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Evaluation of Pre- or Postharvest Application of Some Minerals and Organic Agents on the Growth, Flowering and Vase Life of *Rudbeckia hirta*, L.

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Abstract

The experiments were carried out during 2014 and 2015 summer seasons at the greenhouses of the Experimental Farm of Faculty of Agriculture, Kafr El-Sheikh University. The experiments were conducted in two phases: First one (pre-harvest): *Rudbeckia hirta* seedlings were transplanted during the first week of May to 30 cm diameter plastic pots filled with a soil mixture of clay and sand (1:1, v:v). Pots were divided in two equal groups, the first one, plants were foliar sprayed with one of the following:- Distilled water for the control treatment, $CaCl_2$ (125, 250, 375 mg·L^{-1}), $NiSO_4$ (30, 45, 60 mg·L^{-1}), $CoCl_2$ (50, 75, 100 mg·L^{-1}), K_2SiO_3 (100, 150, 200 mg·L^{-1}) and SA (100, 150, 200 mg·L^{-1}) at 60, 45, 30 and 15 days before harvest. The second group was without pre-harvest application assay (untreated plants).

Second phase (postharvest) was conducted in two different methods as follows: First method, flower stems resulted from each pre-harvest treatment were preserved in 250 mL graduated test tube filled with 200 mL of standard holding solution consists of sucrose (4%) + 8-Hydroxyquinoline citrate (250 mg·L^{-1}). The second method, flower stems resulted from plants without pre-harvest application preserved in holding solution consists of a constant sucrose (4%) and 8-Hydroxyquinoline citrate (250 mg·L^{-1}) beside one of the following additives: Distilled water for the control treatment, $CaCl_2$ (125, 250, 375 mg·L^{-1}), $NiSO_4$ (30, 45, 60 mg·L^{-1}), $CoCl_2$ (50, 75, 100 mg·L^{-1}), K_2SiO_3 (100, 150, 200 mg·L^{-1}) and Salicylic acid (100, 150, 200 mg·L^{-1}). Results showed that, pre harvest spraying plants with higher levels of K_2SiO_3 or $CaCl_2$ recorded the highest values for all plant vegetation characters. K_2SiO_3 followed by SA excelled on others in most flowering aspects. At the post harvest stage, SA, K_2SiO_3 and $CaCl_2$ exchanged the excellence between them for most vase life measurements. Flowers resulted from plants that preharvest treated was better than those that did not preharvest treated.

Keywords: *Rudbeckia hirta*, vase life, pre and postharvest applications, minerals or organic agents

1. Introduction

Maintaining cut flowers quality and extending vase life are considered important and practical for having acceptable products. *Rudbeckia hirta* L. (Indian Summer variety) commonly called black-eyed Susan, is a member of the Asteraceae family and native to the Eastern and Central North America. It is important in the horticulture industry due to its golden orange that characterized by flowers long postharvest life, tolerance to cold storage, suitable for wholesale marketing furthermore, adaptable and attractive native plant that requires little maintenance (Fulcher et al., 2003). Rudbeckia is a short-lived perennials or annual, obligate long-day plant with a critical photoperiod of 13-14 hours, starts blooming in mid-summer and continues to fall. These late summer workhorses in the garden are wonderful massed in borders, staged in small groups throughout the bed or in containers. Rudbeckia roots and flowers sometimes used in place of *Echinacea* when it was not available as teas or compresses to treat snakebites, worms, earaches, indigestion, burns and sores (Gilman & Howe, 1999).

Vase life of cut flowers is mainly affected by two main factors, namely ethylene which accelerates the senescence of many flowers and microorganisms which cause vascular blockage and thus reduce the vase life of cut flowers (Van Doorn et al., 1994; Zencirkiran, 2005, 2010).

