

# Flower longevity and quality attributes of gerbera cut flower affected by different nutrient solutions

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## Abstract

Nutrition is the cornerstone of plant production. Here, efforts have been made to study the effect of different nutrient solutions from the Netherlands floriculture companies (S1; Schreurs, S2: Florist, and S3: Research Station for Floriculture and Greenhouse Vegetables (RSFGV)) on two gerbera cultivars ('Stanza' and 'Double Dutch'). Total chlorophyll index (SPAD), flower harvest per plant, flower stem height, disk diameter, total carbohydrate, lignin, and cell membrane stability were significantly affected by treatments. The highest number of cut flowers was harvested in RSFGV solution which was about 24% and 50% more than Florist and Schreurs solutions, respectively. Schreurs's solution showed the best impact on cell membrane stability, total carbohydrate, and lignin production. Flower stem height, disk diameter, and hemi-cellulose content were significantly increased by RSFGV solution. The cultivar 'Double Dutch' showed the highest cell membrane stability, total carbohydrate, hemi-cellulose, lignin, and vase life. Flower stem height was highest in the cultivar 'Stanza'. The interaction of nutrient solution and cultivar affected the studied parameters significantly, and the highest vase life was obtained in the cultivar 'Double Dutch' fertigated with Schreurs solution (11.4 d). Results indicated that Schreurs and RSFGV solutions could be the proper solutions for producing high-quality cut gerberas commercially.

**Key words:** Cellulose, Double Dutch, gerbera vase life, hydroponics, lignin, Stanza

## Introduction

Gerbera cut flower (*Gerbera jamesonii* Bolus ex. Hook f.) is a popular flower in family Asteraceae, which consists of a terminal composite head (capitulum) and a flower stem called scape (Perik *et al.*, 2012). Gerbera cut flower longevity is limited and in most cases terminates by stem bending (Van Meeteren, 1978) and petal wilting (Gerasopoulos and Chebli, 1998). Soilless cultivation system uses advanced technology, is highly productive, conserves water and nutrients, protects environment, and is an intensive cultivation system and provides a medium to roots have unlimited access to water and nutrient elements, consequently plants grow up 10 times faster and healthier than soil grown plants (Wahome *et al.*, 2011). Efficient nutrition, availability of cultivation in nonarable lands, and higher density planting leads to increase in yields per unit area in hydroponically grown plants (Resh, 2012). Additionally, different plants and cultivars have different nutrient elements need. Moreover, crop yield and quality is a result of the interaction between plant genetic traits and production condition management (Diacono *et al.*, 2012).

Mineral nutrition affects gas exchange in leaves by influencing stomatal behaviour and the water relations (Neocleous and Savvas, 2015). Therefore, changes in nutrient solution composition influences growth and productivity of plants. Şirin (2011) studied five different nutrient solutions on gerbera and reported that the highest flower quantity and quality was obtained in Çolakoğlu-2 solution. Additionally, different nutrient solutions (e.g., Hoagland, Hewitt, and Steiner) showed different effects on growth of fig trees (Kilinc *et al.*, 2007). This study was set up to evaluate the

effect of different nutrient solutions on productivity and quality of cut gerbera flowers, which is a very popular cut flower in many parts of the world.

## Material and methods

This experiment was conducted in the national institute of ornamental plants (NIOP), Mahallat, Iran, 2016. A factorial experiment based on completely randomized design with three replicates (5 plants per replicate) was performed. Different nutrient solutions procured from the Netherlands companies (S<sub>1</sub>: Schreurs, S<sub>2</sub>: Florist, and S<sub>3</sub>: Research Station for Floriculture and Greenhouse Vegetables; (RSFGV)) and two gerbera cultivars ('Stanza' and 'Double Dutch') were studied. Cultivation medium was a volume mixture of Peat: Perlite: Expanded clay (70:25:5 V/V) respectively. Gerbera seedling were cultivated in pots (3L), irrigated with tap water (Table 1). The greenhouse condition (day/night temp: 25/18±1°C; RH: 65%) was controlled accurately.

Plants were irrigated with full concentration of nutrient solutions (Table 2) with pH 5.5-5.8.

