 cm, 23.20 cm, and 2.35 g, respectively), in the second season, the values of same parameters with Nami fertilizer were 25.63 cm, 24.86 cm, 2.19 g, respectively. These results may be due to the effect of the foliar solution fertilizer when applied at adequate levels for promoting vegetative growth and dry masses accumulation.

The result of the appropriate level of the foliar fertilizer solution in which the required macro-elements (P, K, N, and Mg) and micro-elements (Cu, Zn, Fe, Mn, Mo and B) in the fusion of organic nitrogen compounds within the plant for optimum growth, be contingent on the amount of inorganic Mg^{+2} for chlorophyll creation, P for the synthesis of nucleic acids and K which is important for nitrogen conversion into protein [31]. The stimulating effects of micro and macro-elements may be owing to the activation of apical meristems as well as protoplasm creation, elongation and partition of meristems cells, enhancing the biosynthesis of carbohydrates and proteins. Collectively these led to enhancing the development. Alike results were obtained by [3] on carnation plants, [13] on carnation plants, and [2] on carnation, [32] on petunia plants. In contrast, using the very best foliar fertilization solutions level (1.0% and/or 0.08) decreased these growth traits. This influence might be credited to the accumulation of salts on the leaf surface, which causes leaf burning and scorching [33].

Fertilization	Levels	Vegetative growth							
		Stem dimeter (mm)		Shoot dry mass plant^{-1} (g)		Root length (cm)		Root dry mass plant^{-1} (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Tera-sorb	0	2.66 ± 0.27^{c}	2.32 ± 0.25^{d}	1.85 ± 0.60^{f}	1.89 ± 0.52^{f}	17.47 ± 1.22^{def}	17.56 ± 0.05^{ef}	1.44 ± 0.52^{bcd}	1.11 ± 0.46^{de}
	2 g/l	2.92 ± 0.45^{bc}	3.20 ± 0.43^{bcd}	2.75 ± 0.28^{b-e}	3.13 ± 0.30^{bcd}	18.43 ± 1.80^{cde}	21.90 ± 1.51^{b}	1.13 ± 0.35^{d}	1.71 ± 0.86^{a-d}
	4 g/l	3.04 ± 0.39^{bc}	3.75 ± 0.76^{ab}	3.16 ± 0.07^{ab}	3.20 ± 0.30^{bc}	20.73 ± 0.55^{b}	19.30 ± 1.24^{cde}	1.32 ± 0.36^{bcd}	1.37 ± 0.52^{cde}
Triamin	0	2.61 ± 0.36^{c}	2.50 ± 0.31^{d}	2.01 ± 0.49^{f}	2.53 ± 0.26^{def}	17.10 ± 1.30^{ef}	16.53 ± 1.06^{f}	1.48 ± 0.19^{bcd}	1.18 ± 0.08^{cde}
	2 g/l	3.00 ± 0.59^{bc}	3.04 ± 0.25^{bcd}	3.08 ± 0.15^{ab}	2.85 ± 0.17^{cde}	16.02 ± 1.38^{f}	19.20 ± 0.95^{cde}	1.66 ± 0.14^{bc}	1.68 ± 0.50^{a-d}
	4 g/l	3.12 ± 0.30^{bc}	3.14 ± 0.36^{bcd}	3.12 ± 0.34^{ab}	3.08 ± 0.19^{bcd}	16.76 ± 1.01^{ef}	16.43 ± 0.25^{f}	1.62 ± 0.06^{bc}	1.30 ± 0.08^{cde}
Turo-fort	0	2.45 ± 0.11^{c}	2.42 ± 0.96^{d}	2.16 ± 0.63^{def}	2.61 ± 0.31^{cde}	19.37 ± 0.83^{bc}	18.40 ± 0.35^{def}	1.70 ± 0.19^{b}	1.12 ± 0.25^{de}
	2 g/l	3.51 ± 0.23^{b}	3.92 ± 0.61^{ab}	2.89 ± 0.44^{abc}	3.16 ± 0.32^{bcd}	22.80 ± 1.34^{a}	21.91 ± 2.60^{b}	2.25 ± 0.25^{a}	2.15 ± 0.45^{ab}
	4 g/l	4.40 ± 0.45^{a}	4.31 ± 0.46^{a}	3.56 ± 0.33^{a}	3.85 ± 0.52^{a}	20.29 ± 1.24^{bc}	21.38 ± 1.81^{bc}	1.59 ± 0.13^{bcd}	1.86 ± 0.12^{a-d}