Calcium has been known as one of the most important components to award resistance and strength of cell walls. It promotes postharvest life of flowering plants as well as accelerates bud opening and delays the senescence (Fergusen, 1984; Michalczuk et al., 1989). Calcium treatment causes a delayed protein and phospholipids reduction off the cell membrane and increases ATP activity in petals (Malakooti, 2001). Calcium can help to ameliorate the adverse effect of salinity on plants. It was reported to maintain membrane integrity and regulate ion transport and is essential for K/Na and Ca/Na selectivity (Renault, 2005). Silicon is not consider as an essential element for the plant growth and development, but it possesses beneficial impact on overall aspects of plant life such as suppressing biotic and abiotc stresses. Accumulation of Si in the epidermal tissue of the plant is the main mechanism which provides defense against insect and fungal attacks. It might make complex with organic compounds in the cell walls of epidermal cells, therefore increasing their resistance to degrading enzymes (Snyder et al., 2007).

Ni is the most recently element which is classified as essential for plant life cycle (Brown et al., 1987). Ni has an inhibitory effect on the enzyme responsible for production of ethylene (ACC oxidase) by forming an enzyme metal complex (Smith & Woodburn, 1984). Inhibitory effect of Ni on ethylene makes this element a good choice for improving the postharvest life of the horticultural crops especially cut flowers. Lower total soluble carbohydrates is an indication on the delay in flowers senesce. On the other hand the nitrogen cycle within plants can be affected by Ni (Bai et al., 2006) and this element have beneficial influence on rigidity of protein structures which might increase the total resistance of plants against senescence (Wood & Reilly, 2007). Cobalt can impede the production and accumulation of ethylene which feature an account for vase life augmentation. It caused a delaying in senescence by arresting the decline of chlorophyll and protein of lettuce (Tosh et al., 1979). An increment in vase life of marigold, chrysanthemum, rose and maidenhair fern has been reported after Co application. Also this element has a long-lasting effect in preserving apple as the fruits are kept fresh by Co application after ripening (Talukder & Sharma, 2007).

Salicylic acid is an endogenous growth regulator of phenolic nature, which participates in the regulation of plant physiological processes. It is plays a role of natural inductor of thermo genesis in Arum lily, induces flowering in a range of plants, controls ion uptake by roots stomatal conductivity and photosynthetic rate and considered to be a potent plant hormone because of its diverse regulatory roles in plant metabolism (Raskin, 1992; Popova et al., 1997; Khan et al., 2003). There are experimental data indicating participation of Salicylic acid in signal regulation of gene expression in the course of leaf senescence in Arabidopsis (Morris et al., 2000). Acetyl salicylic acid has been reported to inhibit ethylene production (Leslie & Romani, 1988; Srivastava & Dwivedi, 2000).

This study aims to conclude the best pre or postharvest treatments for improving the keeping quality of *Rudbeckia hirta* cut flowers.

2. Materials and Methods

2.1 Plant Material

The experiments were carried out during 2014 and 2015 summer seasons at the greenhouses of the Experimental Farm of Faculty of Agriculture, Kafr El-Sheikh University as experiments were conducted in two phases:

2.1.1 First Phase (Pre-Harvest Treatments)

During the second week of March of each season, *Rudbeckia hirta* seeds were sown in trays (82 cells) and seedlings were transplanted (one plant in each pot) during the first week of May to 30 cm diameter plastic pots filled with a soil mixture of clay and sand (1:1, v:v). The experimental layout was Randomized complete block design with three replicates (three pots in each replicate). Pots were divided in two equal groups.

i). First group: Plants were foliar sprayed with: Distilled water for the control treatment, $CaCl_2$ (125, 250, 375 $mg \cdot L^{-1}$), $NiSO_4$ (30, 45, 60 $mg \cdot L^{-1}$), $CoCl_2$ (50, 75, 100 $mg \cdot L^{-1}$), K_2SiO_3 (100, 150, 200 $mg \cdot L^{-1}$) and Salicylic acid (100, 150, 200 $mg \cdot L^{-1}$). Each plant was sprayed to run-off stage (approximately 25 mL per each plant) using hand atomizer to assure complete coverage of foliage and Tween-20 was used as a surfactant with these treatments at the rate of 0.01%. The application frequency was four times at 60, 45, 30 and 15 days before harvest).

ii). Second group: Plants without pre-harvest application assay (untreated plants).

