Improving some Quantitative and Qualitative Characteristics of *Solidago canadensis* "Tara" using CYCOCEL and Planting Density under Drip Irrigation and Lighting Systems

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Abstract: *Solidago canadensis* L.cv. "Tara" belongs to family Asteraceae and grows as wild flower in North America, Asia and Europe. It is widely used as a landscaping flowering plant, as an excellent cut flower for arrangements and bouquets with high post harvest durability and as a dried flower. The present investigation was conducted in two successive seasons, started in February 2012 and ended in July of the same year and repeated during the same period of time in 2013, in Meniat bani Mansour village, Etey Ellbaroud, El-Behira Governorate, Egypt (30" 54' 34, 87" N and 30" 42' 33, 78" E) in an open private commercial field provided with drip fertigation and lighting system. The experimental design was a Randomized Complete Block Design (RCBD) to determine the response of *S. canadensis* L.cv. "Tara" to six cycocel (CCC) concentrations (control zero, 500, 1000, 1500, 2500 and 3500 ppm) as foliar spray, two planting densities (20 and 40 plants m^{-2}) and interactions between them in an attempt to increase its landscape value, its quality as a cut flower production for reaching the maximum export value as well as increasing offsets production as a vegetative propagation method under Egyptian conditions. The results revealed that stem height, stem circumference, fresh and dry weight, number of leaves $plant^{-1}$, total leaves area $plant^{-1}$, inflorescence length, percentage inflorescence length $stem^{-1}$, number of flowering branches inflorescencestem $plant^{-1}$, flowering branches length $inflorescence^{-1}$, vase life, total chlorophyll and carotene contents of leaves increased significantly by reducing planting density. While, significant delay from (121 to 127 days) in flowering occurred due to increasing planting density. Applications of (2500 and 3500ppm) CCC significantly decreased stem height, while application of (3500ppm) CCC significantly increased stem circumference, fresh and dry weight, number of leaves $plant^{-1}$, total leaves area $plant^{-1}$, inflorescence length, percentage inflorescence length $stem^{-1}$, number of flowering branches inflorescencestem $plant^{-1}$, flowering branches length $inflorescence^{-1,}$ vase life, number of offsets $plant^{-1}$, total chlorophyll and carotene. With respect to almost all characteristics, we can recommend that the best results were recorded in plants treated by combination of CCC at 3500 ppm with 20 plants m^{-2}.
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Key words: *Solidago canadensis*, Density, chlormequat (2-chloroethyl) trimethylammonium chloride, lighting, drip irrigation.

1.Introduction

Solidago canadensis L.cv. "Tara" is one of the photoperiodic crops; Day length manipulation is required to have total control for the timing of the harvest. The plant tolerates many different temperatures. During the vegetative growing period a 14°C night temperature and a 18°C day temperature are best, though production has proven to be satisfactory under much higher temperatures. *Solidago* belongs to family Asteraceae and grows as a wild flower in North America, Asia and Europe **(Jeffrey *et al.*, 2001**). Using as an excellent cut flower with high post-harvest durability and as a dried flower. Good quality of *Solidago canadensis* cut flower, especially for export is usually achieved by manipulating growth factors such as temperature and light. These physical factors are very difficult to control and perhaps expensive in Egypt. Agricultural factors such as spacing have critical effects on quantitative and qualitative characteristics of plants (**Naghdi Badi *et al.*, 2004).** Plant growth and flowering depend on PGRs equilibrium and plants quickly respond to change of hormonal balance (**Khangoli, 2001**). **CYCOCEL** (CCC) or chlormequat (2-chloroethyl) trimethylammonium chloride is a plant growth regulator for use on bedding plants and containerized ornamentals in greenhouses, shadehouses, and nurseries which enhances the crop aesthetic appeal and improves durability during postproduction shipping and handling. (**Kazaz *et al.*, 2010**) showed that CCC significantly affected days to flower, stem length, flower number and chlorophyll content. Shorter plants are more attractive and easier to handle during marketing and planting. Treated crops are more compact flowering plants with shorter internodes, stronger stems, uniform shoot growth and greener leaves. CCC penetrates into the plant to provide maximum effect while the spray solution stays wet. Therefore, greater effect is obtained if sprays are applied under conditions that support slow drying of