**Photosynthetic capacity:** Leaf number was measured at the end of experiment. Plants chlorophyll was measured using leaf Porometer (CCM-200; USA). To measure the photosynthetic pigments (Chl a, b, carotenoids, and total Chl), fully expanded mature leaves were sampled and dissolved in acetone (80%) and centrifuged, followed by measurement of the absorbance of each sample using a spectrophotometer (Perkin Elmer, Lambda 25, UV/VIS Spectrophotometer) at wavelengths of 663.2, 646.8 and 470 nm. The amount of pigments was calculated based on

Table 1. Chemical composition of tap water used for irrigation of gerbera seedling

Water type	pH	EC ( $\mu\text{S/m}$ )	$\text{NO}_3^-$	$\text{Ca}^{2+}$	$\text{Mg}^{2+}$	$\text{HCO}_3^-$	$\text{CO}_3^{2-}$	$\text{Na}^+$	$\text{Cl}^-$
			mg.L <sup>-1</sup>						
Tap water	5.7	363	20	32	12	70.15	0	16	88
Nutrient solution	$\text{NO}_3^-$	$\text{NH}_4^+$	$\text{H}_2\text{PO}_4^-$	$\text{K}^+$	$\text{Ca}^{+1}$	$\text{Mg}^{+1}$	$\text{SO}_4^{-2}$	$\text{NO}_3^-:\text{NH}_4^+$ ratio	
	mmol.L <sup>-1</sup>								
S <sub>1</sub>	8.5	0.2	1.2	4.25	4	1	1.3	42.5	
S <sub>2</sub>	9.5	-	1.8	5.4	5.3	2	3	9.5	
S <sub>3</sub>	11.25	1.5	1.25	5.5	3	1	1.25	7.5	
	Fe	Mn	Zn	Cu	$\text{MoO}_4^{-2}$	B	EC (dS.m <sup>-1</sup> )		
	$\mu\text{mol.L}^{-1}$								
S <sub>1</sub>	35	3	3	1	1	35	1.45		
S <sub>2</sub>	40	5	5	1	1	35	1.7		
S <sub>3</sub>	35	5	4	0.75	0.5	30	1.5		

Nutrient solutions; S<sub>1</sub>: Schreurs, S<sub>2</sub>: Florist, S<sub>3</sub>: RSFGV

Table 2. Elements concentration in applied nutrient solutions

Nutrient solution	$\text{NO}_3^-$	$\text{NH}_4^+$	$\text{H}_2\text{PO}_4^-$	$\text{K}^+$	$\text{Ca}^{+1}$	$\text{Mg}^{+1}$	$\text{SO}_4^{-2}$	$\text{NO}_3^-:\text{NH}_4^+$ ratio
	mmol.L <sup>-1</sup>							
S <sub>1</sub>	8.5	0.2	1.2	4.25	4	1	1.3	42.5
S <sub>2</sub>	9.5	-	1.8	5.4	5.3	2	3	9.5
S <sub>3</sub>	11.25	1.5	1.25	5.5	3	1	1.25	7.5
	Fe	Mn	Zn	Cu	$\text{MoO}_4^{-2}$	B	EC (dS.m <sup>-1</sup> )	
	$\mu\text{mol.L}^{-1}$							
S <sub>1</sub>	35	3	3	1	1	35	1.45	
S <sub>2</sub>	40	5	5	1	1	35	1.7	
S <sub>3</sub>	35	5	4	0.75	0.5	30	1.5	

Nutrient solutions; S<sub>1</sub>: Schreurs, S<sub>2</sub>: Florist, S<sub>3</sub>: RSFGV

(Lichtenthaler & Wellburn, 1983).

$$\text{Chl a} = (12.25 \times A_{663.2}) - (2.79 \times A_{646.8})$$

$$\text{Chl b} = (21.21 \times A_{646.8}) - (5.1 \times A_{663.2})$$

$$\text{Total Chl} = (7.15 \times A_{663.2} + 18.71 \times A_{646.8})$$

$$\text{Carotenoid} = ((1000 \times A_{470}) - (1.8 \times \text{Chl a}) - (85.02 \times \text{Chl b})) / 198$$

**Stalk length:** Average length of three stalks from cutting base to flower disk, was considered as stalk length.

**Flower diameter:** Flower disk diameter was measured by digital caliper.

**Yield or flower harvested per plant:** Average of harvested cut flowers in three plants, during the cultivation period was considered as cut flower number.