Nami	0	2.44 ± 0.69^{c}	2.73 ± 0.81^{cd}	2.06 ± 0.58^{ef}	2.39 ± 0.40^{ef}	15.68 ± 0.77^{f}	16.46 ± 1.18^{f}	1.22 ± 0.08^{cd}	1.41 ± 0.15^{bcd}
	2 g/l	3.61 ± 0.47^{b}	3.56 ± 0.70^{abc}	2.83 ± 0.03^{bcd}	3.14 ± 0.64^{bcd}	19.06 ± 0.61^{bcd}	20.54 ± 0.64^{bcd}	2.26 ± 0.44^{a}	2.04 ± 0.43^{abc}
	4 g/l	3.54 ± 0.60^{b}	3.61 ± 0.08^{abc}	2.24 ± 0.52^{c-f}	3.66 ± 0.36^{ab}	23.20 ± 0.41^{a}	24.86 ± 2.02^{a}	2.35 ± 0.08^{a}	2.19 ± 0.64^{a}
Mean		3.11	3.20	2.64	2.96	18.90	19.54	1.67	1.55

Table 3: Effect of different levels of foliar fertilizer solution on the vegetative growth of (Dianthus chinensis x barbatus var. Dianthus Interspecific Pink) plant grown on the two seasons (2017/2018 and 2018/2019).

Values in each column followed by the different letter(s) are significantly different at $P \leq 0.05$.

± Standard deviation.

Effect of foliar application solutions of fertilizers on flower yield

The results in table 3 obviously showed noticeable improvement within the flowering parameters [number of inflorescences per plant, inflorescences diameter (mm), flowering date (days), dry mass of inflorescences (g)] as a result of the spraying carnation plants with the fertilizer solution groups (amino acid and chemical fertilizer), compared to the control.