spray solutions. The optimum usage of CCC varies depending on the crop, the individual user's production situation and the desired final plant height and appearance. Users should determine the optimum CCC rate, timing, and frequency under their individual production situations. The retarding effect of CCC is due to its opposing effect to Gibberellin biosynthesis (anti-gibberellin dwarfing effect) which leads to the deficiency of gibberellins and blocking the conversion of geranyl pyrophosphate to capaly pyrophosphate in gibberellins synthesis causing reduction in cell elongation (**Rademacher, 1993 and Boldt, 2008)**. The experiment was undertaken to estimate the proper planting density and concentrations of CCC for improving quantitative and qualitative characteristics of *Solidago Canadensis* "Tara" under drip irrigation and lighting systems.

2.Material And Methods

The experiment was carried out in two successive seasons, started in February 2012 and ended in July of the same year and repeated during the same period of time in 2013, in Meniat bani Mansour village, Etey Ellbaroud, El-Behira Governorate, Egypt (30" 54' 34, 87" N and 30" 42' 33, 78" E) in an open private commercial field provided with drip fertigation and lighting systems.

Planting material:

Rooted cutting of *Solidago canadensis* L. cv. "Tara" of length 5 cm with eight to nine leaves per cutting were planted in beds of length 6 m and width 1 m in sand clay loam soil composed of Sand: Clay: Silt at 65: 25: 10 v/v, respectively, two planting densities were used 20 and 40 plants m^{-2}. Soil analysis was carried out in the soil testing laboratory, Desert Development Center, American University in Cairo (Table 1).

Table 1: soil analysis

Soil texture	EC dsm^{-1}	PH	N mmol l^{-1}	P mmol l^{-1}	K mmol l^{-1}	Organic matter (%)	Na+ mmol l^{-1}	Ca++ mmol l^{-1}	Mg++ mmol l^{-1}
Sand Clay Loam	7.3	7.9	0.91	0.23	0.42	0.9	42	9	7

Irrigation & Lighting system

Plants were irrigated using drip irrigation system and grown under natural temperature and controlled day lengths of (16 – 18 lighting hours per day) using Tungsten lamps for extending day length from 9 PM to 3 AM (at a rate of 15 watts m^{-2}) with cyclic lighting of 15 min. on and 15 min. off. The lamps were fixed at 2.5m from soil surface. *Solidago* stays rosette when minimum temperature and day length are less than 15◦C and 12 hours, the influence of day length over the rosette formation is stronger than the influence of cold temperatures. With the usage of lighting and heating, a program of year-round production is possible **(Highsun, 2008).** The application of lighting and heating **(**temperature over 10◦C and light 16 hours) after pruning back the plants, *Solidago* keeps producing flower stalks. When the stalks reach to 30 – 40 cm or the targeted stem length, stop lighting and then *Solidago* grows generative and forms its flowers.

Six cycocel (CCC) concentrations (control zero, 500, 1000, 1500, 2500 and 3500 ppm) were used as a foliar spray application; applied four times in the morning till running off point; the first spray was applied 45 days after planting, then three applications one week apart.

Fertilizing system: Two weeks after planting, ammonium nitrate at a rate of 0.5 g L^{-1} was added to the irrigation water to all treatments for one month then substituted by calcium nitrate at 0.5 g L^{-1}, when the plants height reached 25 cm a compound fertilizer of N: P_2O_5: K_2O (13:3:42) was used at the rate of 0.5 g L^{-1}.

Statistical analysis of data: The experimental design was a Randomized Complete Block Design (RCBD) in a factorial experiment with three replicates; each replicate contained three samples, the main effect was the planting density and sub effect was the cycocel (CCC) concentrations. Data were subjected to analysis of variance (ANOVA) using the SAS program **(SAS Institute, 2002)** and the mean values were compared using Tukey's test at P= 0.05 level **(Snedecor and Cochran, 1974)**.