**Petal ion leakage:** Petal ion leakage was measured based on Lutts et al (1996) with some modifications. Briefly, 1 g of the fresh petal tissue was transferred into a falcon containing 20 mL of deionized water. After 24 hours (25°C), the ionic leakage of the samples (L<sub>1</sub>) was read by a conductivity meter (Aqualytic Sensodirect, CD24). Afterwards, samples were autoclaved for 20 min at 120°C. Samples were cooled down and the ionic leakage of the solution (L<sub>2</sub>) was read. The petal ion leakage was calculated according to the following formula:

$$\text{Ion leakage (\%)} = (L_1/L_2) \times 100$$

**Total carbohydrate:** Irigoyen et al (1992) method with some modifications was applied to measure total carbohydrate content. Briefly, 0.1 g of stem (10 cm below the capitulum), was weighed and ground in a porcelain mortar with 95% ethanol. The upper extract was put in a falcon and the residue was ground again with 10 mL of 70% ethanol and the obtained mixture was centrifuged at 3500 rpm for 10 minutes. Afterwards, 0.1 mL of the extract and 3 mL of fresh anthrone (100 mg anthrone+100 mL 72% sulfuric acid) was transferred into the test tube and the samples were put in hot water bath for 10 minutes. Samples were cooled down and the amount of absorption at 630 nm wavelength was measured using spectrophotometer (Perkin Elmer, Lambda 25,UV/VIS Spectrophotometer). Total carbohydrate content was determined by comparing to standard curve.

**Lignin:** The lignin content of gerbera flower stem was determined by the thioglycolic acid (TGA) method (Bruce and West, 1989). The proximal and distal end of the flower stem at fully opened stage (3 g, 10 days after harvest) was homogenized in 6 mL of 99.5% ethanol (Sigma-Aldrich; Germany) and the crude extract was centrifuged at 10,000 X g for 15 min. The pellet was transferred to a glass Petri dish, and air-dried overnight. 30 mg of the dried residue was placed in a screw-cap tube to which 5 mL of 2N HCl and 0.5 mL of thioglycolic acid (Sigma-Aldrich; Germany) were added and the mixture heated at 100°C for 12 h. After cooling, the mixture was centrifuged at 12,000 x g for 45 min at 4 °C. The pellet was washed with 2.5 mL of water and then resuspended in 5 mL of 0.5 N NaOH. The solution was agitated gently at 25 °C for 24 h. After centrifugation at 12,000 X g for 30 min, the supernatant was transferred to a new tube. One microliter of concentrated HCl was added to the test tube and the lignin thioglycolate was allowed to precipitate at 48°C for 6 h. After centrifugation at 10,000 X g for 30 min, the pellet was dissolved in 1 mL of 0.5 N NaOH. The absorbance was measured against a NaOH blank at 280 nm using spectrophotometer (Perkin Elmer, UV/VIS, Lambda 25). The amount of lignin was calculated from a linear calibration curve with commercial alkali lignin (Sigma-Aldrich; Germany).

**Cellulose and Hemi-Cellulose:** Cellulose was isolated for GLC analysis by an extraction procedure based on Updegraff, (1969) with some modifications. Finely ground samples (30-150 mg depending on the cellulose content) were weighed into 15 X 125 mm Teflon-lined screw-capped test tubes. Acetic-nitric acid

reagent (3 mL of a mixture containing 150 mL of 80% acetic acid and 15 mL of concentrated nitric acid) was added slowly to each tube while the contents were being mixed. Each tube was tightly capped and heated for 30 min at 100°C, after which the tubes were cooled and centrifuged. The supernatant was removed and discarded. The fibrous precipitate was washed twice with the acetic-nitric acid reagent (3 ml) and twice with acetone 2 ml. Most of the residual acetone remaining after the last wash was removed by evaporation. The cellulosic residue was analyzed as described by Sloneker (1971).

**Longevity:** Average of three cut flowers in every plant was measured as day until flowers wilted and lost marketability (He *et al.*, 2006).