Fertilization	Levels	Flower yield							
		Number of inflorescences plant^{-1}		Inflorescence diameter (cm)		Flowering date (days)		Inflorescences dry mass plant^{-1} (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Tera-sorb	0	7.33 ± 0.57^{gh}	6.03 ± 1.05^{gh}	3.16 ± 0.23^{cd}	3.14 ± 0.05^{f}	115.32 ± 0.57^{a}	116.01 ± 1.00^{a}	0.97 ± 0.10^{c}	0.69 ± 0.14^{de}
	2 g/l	8.28 ± 1.01^{efg}	8.73 ± 0.64^{e}	3.30 ± 0.17^{bcd}	3.19 ± 0.20^{ef}	100.04 ± 2.08^{cd}	101.35 ± 1.00^{e}	1.06 ± 0.26^{c}	1.16 ± 0.20^{cde}
	4 g/l	9.01 ± 1.00^{ef}	9.13 ± 0.23^{e}	3.36 ± 0.05^{bc}	3.60 ± 0.10^{bc}	98.33 ± 2.00^{de}	101.00 ± 1.78e	1.12 ± 0.22^{c}	1.23 ± 0.24^{cd}
Triamin	0	6.07 ± 1.15^{i}	6.40 ± 1.44^{fgh}	3.10 ± 0.10^{d}	3.06 ± 0.11^{fg}	109.69 ± 3.21^{b}	113.02 ± 1.05^{b}	0.63 ± 0.24^{c}	0.74 ± 0.46^{de}
	2 g/l	8.31 ± 1.15^{efg}	8.03 ± 0.95^{ef}	3.36 ± 0.11^{bc}	3.69 ± 0.10^{b}	103.35 ± 2.30^{c}	106.32 ± 0.57^{d}	0.95 ± 0.14^{c}	0.92 ± 0.05^{cde}
	4 g/l	11.36 ± 0.57^{d}	13.66 ± 0.57^{c}	3.43 ± 0.15^{b}	3.50 ± 0.10^{bcd}	94.29 ± 3.05^{f}	95.69 ± 0.58^{f}	1.22 ± 0.38^{c}	1.56 ± 0.60^{abc}
Turo-fort	0	6.29 ± 0.37^{hi}	6.06 ± 0.95^{gh}	3.13 ± 0.11d	3.16 ± 0.15^{ef}	108.70 ± 3.21^{b}	110.67 ± 1.15^{c}	0.89 ± 0.07^{c}	0.67 ± 0.34^{de}
	2 g/l	9.66 ± 0.35^{e}	11.44 ± 1.73^{d}	3.26 ± 0.05^{bcd}	3.43 ± 0.05^{cd}	94.04 ± 2.64^{f}	95.29 ± 0.59^{f}	1.21 ± 0.31^{c}	1.40 ± 0.03^{bc}
	4 g/l	20.35 ± 0.87^{b}	19.02 ± 2.25^{b}	3.46 ± 0.15^{b}	3.53 ± 0.11^{bc}	91.02 ± 1.73^{f}	93.34 ± 1.15^{g}	2.27 ± 0.46^{b}	2.01 ± 0.50^{ab}
Nami	0	7.28 ± 0.48^{gh}	7.68 ± 1.52^{efg}	3.10 ± 0.10^{d}	2.90 ± 0.10^{g}	107.65 ± 1.52^{b}	109.33 ± 0.59^{c}	1.14 ± 0.50^{c}	0.57 ± 0.17^{e}
	2 g/l	14.67 ± 0.66^{c}	15.06 ± 0.11^{c}	3.47 ± 0.05^{b}	3.35 ± 0.11^{de}	94.71 ± 0.57^{ef}	95.68 ± 0.53^{f}	1.96 ± 0.08^{b}	2.08 ± 0.31^{a}
	4 g/l	27.30 ± 1.15^{a}	24.31 ± 0.57^{a}	3.81 ± 0.08a	4.00 ± 0.09^{a}	93.62 ± 0.53^{f}	94.65 ± 0.50^{fg}	2.98 ± 0.93^{a}	2.13 ± 0.73^{a}
Mean		11.36	11.20	3.32	3.38	100.88	102.69	1.36	1.26

Table 4: Effect of different levels of foliar fertilizer solution on the vegetative growth of (Dianthus chinensis x barbatus Cv. Dianthus Interspecific Pink) plant grown on the two seasons (2017/2018 and 2018/2019).

Values in each column followed by the different letter(s) are significantly different at $P \leq 0.05$.

± Standard deviation.

The results of the flowering parameters, except for flowering date, indicated that the times taken to showing colour in the two seasons were significantly increased with the spraying of foliar solution applications. The earliest decrease within the period from planting time until the looks of flowering colour was obtained by 4 g·L^{-1} Turo-fort fertilizer, colour appeared on day 91.02 and 93.34 within both seasons, respectively, compared with the control where colour appeared on day 108.70 and 110.67 respectively, in each season. The increment in the number of inflorescences per plant, inflorescences diameter (mm), dry mass of inflorescences (g) as results of using suitable foliar fertilizer solution level at best doses of 4 g·L^{-1} Nami fertilizer gave 27.30, 3.881 mm and 2.98g, respectively in the first season, and 24.31, 4.00 mm, 2.13g, respectively, in the second season. These results could also be thanks to the role of nutrient elements like nitrogen, potassium, and phosphorus which are essential for the synthesis of cytokinin and protein; consequently, affecting cellular division [2] incarnation.