Stem height, stem circumference, fresh weight, dry weight, number of leaves $plant^{-1}$, total leaves area $plant^{-1}$, inflorescence length, percentage of inflorescence length $stem^{-1}$, number of flowering stem $plant^{-1}$, number of flowering branches inflorescence stem $plant^{-1}$, flowering branches length $inflorescence^{-1}$, days to flowering,, vase life,, number of offsets, chlorophyll a, chlorophyll b, total chlorophyll and caroten were recorded in this study and the values are means of two seasons, 2012 and 2013 were presented in results part.

chlorophyll a, chlorophyll b, total chlorophyll and carotene contents of leaves were assayed in the commercial cut stage1/3 open inflorescence according (**Wintermans and Mat, 1965**), absorption at 662, 644 and 440 nm were detected using spectrophotometer (UNICO 3200). Vase life, the stem were cut to a uniform length and lower leaves were removed leaving

only few upper leaves after that, the stems were put in 250 ml conical flask containing distilled water at room temperature (30 C°±2 and 75% humidity) until fading.

3.Results and Discussion

Vegetative Growth:

The analysis of variance showed that, the F-values of planting density, CCC concentration and interactions between them were significant at 0.05 level of significance. In general, data of stem height, stem circumference, fresh weight, dry weight, number of leaves plant^{-1} and total leaves area plant^{-1} were reduced significantly by increasing planting density from 20 - 40 plants m^{-2} **(Table 2)**. The reduction in parameters might be due to the excessive competition between plants on nutrients and water and reduction in light intensity and light penetration to lower leaves **(Rahnama and Bakhshandeh, 2006 and Osman *et al*., 2008**).

Stem height decreased significantly by increasing CCC concentration reaching the shortest stem at 2500ppm and 3500 ppm CCC (77.38 and 77.6 cm), respectively compared to control at Zero ppm concentration and the highest stem length (85.2 cm) was achieved at Zero ppm CCC combined with 20 plants m^{-2} **(Table 2)** same results were reported by (**Holcomb and Gohn, 1995; Bhat *et al*., 2011 and Osman *et al*., 2011**), This result might be due to the anti-gibberellin dwarfing effect of CCC which lead to the deficiency of gibberellin and finally blocking the conversion of geranyl pyrophosphate to capalyl pyrophosphate which is the first step in gibberellin synthesis then reducing gibberellin biosynthesis and reduction of cell division and elongation (**Moore 1989 and Boldt 2008**). Also CCC affects the sub apical meristem by prohibiting cell division **(Fisher *et al*., 1996)**. Reduction in height probably was caused by restriction in cell elongation rather than cell division.

Stem circumference increased significantly by increasing CCC concentration compared to control which is in agreement with **(Reddy, 2005; Boldt, 2008 and Passam *et al*., 2008)**. The best Stem circumference (2.5 and 2.7 cm) was found by combination CCC concentration at (2500 and 3500 ppm) with 20 plants m^{-2}, respectively **(Table 2)**. The occurrence of variation in stem circumference due to the influence of CCC might be attributed to the stimulation of cell production in the cambium, accompanied by a delay in cell differentiation and to an increase in cell volume of the parenchymatous cortical cells (**Bora and Sarma, 2006**). This is in agreement with the results obtained by (**El-Sheibany *el al*., 2007**) in Chrysanthemum

Number of leaves per plant and **total leaf area** increased significantly by increasing CCC concentration. The increase in total leaf area might be due to the increase in total number of leaves per plant which due to decrease in the internodal length **(Sridhar, 2006)**, CCC have the ability to delay senescence of leaf, arresting chlorophyll degradation and promoting the synthesis of soluble proteins and enzymes resulting in more assimilation surface area. The best number of leaves plant^{-1} and total leaf area (74 leaves plant^{-1} and 640.5 cm^{2}) were found by combination CCC concentration at (3500 ppm) with (20 plants m^{-2}), respectively **(Table 2).**

The highest **fresh weight** and **dry weight** (96 g and 50g) were found by combination CCC concentration at (3500 ppm) with (20 plants m^{-2}), respectively. These results might be due to effect of CCC and planting density on vegetative (number of leaves, leaf area and Stem circumference) and flowering growth which agree with **(Reddy, 2005 and Nadia *et al*., 2006)** who found that spraying of 3000 ppm CCC increased fresh flower weight in Iris. CCC may also promote cell growth by causing decrease in the osmotic potential of cells **(Attia, 2004)** that was reflected on enhancing leaf bud development as well as blade area and its fresh and dry weight **(Table 2**).