**Statistical analysis:** Data analysis was performed using SAS V9.2 software. (SAS Institute Inc., Cary, NC, USA). Means were compared using Duncan's multiple range test at  $P < 0.01$  and  $P < 0.05$ .

## Results and discussion

Cut gerbera 'Stanza' and 'Double Dutch' showed different morpho-physiological traits and their responses to the applied nutrition varied significantly. Nonetheless, the interactive effect of nutrient solution and cultivar did not show a significant effect on studied parameters.

**Photosynthetic capacity:** According to the results, neither treatments (Variety or Solution), nor their interactive effect (Variety  $\times$  Solution) affect leaf number, chlorophyll a, and carotenoids significantly. SPAD index was significantly affected by treatments (Variety and Solution). Moreover, chlorophyll b content was significantly affected by variety. According to the results, the highest SPAD index was in RSFGV solution ( $57.9 \pm 0.79$  a), Florist ( $57.3 \pm 0.96$  a), and Schreurs ( $54.04 \pm 0.82$  b) respectively (Fig. 1). Additionally, SPAD index ( $57.69 \pm 0.7$  a) and Chl b ( $3.145 \pm 0.13$  a) in cut gerbera 'Stanza' were higher than

SPAD index ( $54.84 \pm 0.8$  b) and Chl b ( $2.493 \pm 0.16$  b) in 'Double Dutch' (Data not shown). Chlorophyll content was approximately proportional to leaf nitrogen content (Bojović and Marković, 2009). Probably, high content of total chlorophyll in plants fertigated with RSFGV solution is related to higher concentration of N in RSFGV solution compare to other solutions.

**Stalk length:** Stalk length is among the most important indexes of cut gerbera marketability. Cultivars showed a significant

Table 3. Quality indices of gerbera cut flowers under different nutrient solutions

Nutrient solutions	Stalk length (cm)	Flower diameter (cm)	Petal ion leakage (%)	Yield (flower harvested/plant)
S <sub>1</sub>	$47.93 \pm 0.93^{b\ddagger}$	$11.33 \pm 0.16^b$	$15.11 \pm 0.25^a$	$193.5 \pm 1.23^c$
S <sub>2</sub>	$49.64 \pm 1.22^b$	$11.42 \pm 0.1^b$	$16.08 \pm 0.62^b$	$234.5 \pm 14.67^b$
S <sub>3</sub>	$52.22 \pm 0.69^a$	$12.01 \pm 0.05^a$	$16.8 \pm 0.49^b$	$291.17 \pm 19.94^a$

Nutrient solutions; S<sub>1</sub>: Schreurs S<sub>2</sub>: Florist S<sub>3</sub>: RSFGV  
 $\ddagger$ Dissimilar words indicate significant difference basis on Duncan's multiple test range ( $P < 0.05$ ).  $\ddagger$ Mean  $\pm$  SE (n=3).

difference on stalk length. Moreover, the length of stalk was significantly affected by nutrient solution (Table 3).

The highest stalk length was in cut gerbera 'Stanza' (Table 4). The difference between stalk length of studied gerbera cultivars was probably related to the genetic diversity among cultivars (Shammy *et al.* 2012).

RSFGV nutrient solution increased length of stalks. Probably, increase of stalk length in RSFGV was related to nitrogen concentration in this solution, which was higher compare to Schreurs and Florist solutions. Adequate nitrogen supply in nutrient solution and its efficient uptake stimulated cell growth leading to increase in flower stem length (Singh, 2000). Additionally, Şirin (2011) studied the effect of five different nutrient solutions on quality and productivity of cut gerbera and reported that the highest stalk length was produced in Hewitt, 1966 nutrient solution.

**Flower diameter:** In this experiment, cultivars did not show significant difference on flower diameter, however, nutrient solution affected flower diameter significantly. The highest flower diameter was obtained in flowers supplied with RSFGV formula (12.02 cm) (Table 3) which was about 6 and 5% higher than Schreurs and Florist nutrient solutions, respectively. Probably, the differences between nutrients concentration, especially nitrogen and potassium, which are higher in RSFGV solution, have increased flower diameter size through affecting cell division and growth. Although, Dufault *et al.* (1990) reported that gerbera flower size was not affected by application of nitrogen in soil cultivation (Fig. 2A).