These data are almost like those obtained by [7] on rose and [34] on *Anthurium andreanum*. In contrast, the observed reduction in these parameters as results of spraying the plants with the very best foliar solution fertilizer levels (1.0 %) could also be thanks to the attendance of high salt levels within the spray which can increase the respiration rate and increase the speed of metabolic catabolism [35]. These results are consistent with those obtained by [8] on *Chrysanthemum morifolium*, [12] on gladiolus, [36] on gladiolus, [2] on carnation, and [32] on petunia plants.

Chemical composition

Effect of foliar solution fertilizers on total chlorophyll, total carotenoids, anthocyanin and total carbohydrates in leaves

The results of chemical analysis of fresh leaf samples exposed that the a, b and total chlorophyll (a+b), carotenoids, anthocyanin and total carbohydrates (%) within "Dianthus Interspecific Pink" carnation plants attended increase normally as results of spraying fertilizer solution on the plants for both groups of foliar solution fertilization, compared to the control (Figure 1, 2 and 3A). The very best significant increase in chlorophyll, carotenoids, and anthocyanin contents were obtained from spraying of Turo-fort foliar nutrition at 2 g·L^{-1} which gave 9.00, 1.37 and 0.087 mg g^{-1} (FM), respectively. While the total carbohydrates content was significantly increased as the foliar solution fertilization level increased up to the very best fertilizer level of 4 g·L^{-1} of Nami foliar fertilizer solution (27.81%).

This development in the total chlorophyll, anthocyanin, carotenoids content and total carbohydrates content as results of spraying fertilizer solution might be accredited to the mode of action of micro- and macro-nutrients in enhancing the enzymes of carbohydrates transformation and photosynthetic activity. Such results were mentioned by [37] on rose flowers and [15] on *Datura metal* L., [3] on carnation plants; [36] on gladiolus, and [2] on carnation.

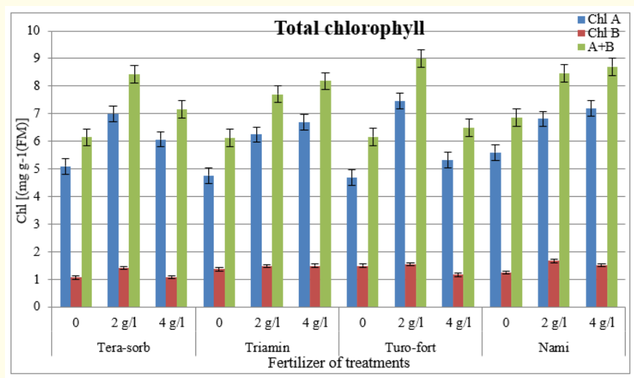

Figure 1: Effect of different levels of foliar fertilizer solution on the a, b and total chlorophyll of (*Dianthus chinensis x barbatus* Cv. Dianthus Interspecific Pink) plant grown on the two seasons (2017/2018 and 2018/2019).

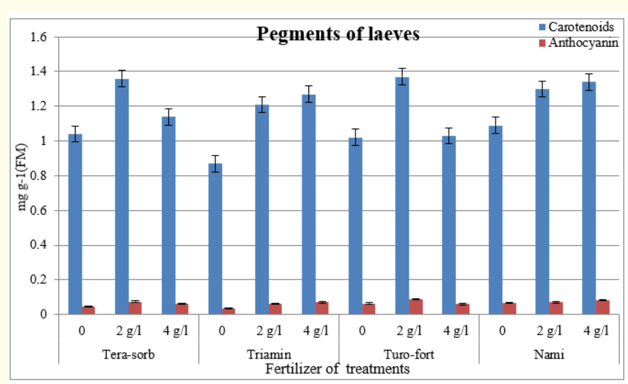

Figure 2: Effect of different levels of foliar fertilizer solution on the carotenoids and anthocyanin of (*Dianthus chinensis x barbatus* Cv. Dianthus Interspecific Pink) plant grown on the two seasons (2017/2018 and 2018/2019).