All cultural practices, irrigation, fertilization etc. were carried out as recommended in the *Rudbeckia hirta* plants production program. At the end of the first phase (last week of June), the following vegetation parameter were recorded: Plant height, plant width (measuring the maximum width of the plant, then taking another width measurement perpendicular to the initial measurement, and averaging the two numbers), stems number and

shoots fresh and dry weights in addition, total green color was measured in SPAD values using a portable chlorophyll meter (Minolta SPAD-502, Japan). Furthermore, some flowering measurements were recorded like transplanting-flowering period, flowers number, flower diameter, and flower fresh weight (initial flower fresh weight).

2.1.2 Second Phase (Postharvest Treatments)

Flowers were harvested in the morning at the anthesis stage and immediately taken within 1 hrs to the Horticulture Laboratory of Faculty of Agriculture. Flowers were selected for uniformity in terms of development and pre-cooling was performed by placing flowers stem in ice cold water for 3 hrs to remove the field heat (Capdeville et al., 2005). Postharvest phase was conducted in two different methods as follows:

i). First one: Three cut flower stems resulted from each pre-harvest treatment were slantly re-cut to 25cm under water and the leaves were eliminated till nod 5, then puted in 250 mL graduated test tube filled with 200 mL of standard holding solution consists of sucrose (4%) + 8-Hydroxyquinoline citrate (250 $mg \cdot L^{-1}$) with 10 cm depth and was considered as a replication.

ii). Second method: Cut flower stems resulted from the second group (plants without pre-harvest application) have been processed in the corresponding technique before placing in 250 mL graduated test tube filled with 200 mL holding solution consists of a constant sucrose (4%) and 8-Hydroxyquinoline citrate (250 $mg \cdot L^{-1}$) beside one of the following additives: Distilled water for the control treatment, $CaCl_2$ (125, 250, 375 $mg \cdot L^{-1}$), $NiSO_4$ (30, 45, 60 $mg \cdot L^{-1}$), $CoCl_2$ (50, 75, 100 $mg \cdot L^{-1}$), K_2SiO_3 (100, 150, 200 $mg \cdot L^{-1}$) and Salicylic acid (100, 150, 200 $mg \cdot L^{-1}$).

The test tube mouths were covered with a sheet of Aluminum foil to minimize evaporation and contamination. The flowers were kept in a postharvest laboratory at room temperature (25±4 ºC), relative humidity of 65±5% and 24 hrs light with energy saver, cool light lamps to complete vase life and the following measurements were recorded:

2.2 Relative Fresh Weight Changes (RFW)

Fresh weight of the flowers was determined just before the immersion of the flowers into the solutions and repeated another three times at 6, 12 and 18 days of the immersion. The fresh weight of each flower was expressed relative to the initial weight to represent the water status of the flower (Joyce & Jones, 1992).

$$RFW = (Final\ weight/initial\ weight) \times 100 \quad (1)$$

2.3 Vase Life

Vase life was calculated as the days number between harvest time and that of experiment termination which was recorded when stem collapsed or the petals began to turn brown (Bleeksma & Van Doorn, 2003).

2.4 Solution Uptake(S)

Solution uptake was determined using a balance by weighing each vase containing its solution without flowers and correcting the probably evaporation from the evapo-control vase (vase which did not contain any flowers and located between the vases that contained flowers) by subtracting the average of evaporation data from solution uptake every 3 days. Vase solution uptake was calculated using the following formula:

$$Solution\ uptake = [S(t-3) - St/initial\ fresh\ weight] \times 100 \quad (2)$$

Where, St = Solution weight (ml/3 flowers) at 3, 6, 9 and 12 days (Chamani et al., 2005).

2.5 Protein Content

Protein concentration of the supernatant was estimated using the method of Bradford (1976). The absorbance of blue color was read at 595 nm using uv-visible spectrophotometer and amount of protein was quantified by using a standard curve and results were expressed as mg protein per g fresh weight of petals.