**Yield (flower harvested/plant):** Flower harvested/plant

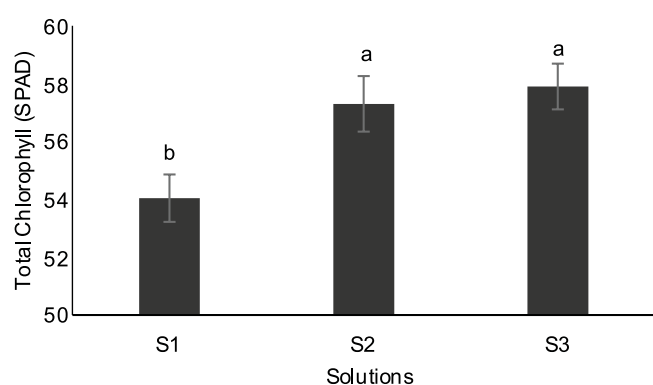


Fig. 1. Effect of nutrient solutions on total chlorophyll index (SPAD) in gerbera cut flowers 'Stanza' and 'Double Dutch'

\*Dissimilar words and error bars indicate significant difference basis on Duncan's multiple test range ( $P < 0.01$ ) and (Mean  $\pm$  SE, n=3), respectively.

Table 4. Effect of different cultivars on quality indices of cut gerbera (*Gerbera jamesonii*)

Cultivar	Stalk length (cm)	Petal ion leakage (%)	SPAD index	Longevity (day)	Lignin (%)	Yield (flower harvested/plant)
Stanza	$51.4 \pm 0.68^a$	$16.7 \pm 0.4^b$	$57.6 \pm 0.7^a$	$9.9 \pm 0.3^b$	$3.5 \pm 0.13^b$	$262.3 \pm 19.8^a$
Double Dutch	$48.4 \pm 0.97^b$	$15.2 \pm 0.2^a$	$54.8 \pm 0.8^b$	$11.5 \pm 0.4^a$	$4.3 \pm 0.09^a$	$217.1 \pm 14.0^b$

$\ddagger$ Dissimilar words indicate significant difference basis on Duncan's multiple test range ( $P < 0.05$ ).

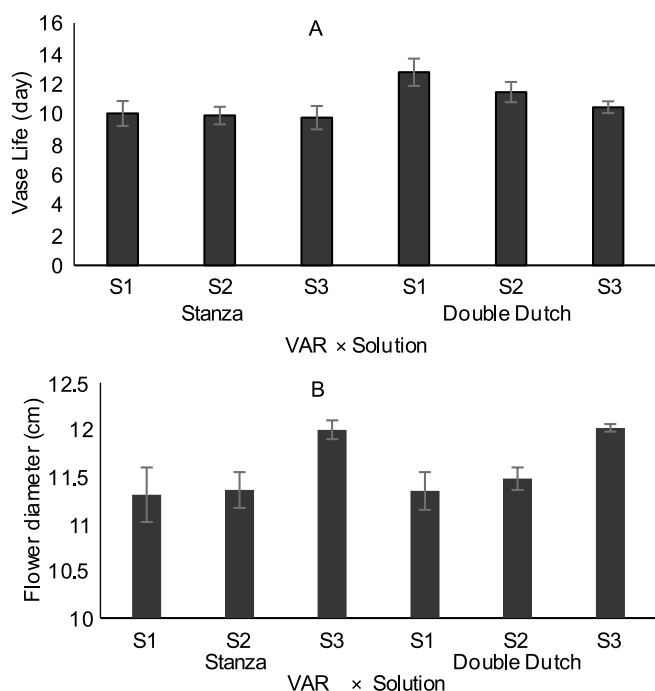


Fig. 2. Interaction effect of Variety  $\times$  Solution on vase life (A) and flower diameter (B) in gerbera cut flower. \*Error bars indicate (Mean  $\pm$  SE, n=3).