Flowering Characteristics:

The analysis of variance showed that, the F-values of planting density, CCC concentration and interactions between them were significant at 0.05 level of significance. Generally, all data on means of *Solidago canadensis* L. cv. "Tara" including inflorescences length, percentage inflorescences length stem^{-1}, number of flowering branches inflorescence^{-1} and flowering branches length inflorescence^{-1} in **(Table 3**) reduced significantly by increasing planting density from 20 - 40 plants m^{-2}. The reduction in parameters might be due to the competition between plants on nutrients and water which led to reduction in vegetative growth then reflected on flowering growth (**Bugbee and Salisbury, 1988** and **Osman *et al.*, 2008**). While a significant delay in flowering occurred due to increasing planting density from 121 to 127 days (**Table 3**). This result might be due to plant response to light intensity due to tight spacing which cause delay in emergence of flowers which agrees with **(Sloan *et al*., 2003**) on sunflower and **(Osman *et al*., 2011)** on *Solidago*.

Inflorescences length decreased significantly by increasing CCC concentration compared to control then increased to reach its peak at (3500 ppm) CCC (46.6 cm). The highest inflorescence length (57.1 cm) was achieved at 3500 ppm CCC combined with 20 plants m^{-2} **(Table 3)** and percentage of inflorescences length stem^{-1} increased significantly by increasing CCC concentration compared to control reaching its peak at (3500 ppm) CCC (52.22 %) and the best percentage inflorescences length stem^{-1} (53.7 and 57.7%) were obtained at (3500 ppm and 1500 ppm)

CCC combined with 20 plants m^{-2}, respectively. These results might be due to CCC enhances plant growth by increasing the cell division and cell size which agreement with **(Wittwer and Tolbert, 1960)**.

Number of flowering stem plant^{-1} increased by increasing CCC concentration compared to control however, this increase was not significant. The highest number of flowering stem plant^{-1} (3 and 2.6) **(Table 3)** were found by combination CCC concentration at (2500 and 3500 ppm) with 20 plants m^{-2}, respectively. This result agrees with **(Patil and Dhomne, 1997 and Kumar and Haripriya, 2010)** who mentioned that CCC treatment improved the yield and flower quality parameters in sunflower. These results might be due to the production and accumulation of more photosynthesis that were diverted to the sink (flower) with better translocation in response to the suppression of apical dominance.

Number of flowering branches inflorescence^{-1} decreased by increasing CCC concentration compared to control however, this decrease was not significant then increased significantly at 3500ppm CCC concentration. The highest numbers of flowering branches inflorescence^{-1} after control (41.3) **(Table 3)** were found by combination CCC concentration at (3500 ppm) with 20 plants m^{-2}. These results might be due to the effect of CCC on decreasing the internodal length **(Yassin *et al.*, 2013)**.

Flowering branches length inflorescence^{-1} decreased significantly by increasing CCC concentration compared to control then increased at higher concentration. The highest flowering branches length inflorescence^{-1} (24.6 cm) **(Table 3)** was found by combination CCC concentration at (3500 ppm) with 20 plants m^{-2} **(Yassin *et al.*, 2013)**.

Increased CCC concentration led to delay in **flowering.** The most obvious treatments to delay flowering (127.8 days) were found at the highest CCC concentration at 3500ppm with 40 plants m^{-2}. This result agrees with (**Taha, 2012**) who mentioned that increase CCC concentration led to delay in **flowering** in Iris. This result might be due to Flowering is a complex physiological process controlled by many factors including photoperiod, light intensities, durations, environmental and physiological causes **(Joiner and Harrison, 1967); (Thomas and Vince-Prue, 1997) and (Karunananda and Peiris, 2010)**.