Effect of foliar solution fertilizers on nutrient content

The leads to figure (3B) presented the percentage of N within the leaves on a dry mass basis. It had been significantly increased because the foliar solution fertilization level increased up to the very best fertilizer level of 4 g·L^{-1} of foliar fertilizer solution. Phosphorus (%) and Potassium (%) nutrient followed an equivalent trend as nitrogen. These results reproduce the positive relationship between the level of foliar fertilizer solution, and therefore, the macro- and micro-nutrient content of the plants (Figure 3C and 3D). This might be attributed to the quick absorption of those nutrients by, especially the surface leaves and their translocation within the plant [5,31]. Similar results were found a by [38] on carnation, [13] on carnation, [32] on petunia plants, and [18] on radish.

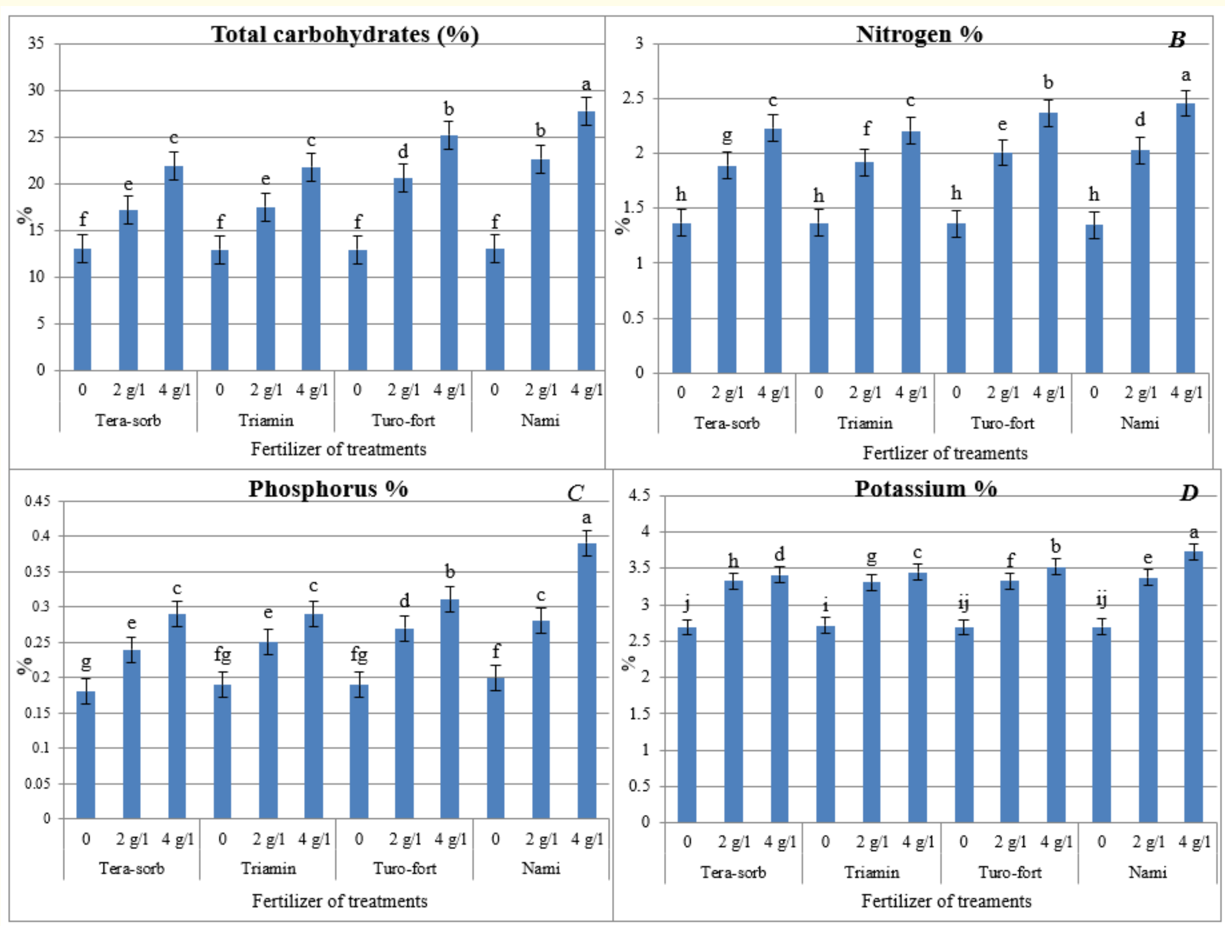

Figure 3: Total carbohydrates (A), Nitrogen (B), Phosphorus (C) and Potassium (D) in parameters of different levels of foliar fertilizer solution on (*Dianthus chinensis x barbatus* Cv. Dianthus Interspecific Pink) plant grown on the two seasons (2017/2018 and 2018/2019).

Gas exchange measurements

The differences between g_s, E, C_i and the foliar fertilizer solution were significant (Figure 3). Heights value of g_s was observed in carnation leaves furnished with 4 g·L^{-1} of foliar fertilizer solution (Tera-Sorb). However, minimum g_s value was recorded in plants fertilized with 4 g·L^{-1} of fertilizer solution (Nami) (Figure 3A). The highest E value was obtained when carnation plants were grown with 2 g·L^{-1} of fertilizer solution (Turo-fort). On the other hand, plants treated with 4 g·L^{-1} of fertilizer solution (Nami) showed the lowest E value (Figure 3C). The highest C_i was recorded in plants fertilized with 4 g·L^{-1} of fertilizer solution (Nami), while the lowest C_i was detected in plants supplied with 2 g·L^{-1} of fertilizer solution (Turo-fort) (Figure 3D). Gas exchange measurements or physiological indices are directly related to physiological processes like transpiration and photosynthesis rates. Different types of adding fertilizer