2.6 Anthocyanin Contents

Anthocyanin contents in fresh petal samples were determined calorimetrically according to Husia et al. (1965).

2.7 Soluble Carbohydrates Contents

Approximately 0.25g dry grinds of flowers and leaves materials were fixed in ethanol (95%), then macerated and centrifuged (3500 X, 10 min). The supernatants were pooled and used for estimation of carbohydrate contents using the method of Pakqain and Lechacer (1976).

2.8 Total Carotenoids

Total carotenoids were determined in fresh petals samples according to Nornai (1982).

2.9 Statistical Analysis

The experiments were conducted twice in a completely randomized block design with 3 replications and the obtained data were subjected to statistical analysis of variance (ANOVA). Both ANOVA were computed using MSTAT-C (MSTAT Development Team, 1989) and the mean separations were carried out according to Duncan's multiple range test (Duncan, 1955) and significance was determined at $p < 0.05$.

3. Results and Discussions

3.1 Pre Harvest Stage

3.1.1 Effect of Pre Harvest Treatments on *Rudbeckia hirta*, L. Vegetation

It was noticed that, control treatment (plants sprayed with distilled water) recorded the absolutely lowest values for all vegetation measurements (Table, 1). The tallest plants resulted from the treatments of $CaCl_2$ (375 mg·L^{-1}) and Salicylic acid (200 mg·L^{-1}), followed by $NiSO_4$ (60 mg·L^{-1}) and $CoCl_2$ (75 mg·L^{-1}), respectively. K_2SiO_3 at 200 mg·L^{-1} recorded the highest values for plant width, stems number and shoots fresh and dry weights. In the second rank lies the treatments $CaCl_2$ (375 mg·L^{-1}) and Salicylic acid (200 mg·L^{-1}). The other treatments gave an intermediate values for most studied growth characters. As for total green color, K_2SiO_3 at 200 mg·L^{-1}, $CaCl_2$ (375 mg·L^{-1}), Salicylic acid (200 mg·L^{-1}) then $NiSO_4$ (60 mg·L^{-1}) recorded the best results compared to other treatments or control. Numerous laboratory, greenhouse and field experiments have shown benefits of Si application on different aspects of plant growth (Snyder et al., 2007). Cobalt application has no effect on chlorophyll contents of *Argyranthemum* cut flowers (Kazemi, 2012).

Table 1. Effect of pre harvest treatments on some growth characters of *Rudbeckia hirta*, L. (Mean of both seasons)

Treatments	Level (mg·L^{-1})	Plant height (cm)	Plant width (cm)	Stems number	Shoots fresh weight (g)	Shoots dry weight (g)	Total green color (SPAD)
Control	-	48.35o	24.57n	6.58p	21.42p	12.08p	36.45p
$CaCl_2$	125	62.60h	32.70k	9.13k	26.83m	16.20m	38.92o
	250	67.05d	37.18e	11.43f	30.52g	18.17i	42.55k
	375	76.09a	41.23b	12.27d	34.09b	20.15c	47.34c
$NiSO_4$	30	50.61n	30.42l	8.07n	24.91n	15.69n	42.50l
	45	55.04m	35.07g	9.26j	28.20j	17.94j	42.98i
	60	65.77e	38.63d	11.60e	31.09f	19.04g	44.23e
$CoCl_2$	50	58.58j	25.95m	7.79o	23.84o	14.77o	42.16m
	75	65.03f	33.76j	8.64l	27.91k	18.77h	44.10g
	100	63.12g	34.22i	9.75i	30.12h	16.89l	43.58h
K_2SiO_3	100	56,20l	37.11e	10.21h	33.18d	19.50e	41.04n
	150	57.22k	40.87c	12.75b	34.07c	19.57d	47.61b
	200	61.32i	45.70a	14.94a	37.88a	22.35a	48.22a
SA	100	65.69e	25.03m	8.31m	27.61l	17.39k	42.68j
	150	69.84c	35.20h	10.75g	29.83i	19.11f	44.12f
	200	71.03b	36.55f	12.33c	32.80e	20.62b	46.77d

Note. Means within a column having the same letters are not significantly different in Duncan's Multiple Range Test.