was significantly affected by cultivar and solution whereas the interactive effect of cultivar and solution did not show a significant effect on cut flower number. The highest number of cut flowers was harvested in RSFGV solution ( $291.17 \pm 19.94a$ ) compared to Schreurs solution ( $193.5 \pm 1.23c$ ) and Florist solution ( $234.5 \pm 14.6b$ ) (Table 3). Additionally, the number of cut flowers harvested in 'Stanza' cultivar was about 21 % higher than 'Double Dutch' (Table 4). There was a high correlation between N concentration and flower harvested/plant (Fig. 3), which supported the idea that N concentration affected productivity in gerbera cut flowers. Singh *et al.* (2015) reported that increase in N and K concentration led to higher productivity of cut carnation 'Master'. Therefore, considering the high concentration of N and K in RSFGV solution compare to other solutions, probably the effect of N and K on higher productivity of cut flowers is related to increase in chlorophyll content and subsequently photosynthetic rate. Moreover, Şirin (2011) who studied the effect of five different nutrient solutions on cut gerbera productivity revealed that the highest cut flower number was obtained in Çolakoğlu-2 solution.

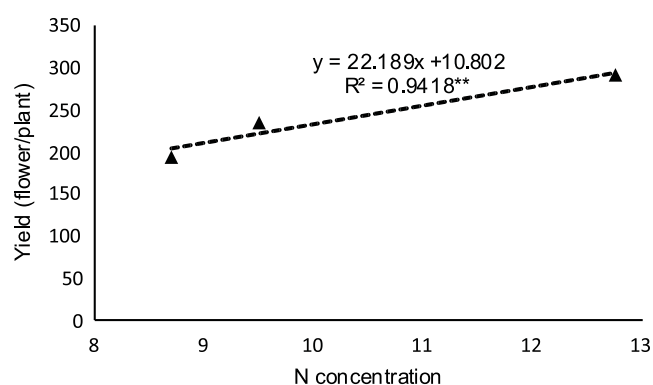


Fig. 3. Correlation between N concentration in nutrient solution and cut gerbera flower harvested/plant. (n=3 for each point)

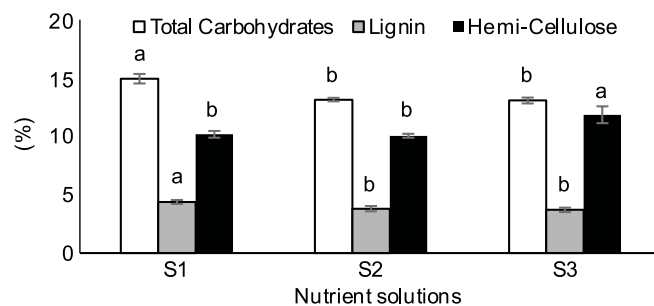


Fig. 4. Effect of nutrient solutions on total carbohydrate, lignin, and hemicellulose in gerbera cut flower 'Stanza' and 'Double Dutch'.

\*Dissimilar words and error bars indicate significant difference basis on Duncan's multiple test range ( $P < 0.01$ ) and (Mean  $\pm$  SE, n=3), respectively.

**Petal ion leakage:** According to the results, petal ion leakage was significantly affected by cultivar and nutrient solution. The highest cell membrane stability was in Schreurs solution (Table 3). Moreover, cut gerbera 'Double Dutch' showed the best cell membrane stability (Table 4). Ion leakage is a remarkable index of cell membrane stability and plays an important role in flower stem rigidity and cut flowers longevity. Nazarijeljou *et al.* (2011) in an experiment for screening cut gerbera cultivars reported that cut gerbera 'Candela', 'Entourage', 'Derim', 'Onedin', and 'Popov' showed the highest ion leakage, and 'Sazo', 'Stanza', 'Dune', and 'Cabana' showed the lowest ion leakage.