solutions reflected various results on g_s, E and C_i values. Where the application of Tera-Sorb and Turo-fort solutions greatly increased g_s, Turo-fort and Nami solutions increased E, while application of Nami solution only resulted in a higher C_i value. These results indicated that the role of K nutrient in the fertilizer solution as stomatal conductance activities are suggested to be regulated through K^+ [39] and activates several enzymes involved in photosynthesis and respiration ratios [40,41]. On the other hand, a nutrient and water movement through the plant into the cell needs a big number of procedures for regulating the g_s and E [42,43] mentioned that N fertilization had a significant influence on photosynthetic assimilation processed by limiting the CO_2 supply to Rubisco activity (a main enzyme goal of the BBC cycle) as results of the subsequent exhaustion of the C_i and the exhaustion of g_s. The regulation of g_s has been labelled as a process linked to transport and absorption of elements [43,44].

Figure 4: Stomatal conductance to H2O (A), Photosynthetic rate (B), Transpiration rate (C) and Intercellular CO2 concentration (D) in parameters of different levels of foliar fertilizer solution on (*Dianthus chinensis x barbatus* Cv. Dianthus Interspecific Pink) plant grown on the two seasons (2017/2018 and 2018/2019).

Conclusion

The results showed the response of carnation "*Dianthus chinensis x barbatus* cv. Dianthus Interspecific Pink" to different levels of two groups (amino acid and chemical) of fertilizers. The results showed the superiority of the chemical fertilizer groups over the amino acid group. These results may be due to the effect of the optimum level (4 $g \cdot L^{-1}$) of the foliar fertilizer solution (Turo-fort) in encouraging the vegetative growth and dry mass accumulation. While these results showed that spraying of foliar fertilizer solution (Nami) at a suitable level (4 $g \cdot L^{-1}$) had a significantly beneficial effect in improving the flowering parameters of "Dianthus Interspecific Pink" carnation plants under net greenhouse condition.

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