3.1.2 Effect of Pre Harvest Treatments on *Rudbeckia hirta*, L. Flowering

Data in Table 2 showed that, control treatments was too little too late in flowering date compared to all other treatments. The shortest transplanting-flowering period resulted from $CoCl_2$ (100 mg·L^{-1}), $CaCl_2$ (375 mg·L^{-1}) and K_2SiO_3 (200 mg·L^{-1}) treatments followed by Salicylic acid (200 mg·L^{-1}) and $NiSO_4$ (60 mg·L^{-1}), respectively. the other treatments recorded intermediate period to bloom.

As for flowers number, data illuminate that flowers number gradually declined as the used substances concentration increase. in contrast, both flower diameter and initial flower fresh weight exhibited a gradual increase whenever each substance level increase. These results are in harmony with those reported by Jamshidi et al. (2012) who pointed out that Salicylic acid significantly increased flower diameter of Gerbera plants.

Table 2. Effect of pre harvest treatments on some flowering mesurments of *Rudbeckia hirta*, L. (Mean of both seasons)

Treatments	Level ($mg \cdot L^{-1}$)	Transplanting-Flowering (day)	Flowers numer	Flower diameter (mm)	Initial flower fresh weight (g)
Control	-	115.03a	18.04m	56.8o	12.74p
$CaCl_2$	125	83.61h	23.55i	86.5f	15.33m
	250	75.83j	20.71k	87.9e	16.82e
	375	67.60m	21.10j	90.4d	17.06b
$NiSO_4$	30	100.44c	30.51d	68.8l	14.69o
	45	95.37g	27.08g	72.0j	15.75j
	60	97.04e	26.43h	79.5h	16.20h
$CoCl_2$	50	67.50n	34.10b	71.1k	14.94n
	75	64.77o	27.41f	78.9i	15.38l
	100	60.34p	27.06g	81.0g	15.82i
K_2SiO_3	100	81.22i	19.11l	93.6c	16.47g
	150	74.12k	17.45n	98.4b	17.00c
	200	70.88l	15.32o	102.6a	17.37a
SA	100	107.26b	28.22e	59.2n	15.70k
	150	98.50d	37.41a	64.7m	16.72f
	200	95.78f	33.18c	68.9l	16.93d

Note. Means within a column having the same letters are not significantly different in Duncan's Multiple Range Test.

3.2 Postharvest Stage

3.2.1 Effect of Pre and Postharvest Treatments on Relative Flower Fresh Weight Changes

It was observed that, all pre or post treatments exceeded control in relative flower fresh weight all (Table 3). Flower relative fresh weight gradually increased by the time till the twelfth day then begin to decrease as the flower vase life increased. In general, Pre harvest treatments showed a highest relative flower fresh weights than that postharvest treated one. The highest levels of the treatments of $CaCl_2$, $NiSO_4$ and K_2SiO_3, followed by Salicylic acid and $CoCl_2$ recorded the highest relative flower fresh weight changes over all other pre harvest treatments. Whereas, in case of postharvest treatments, it was found that the highest levels of $NiSO_4$ and K_2SiO_3 surpassed all other treatments during all vase life period. There are an insignificant differences among the second and the third readings of relative flower fresh weight changes. Ichimura et al. (2001) found that addition calcium chloride increases fresh weight and delays weight loss. Also, Mortazavi et al. (2007) reported that the addition of calcium to vase roses increased the relative water content in petals, the water flow in the stalk segments tended to be greater with the $CaCl_2$ (10 mM) treatment at the beginning of the experiment. This suggests a greater effectiveness of this cation as a water stimulant. Likewise, Cortes et al. (2011) stated that, addition $CaCl_2$ to the preservative solution recorded the greatest total fresh weight for cut rose flowers head. The lowest fresh weight recorded for the flower head on the fifth day was obtained from the treatment with individual sucrose. Likewise, Ni and Co impede the production and accumulation of ethylene which feature an account for vase life augmentation which will positively reflect on flowers fresh weight. A gradual decrease in fresh weight was observed over the senescence period in control and treated flower, but cut spikes that were treated with 150 mg/L (SA) suppressed declining of fresh weight in early days of vase life. SA have important role in decreasing transpiration and evaporation of tissues, as well as decreasing respiration, so caused preventing from loss of fresh weight in cut flowers (Hatamzadeh et al., 2012). Calcium has presented remarkable effects in stomata closure, a mechanism that regulates water stress (Yang et al., 2003).