**Total carbohydrate:** The effect of cultivar and solution on

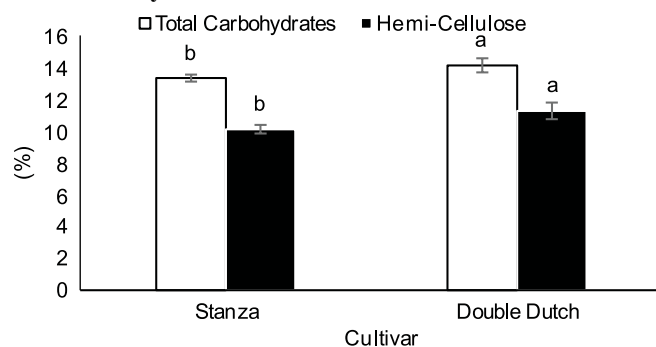


Fig. 5. Effect of cultivar on total carbohydrate and hemicellulose in gerbera cut flower. \*Dissimilar words and error bars indicate significant difference basis on Duncan's multiple test range ( $P < 0.01$ ) and (Mean  $\pm$  SE, n=3), respectively.

total carbohydrate was significant. Schreurs solution led to the highest carbohydrate ( $14.94 \pm 0.41a$ ) compare to Florist solution ( $13.15 \pm 0.15b$ ) and RSFGV ( $13.07 \pm 0.25b$ ), in cut gerbera stem (Fig. 4). Additionally, the content of carbohydrate in cut gerbera 'Double Dutch' was higher compare to 'Stanza' (Fig. 5).

According to the results, total carbohydrate decreased as nitrogen supply in nutrient solution was increased. In this regard, the lowest carbohydrate was in RSFGV solution which supplied the highest nitrogen ( $11.25 \text{ mmol.L}^{-1} (\text{NO}_3^-) + 1.5 \text{ mmol.L}^{-1} (\text{NH}_4^+)$ ) for plant. Druege *et al.* (2000) reported that increase in nitrogen supply, decreases carbohydrate content which is consistent with our finding.

**Lignin:** Lignin content was significantly affected by cultivar and solution treatments. Plants which were supplied by Schreurs nutrient solution produced higher lignin (Fig. 4). Furthermore, higher content of lignin was reported in 'Double Dutch' (Table 4). Concentration of N in nutrient solution led in reduction of lignin

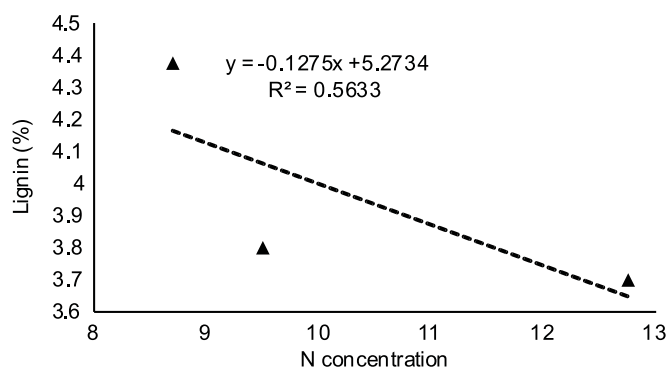


Fig. 6. Correlation between N concentration in nutrient solution and lignin production in cut gerbera stem. (n=3 for each point)

production in cut gerbera stem and there was a close correlation between these parameters (Fig. 6), subsequently high lignin production in plants fertigated with Schreurs solution is related to low N concentration in this solution compare to Florist and RSFGV solutions. Lignin is a determinative factor in gerbera vase life which influences structural function and defensive mechanisms. In plants, lignin is synthesized by catalytic activity of phenylalanine ammonia-lyase (PAL), peroxidase (POD), and cinnamyl alcohol dehydrogenase (CAD), which converts phenylalanine to hydroxyl- and methoxy-cinnamyl alcohols (Boerjan *et al.*, 2003; Vanholme *et al.*, 2010). Hardening of few-flower wildrice (*Zizania latifolia* Turcz.) resulted from lignin deposition and cell wall fibrillation (Liu *et al.*, 2010). Nazarideljou & Azizi (2015) reported that cut gerbera 'Aqua' had higher lignin content compared to 'Beaudine' which reveals that different cultivars have different lignin content.

**Cellulose and Hemi-Cellulose:** Treatments did not show any significant effect on cellulose content of cut gerbera 'Double Dutch' and 'Stanza', whereas hemi-cellulose content was significantly affected by treatments (Fig. 4).

The highest hemi-cellulose content was in plants supplied with Schreurs solution. Moreover, 'Double Dutch' produced higher level of hemi-cellulose while compared to 'Stanza' (Fig. 5). Cellulose is the most abundant natural polymeric material on earth (Ikeda *et al.*, 2002). Lignin grows into the cellulose micro-fibrils and forms a three-dimensional polymer of p-hydroxyphenylpropane units, being much more rigid than cellulose (Yousif *et al.*, 2007). This compound gives rigidity and strength to cell wall structure.