Vase life, Offset production and Chemical analyses:

The analysis of variance showed that, the F-values of planting density, CCC concentration and interactions between them were significant at 0.05 level of significance. In general, all data on means of *Solidago* **vase life, chlorophyll a, chlorophyll b, total chlorophyll and carotene** contents of leaves in **(Table 4)** reduced significantly by increasing planting density from 20 - 40 plants m^{-2} except **number of offsets plant^{-1}** which positively significant affected by increasing planting density. These results could be explained through the role of planting density and CCC in stimulating the vegetative growth, as mentioned previously, and hence high accumulation rate of metabolic components especially carbohydrates such as chlorophyll and carotene. This result was confirmed with the results obtained by **(Yassin *el al.*, 2013)**. There were positively significant effects by increasing CCC concentration on means of *Solidago* **vase life, number of offsets, chlorophyll a, chlorophyll b, total chlorophyll and carotene** contents of leaves; its peak at 3500 ppm CCC (19 days, 2.7 offsets/ plant, 8.3 mgl^{-1}, 15.9 mgl^{-1}, 24.2 mgl^{-1} and 2.5 mgl^{-1}), respectively then declined at lower concentration.

Vase life: it is obvious from results of (**Table 4**) that CCC application pre-harvest significantly increased vase life of *Solidago* inflorescence in comparison with the control and the peak at 3500 and 2500 ppm CCC (18 and 17.5 days) then declined at lower concentration and the longest vase life was observed (19 days) by combination CCC at 2500 or 3500 ppm with 20 plants m^{-2}. Improving the postharvest quality of *Solidago* inflorescence by using CCC could be explained through the role of CCC on Improving water balance, fresh weight **(EL-Saka *et al.*, 2002)** and hence high accumulation of carbohydrates in stem and leaves which consequently increased the vase life **(Hassan *et al.*, 2003).**

Offsets production: number of offsets per *Solidago* plant was positively affected by CCC application in comparison with the control. CCC at (3500 and 2500 ppm) was more effective (2.88 and 2.61), respectively and the highest number of offsets per plant (3.2 and 3) **(Table 4)** were found by combination CCC at (2500 and 3500 ppm) with 40 plants m^{-2}. These results could be explained through the role of CCC and planting density in stimulating the vegetative and flowering growth in *Solidago* plant, as mentioned previously, consequently the plants could produce good plants which can store large amount of food in produce more number of offsets per plant, in addition the long day condition **(Highsun, 2008)** which more available in July under open felid in Egypt condition, that led to more vegetative growth translated into more offsets.

Conclusion

The results in the present study contribute to the booming floriculture industry in Egypt in enhancing the production of cut flowers by promoting more compact flower stem and quality. This could be achieved through treatment of plants with optimum concentration of Cycocel and planting density under drip irrigation and lighting systems. One of the main

prerequisites for successful production of cut flowers is the creation of quality plants which subsequently can grow with more branches and compaction appearance. Cognizant with the findings of this study, combined applications of planting density and Cycocel have shown valid influence on most of evaluated growth parameters. From commercial growers' point of view, obtaining the maximum of quality cut flowers stem of *Solidago* is the main concern as it can determine the sustainability of business. To this effect, the mixed applications, 3500ppm CCC and 20 plants m^{-1} can be considered as a better performing treatment owing to its superiority in respect of increasing the cut flower quality production of *Solidago*. It gave stem height (81.6 cm), stem circumference (2.7 cm), fresh and dry weight (96 and 50 g) respectively, inflorescence length (57.1 cm), percentage inflorescence length/ stem (53.7 %), number of flowering stem $plant^{-1}$ (2.6), number of flowering branches $inflorescence^{-1}$ (41.3), flowering branches length $inflorescence^{-1}$ (24.6 cm), days to flowering (123 days), total chlorophyll and carotene contents of leaves (24.2 and 2.5 mgl^{-1}) respectively, vase life (19 days) and number of offsets/ plant (2.7).

Table 2: Effect of Planting Density (D), CCC concentration (ppm) and their interactions (D × CCC) on Vegetative Growth of *Solidago canadensis* "Tara". (Values are in the form of means of two seasons, 2012 and 2013).