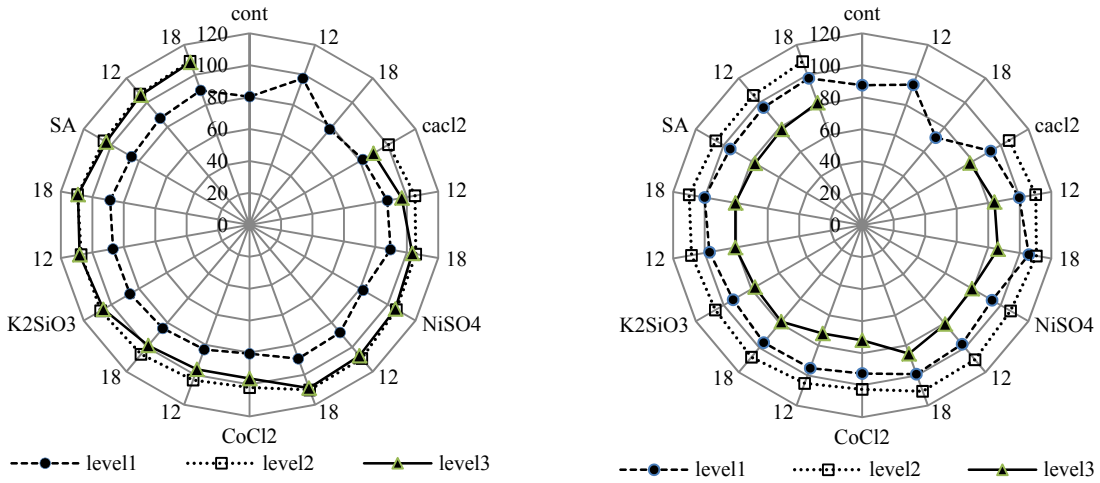

Figure 1. Effect of pre and post harvest treatments on relative flower fresh weight changes of *Rudbeckia hirta*, L. (Mean of both seasons)

3.2.2 Effect of Pre and Postharvest Treatments on Vase Life and Solution Uptake

The highest level of pre harvest $CaCl_2$ application flowed by K_2SiO_3 recorded absolutely longest vase life whereas $NiSO_4$ and SA were secondly lies then came the others treatments (Table 3). Postharvest treatments took a completely different direction, as SA and K_2SiO_3 recorded the longest vase life whereas $CaCl_2$ lies secondly. As for solution uptake, data show that pre harvest $CaCl_2$ and SA application ranked firstly followed by K_2SiO_3 then the other pre harvest treatments. Only post harvest SA treatment lies firstly followed by K_2SiO_3 and $CaCl_2$ treatments. Many researchers have confirmed this finding, Chen et al. (2004) confirmed that, holding cut *Gerbera hybrida* flowers in $CaCl_2$ preservative solution resulted in extending its vase life. Bacterial population in carnation stem or vase solution which cause xylem blockage and increase ethylene production, might be greatly susceptible to $CaCl_2$. In addition, calcium ion affect ethylene action on cell membrane by inhibiting ion leakage and reducing the effect of ethylene on senescence (Torre et al., 1999). Ichimura et al. (2001) that addition calcium chloride to the preservative solution increases the vase life, promotes flower opening. Salicylic acid can modulate plant responses to a wide range of oxidative stresses and prevents cell wall degradation (Shirasu et al., 1997). Also, Nicle and Cobalt inhibits ethylene synthesis and reduces sensitivity of flowers to ethylene. Co significantly extends carnation vase life (Jamali & Rahemi, 2011) likewise, Kazemi (2012) reported that, cobalt significantly prolonged vase life approximately for five days over control (distilled water).