A few number of investigations describe significant cell wall modifications in flower petals which represented changes in texture during senescence (O'Donoghue *et al.*, 2002), such as quantitative loss of hemicellulose in senescing cut carnation (de Vetten *et al.*, 1991). Our results indicated that hemicellulose content was affected by changing nutrients supply in solution, especially the Schreurs solution, which had the lowest N supply and moderate level of calcium, produced the highest hemicellulose content, indicating that nutrients concentration and probably ratio is effective in metabolite synthesis in plant.

**Longevity:** Cut gerbera longevity was not affected significantly by nutrient solution, however, Schreurs solution extended vase life of cut gerbera 'Double Dutch' about 11% and 22% compared to Florist and RSFGV solutions, respectively (Fig. 2). Further, Schreurs solution extended longevity of cut gerbera 'Stanza' comparing Florist and RSFGV solutions. It seems that the high

concentration of nitrogen in RSFGV solution (11.25 mmol.L<sup>-1</sup> (NO<sub>3</sub><sup>-</sup>) + 1.5 mmol.L<sup>-1</sup> (NH<sub>4</sub><sup>+</sup>)) compare to Florist (9.5 mmol.L<sup>-1</sup> (NO<sub>3</sub><sup>-</sup>)) and Schreurs (8.5 mmol.L<sup>-1</sup> (NO<sub>3</sub><sup>-</sup>) + 0.2 mmol.L<sup>-1</sup> (NH<sub>4</sub><sup>+</sup>)) solutions negatively affected cut gerbera longevity. Bernstein *et al.* (2005) reported that *Ranunculus asiaticus* flowers grown under 50 ppm N application in a soilless system with perlite medium, characterized by almost double vase life duration compared to flowers grown under 100 ppm treatment.

On the other hand, calcium concentration in RSFGV solution was low (3 mmol.L<sup>-1</sup>) compared to Florist (5.3 mmol.L<sup>-1</sup>) and Schreurs (4 mmol.L<sup>-1</sup>) solutions. The role of calcium in extending cut flowers longevity is probably related to the formation of crosslinks between carboxyl groups of polyuronide chains found in middle lamella of cell wall (Shafiee *et al.*, 2010). Calcium application increased longevity of gladiolus 'Black Jack' (Gowda and Gowda, 1990), cut gerberas 'Campitano', 'Dino', 'Sangria', and 'Testarossa' (Gerasopoulos and Chebli, 1999), cut gerbera 'Carambole' (Geshnizjany *et al.*, 2014), and cut rose 'Kiss' (De Capdeville *et al.*, 2005).

Cut gerbera longevity was affected significantly by cultivar (Table 4). Cut gerbera 'Double Dutch' (11.55 d) lasted longer compared to 'Stanza' (9.9 d). The increased longevity of 'Double Dutch' is probably related to better cell membrane stability, high lignin formation in flower stem (Table 4) as a factor in extending longevity of cut gerbera (Zamski *et al.* 1991), and higher carbohydrate (Fig. 4) as a source of energy (Acharya *et al.*, 2010), which resulted in longer lasting of cut gerbera 'Double Dutch' compared to 'Stanza'. Various external cues (e.g., relative humidity, temperature, and nutrition) and internal cues (e.g., genotype, carbohydrate, and nutrients uptake) affected vase life on cut gerbera (Acharya *et al.*, 2010). De Jong & Garretsen, (1985) reported there is ample variation in vase life of gerbera. Nazarideljou *et al.* (2011, 2012) demonstrated that longevity of cut gerbera bears close relationship with cultivar. These results are consistent with Mahmood *et al.* (2013), who reported a significant difference between gerbera cultivars. Ferrante *et al.* (2007) in a screening experiment on gerbera cultivars reported that cut gerbera longevity varied between cultivars and ranged from 5 to 24 days.

Schreurs and RSFGV solutions produced stiffer stalks with high quality indexes of cut gerberas and could be the proper solutions for producing cut gerberas commercially.

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