Main effect of planting density (D)							
		stem height (cm)	**Stem circumfer. (cm)**	**Fr. W. (g)**	**D. w. (g)**	**No.leaves /plant**	**Tot. leaves area/ plant (cm^2)**
Treatments							
20 plants m^{-2}		83 a	2.44a	75a	47.85a	66a	478.94a
40 plants m^{-2}		76. 4b	2b	48b	41.98b	62b	347.19b
Main effect of CCC concentration (CCC)							
		stem height (cm)	**Stem circumfer. (cm)**	**Fr. W. (g)**	**D. w. (g)**	**No.leaves /plant**	**Tot. leaves area/ plant (cm^2)**
zero		82.5a	1.97d	49.3c	40.65c	60.8d	328.83c
500		80.611a	2.14c	54.44c	43.8b	63.05bcd	422.61b
1000		79.45a	2.2c	55c	45.5ab	64.83b	437.56b
1500		79.944a	2.23bc	64.06b	45.8ab	61.556cd	434.56b
2500		77.389b	2.3ab	65.44b	46.3a	64.27bc	344.72c
3500		77.611b	2.5a	78.66a	47.2a	68.27a	510.11a
Main effect of interaction between (D × CCC) planting density and CCC concentration							
planting density (D)	**CCC concentration**	**stem height (cm)**	**Stem circumfer. (cm)**	**Fr. W. (g)**	**D. w. (g)**	**No.leaves /plant**	**Tot. leaves area/ plant (cm^2)**
20 plants m^{-2}	**zero**	85.2	2.17	57	44.1	62.6	404
	500	83.5	2.28	69.3	46.2	64.2	444.5
	1000	83.6	2.41	57	48.6	69.1	534.4
	1500	83.6	2.5	82.8	48.8	61	524
	2500	79.8	2.5	87.3	49.2	65.5	326.6
	3500	81.6	2.7	96	50	74	640.5
40 plants m^{-2}	**zero**	79.8	1.7	41.7	37.2	59	253.6
	500	77.6	2	39.5	41.4	61.8	400.6
	1000	75.3	2	53	42.4	60.5	341.2
	1500	76.2	1.97	45.4	42.8	62.6	345.1
	2500	74.8	2.2	43.5	43.4	63	362.7
	3500	73.5	2.3	61.3	44.4	62.5	379.6
L.S.D0.05 for (D× CCC)		4	0.09	4.7	1.32	1.75	57.6

$L.S.D_{0.05}$= least significant differences at 0.05 probability.
Means with the same letter are not significantly different ($P \leq 0.05$) according to tukey.

Table 3: Effect of Planting Density (D), CCC concentration (ppm) and their interactions (D × CCC) on Flowering characteristics of *Solidago canadensis* "Tara". (Values are in the form of means of two seasons, 2012 and 2013).

Main effect of planting density (D)							
		Inflor. length (cm)	% inflo. length/stem	No. flowering stem/ plant	No. flowering branches/ inflor.	Flower. branches length /inflor. (cm)	Days to flowering (days)
Treatments							
20 plants m^{-2}		46.7a	49.2a	2.55a	35.96a	23.33a	121b
40 plants m^{-2}		31.25b	36.55b	2.4a	28.35b	18.2b	127a
Main effect of CCC concentration (CCC)							
		Inflor. length (cm)	**% inflo. length/stem**	**No. flowering stem/ plant**	**No. flowering branches/ inflor.**	**Flower. branches length /inflor. (cm)**	**Days to flowering (days)**
zero		42.83ab	39.16cd	2.4a	32b	20.44ab	122.7b
500		37.11bc	41.22bcd	2.4a	31.11b	19.22b	123.35ab
1000		38bc	42.3bc	2.5a	31.16b	21.38ab	123.4ab
1500		36.6c	44.72b	2.5a	30.8b	19.88b	123.8ab
2500		32.88c	37.83d	2.44a	30.72b	20.88ab	123.95ab
3500		46.6a	52.22a	2.49a	37.05a	22.77a	125.4a
Main effect of interaction between (D × CCC) planting density and CCC concentration							
planting density (D)	**CCC concentration**	**Inflor. length (cm)**	**% inflo. length/stem**	**No. flowering stem/ plant**	**No. flowering branches/ inflor.**	**Flower. branches length /inflor. (cm)**	**Days to flowering (days)**
20 plants m^{-2}	**zero**	50.8	42.5	2	34.4	20.2	118.8
	500	46.7	50.8	2.5	34.2	23	119.8
	1000	47.2	52.1	2.5	35.1	24.3	121
	1500	43.2	57.7	2.1	38.5	24.2	120.8
	2500	35.3	38.2	3	32.1	21.3	121.3
	3500	57.1	53.7	2.6	41.3	24.6	123
40 plants m^{-2}	**zero**	34.7	35.7	2.4	29.5	18.4	126.6
	500	27.4	31.5	2.3	28	15.4	126.9
	1000	28.7	32.5	2.5	27.2	18.4	125.8
	1500	30	31.6	3	23.2	15.5	126.8
	2500	30.4	37.4	1.8	29.3	20.4	126.6
	3500	36.1	50.3	2.2	32.7	20.8	127.8
L.S.D0.05 for (D× CCC)		5.8	2.5	0.22	1.85	1.4	1.1