High concentrations of calcium in vegetal tissues reduce both the ethylene production and the transpiration level. Calcium may have a role as a hormone regulator in senescent tissues (Fernandes, 2002). Also, SA extended vase life in association with inhibition of ethylene production (Srivastava & Dwivedi, 2000). The increases in water uptake and subsequently cut flower fresh weight, are apparently due to the acidifying and stress alleviating properties of SA. Salicylic acid extended vase life of cut rose flowers by regulating water uptake. Improved water balance may be due to possible germicidal activity of SA as an antimicrobial compound acting by inhibiting vascular blockage, allowing greater hydration in the flowers and/or positive regulatory role of SA on stomatal closure which regulates the rates of transpiration and increases the water retaining capacity of the petals (Lee et al., 2004; Alaey et al., 2011).

Table 3. Effect of pre and postharvest treatments on vase life and solution uptake of *Rudbeckia hirta*, L. cut flower (Mean of both seasons)

Treatments	Level ($mg \cdot L^{-1}$)	Pre-harvest treatment		Postharvest treatment	
		Vase life (day)	Solution uptake (ml/3flowers)	Vase life (day)	Solution uptake (ml/3flowers)
Control	-	18.530	56.72p	23.61p	62.43p
$CaCl_2$	125	34.17i	96.35g	28.71h	85.51g
	250	38.96b	108.47d	28.96g	87.04f
	375	39.05a	115.14b	30.44f	89.84e
$NiSO_4$	30	33.07k	84.12n	27.71l	71.66m
	45	33.94j	93.55i	27.15n	83.45h
	60	36.61d	96.08h	28.40j	79.91j
$CoCl_2$	50	26.35n	81.54o	24.86o	68.70o
	75	30.62l	87.28l	27.70m	70.33n
	100	33.07k	89.33k	27.88k	72.90e
K_2SiO_3	100	28.20m	90.68j	28.55i	78.59k
	150	34.19h	105.70e	31.65e	82.26i
	200	37.06c	112.93c	34.82c	94.60c
SA	100	35.01g	84.68m	33.19d	94.18d
	150	35.72f	97.62f	37.11b	108.23b
	200	36.41e	118.80a	37.50a	115.22a

Note. Means within a column having the same letters are not significantly different in Duncan's Multiple Range Test.

3.2 Effect of Pre and Postharvest Treatments on Flower Chemical Constituents

In general, results showed that, flowers protein content of pre harvest treated plants was higher than those post harvest treated one (Table 4). The absolutely highest protein contents resulted from the highest level of both pre harvest application of $NiSO_4$ followed by $CaCl_2$ and SA and from post harvest application of $NiSO_4$ followed by SA, respectively. The other treatments recorded an intermediate protein contents compared to control. Calcium chloride delays protein and phospholipid destruction in the petal membranes and eliminates ethylene production (Torre et al., 1999). Ni has beneficial influence on rigidity of protein structures which might increase the total resistance of plants against senescence (Wood & Reilly, 2007).

As for total soluble carbohydrates, data reveal that generally, there was an inverse relationship between treatment level and flower soluble carbohydrates contents. Pre harvest application of $CaCl_2$ and SA were more effective in reducing flower soluble carbohydrates contents compared to other treatments whereas, there was no evident difference in reduction level among all post harvest treatments. Both pre and post harvest control treatment recorded the absolutely higher soluble carbohydrates contents. These findings coincides with Wood and Reilly (2007) who stated that Ni have beneficial influence on rigidity of protein structures which might increase the total resistance of plants against senescence. Lower total soluble carbohydrates is an indication on the delay in flowers senesce (Bai et al., 2006). Also, Data revel that, water sprayed treatment (control) recorded absolutely highest soluble carbohydrates during petal senescence. Some treatments lifted up total soluble carbohydrates and others were less influential (Van-Doorn & Stead, 1997). In this respect, Faraji et al. (2011) reported that, the highest soluble carbohydrates contents of Gladioli petals was ten days after harvesting. then it began to decline exhausting the substrates.