$L.S.D_{0.05}$= least significant differences at 0.05 probability.
Means with the same letter are not significantly different ($P \leq 0.05$) according to tukey.

Table 4: Effect of Planting Density (D), CCC concentration (ppm) and their interactions (D × CCC) on Vase Life, Offset Production and Chemical Analyses of *Solidago canadensis* "Tara". (Values are in the form of means of two seasons, 2012 and 2013).

Main effect of planting density (D)							
		Vase life (days)	No. offsets/ plant	Chloroph. A (mgl^{-1})	Chloroph. B (mgl^{-1})	Tot. Chloroph. (mgl^{-1})	Caroten (mgl^{-1})
Treatments							
20 plants m^{-2}		15.33a	2.12b	7.6a	12.38a	19.89a	2.38a
40 plants m^{-2}		13.33b	2.57a	7.8a	10.64b	18.62b	2.27a
Main effect of CCC concentration (CCC)							
		Vase life (days)	**No. offsets/ plant**	**Chloroph. A (mgl^{-1})**	**Chloroph. B (mgl^{-1})**	**Tot. Chloroph. (mgl^{-1})**	**Caroten (mgl^{-1})**
zero		6.5d	2.166bcd	7.98a	11.15ab	19.02ab	2.5a
500		12c	2.11cd	7.95a	11.68a	19.65ab	2.46a
1000		16b	2.4abc	7.6a	12.2a	19.81a	2.39a
1500		16b	1.83d	7.83a	10.14b	18.48b	2.27ab
2500		17.5a	2.61ab	7.11b	12.4a	19.45ab	2b
3500		18a	2.88a	7.73a	11.5ab	19.13ab	2.33ab
Main effect of interaction between (D × CCC) planting density and CCC concentration							
planting density (D)	**CCC concen.**	**Vase life (days)**	**No. offsets/ plant**	**Chloroph. A (mgl^{-1})**	**Chloroph. B (mgl^{-1})**	**Tot. Chloroph. (mgl^{-1})**	**Caroten (mgl^{-1})**
20 plants m^{-2}	**zero**	7	2.4	7.5	12	19.6	3.5
	500	13	2	8.6	10.5	19.1	2.1
	1000	17	1.8	8.7	8.4	17.1	2.6
	1500	17	1.6	8.5	12.7	21.2	2.5
	2500	19	2	7.3	16.4	23.7	1.8
	3500	19	2.7	8.3	15.9	24.2	2.5
40 plants m^{-2}	**zero**	6	1.8	8.5	11.6	20	3
	500	11	2.2	8.1	10.8	18.9	2.8
	1000	15	3	8.4	13.7	22.2	1.8
	1500	15	2	8.5	11.6	20.2	2.1
	2500	16	3.2	8.5	12.7	21.2	1.8
	3500	17	3	7.6	9.9	17.5	2
L.S.D0.05 for (D× CCC)		0.6	0.28	0.27	0.8	0.7	0.22

$L.S.D_{0.05}$= least significant differences at 0.05 probability.
Means with the same letter are not significantly different ($P \leq 0.05$) according to tukey.

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