Table 4. Effect of pre and postharvest treatments on flower chemical constituents of *Rudbeckia hirta*, L. cut flower (Mean of both seasons)

Treatments	Level ($mg \cdot L^{-1}$)	Protein contents (mg/g FW)		Total soluble carbohydrates (mg. g^{-1} DW)		Anthocyanin (g/100g. FW)		Total carotenoids (mg/g. FW)	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post
Control	-	23.35p	21.13o	36.56a	37.68a	0.07j	0.09h	0.16m	0.17m
$CaCl_2$	125	30.17i	28.66i	34.29f	35.42e	0.16e	0.10g	0.29g	0.27f
	250	30.54g	29.40f	30.40o	33.21o	0.19b	0.13d	0.40b	0.33b
	375	32.22e	29.72e	26.97p	32.19p	0.20a	0.15b	0.38d	0.30d
$NiSO_4$	30	30.02j	30.16c	33.25k	35.07i	0.15f	0.10g	0.25j	0.20k
	45	34.30b	32.05b	33.20l	34.15k	0.17d	0.12e	0.29g	0.24h
	60	36.80a	33.80a	33.46j	34.11l	0.18c	0.12e	0.36e	0.31c
$CoCl_2$	50	27.21n	26.65m	36.30b	36.20b	0.10i	0.09h	0.19l	0.15n
	75	27.50m	26.95l	35.19d	35.33f	0.13h	0.11f	0.23k	0.18l
	100	27.83l	27.02kl	33.55i	34.90j	0.15f	0.11f	0.27h	0.21j
K_2SiO_3	100	29.66k	27.08k	35.72c	36.02c	0.13h	0.10g	0.26i	0.22i
	150	31.07f	29.11g	34.22g	35.16g	0.16e	0.13d	0.35f	0.29e
	200	30.42h	29.00h	34.19h	35.08h	0.19b	0.15b	0.39c	0.33b
SA	100	24.63o	24.50m	34.84e	35.77d	0.14g	0.12e	0.25j	0.25g
	150	33.08d	28.33j	32.77m	34.04m	0.15f	0.14c	0.36e	0.31c
	200	33.50c	30.06d	31.79n	33.62n	0.18c	0.18a	0.44a	0.35a

Note. Means within a column having the same letters are not significantly different in Duncan's Multiple Range Test.

Anthocyanin content in flowers was increased in response to all treatments comparing with control while, the mastery was attributed to pre harvest $CaCl_2$ and K_2SiO_3 treatments and postharvest salicylic acid treatment. In the second rank lie pre harvest $NiSO_4$ and salicylic acid and postharvest $CaCl_2$ and K_2SiO_3 treatments. The highest carotene contents recorded with pre or postharvest SA treatment followed by the medium level of $CaCl_2$ then came all the other treatments. In this respect, Salicylic acid in holding solution significantly decreased anthocyanin leakage in carnation cut flowers (Kazemi et al., 2011). Also, Kazemi (2012) reported that, cobalt significantly decreased anthocyanin leakage. Moharekar et al. (2003) reported that salicylic acid activated the synthesis of carotenoids and xanthophylls. Ayad (2010) reported that, the higher level of CaCl2 caused a significant reductions in carotenoids contents up to 45%. Likewise, Sharma and Hall (1991) concluded that, the decrease in carotenoids with increasing $CaCl_2$ level lead to the degradation of β-carotene and formation of zeaxanthins, which are apparently involved in protection against photo inhibition.

4. Conclusion

High level Pre-harvest sprayed plants with $CaCl_2$ or postharvest holding flowers with SA recorded the absolutely tallest flowers vase life. generally, preharvest treatment especially with $CaCl_2$, K_2SiO_3 or SA was more impact and effective in improving both *Rudbeckia hirta*, L. plant or flowers characters than postharvest treatment.

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