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Research Journal of Agricultural Sciences
An International Journal

P- ISSN: 0976-1675
E- ISSN: 2249-4538

Volume: 13
Issue: 02

*Res. Jr. of Agril. Sci.* (2022) 13: 383–388

CARAS

Res. Jr. of Agril. Sci. (Mar-Apr 2022)
13(2): 383–388

www.rjas.org

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Full Length Research Article

# Effect of Different Chemicals on the Postharvest Life and Quality of Goldenrod (*Solidago canadensis*)

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Received: 29 Oct 2021 | Revised accepted: 25 Feb 2022 | Published online: 14 Mar 2022


## ABSTRACT

Goldenrod (*solidago canadensis*) a member of the Asteraceae family and also an important landscape plant. Most of them are herbaceous perennial growing from woody caudices or rhizomes. Goldenrod is one of the popular commercial cut flowers and also an excellent filler material. Fillers add a textural contrast as well as it is said to be the backbone of floral decorations. In floriculture industries, postharvest losses of flowers are the major problem due to its highly perishable nature and it ultimately affects the quality and vase life of flowers. To overcome these issues proper postharvest practices are essential. Adding chemical preservatives to the holding solution is recommended to prolong the vase life of the cut flowers. All holding solutions must contain essentially two components sugar and germicides. The sugar provides a respiratory substrate, while the germicides control harmful bacteria and prevent plugging of the conducting tissues. Among all the different types of sugars, sucrose has been found to be the most commonly used sugar in prolonging vase life of cut flowers. The present experiment was carried out in the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar during 2018-2020. The experiment was repeated three times with five replicates in completely randomized design. the treatment consisted of five preservative chemicals viz., 8-hydroxy quinoline sulphate, citric acid, silver thiosulphate, Aluminum Sulphate and Gibberellic acid @ 200 ppm were used alone and also in combination with the treatment sucrose @ 4% along with control (distilled water). The results showed that all treatments had improved the keeping quality and vase life of cut flowers when compared to control. Among all these treatments. The results of the experiment revealed that $T_6$ ($Al_2(SO_4)_3$ @ 200ppm + 4% sucrose) obtained the higher water uptake, reduced transpirational loss of water, water balance, fresh weight, lowest cumulative physiological loss in weight, flower freshness, flower discolouration, vase life and ornamental value compared to control.

***Key words*:** Preservative chemicals, Sucrose, Golden rod flowers

Goldenrod (*Solidago canadensis*) a member of the Asteraceae family and also an important landscape plant. Some *Solidago* species utilized for medicinal purposes originates in Bulgaria, Hungary, Poland, and other eastern European countries. Earlier goldenrod was cultivated by many farmers under small scale, but now it is considered as one among the popular commercial cut flowers and also an excellent filler material. Fillers add a textural contrast as well as it is said to be the backbone of floral decorations. The flowers are used in the preparation of bouquets, wreath, corsage, and various floral arrangements. The genus *Solidago* is derived from the Latin word solidus (whole) and ago (to make) which means "to make whole". It has an excellent healing property and also this plant is known as woundwort. All parts of the goldenrod have some medicinal property. Leaves and flowers are popularly used in the treatment of kidney stones, hay fever, diabetes, inflammation and urinary tract infections. Flowers are edible and they are usually used for the preparation of tea. Goldenrod is a rhizomatous herbaceous perennial plant have a branched inflorescence with numerous yellow small capitula. Harvesting at the optimum stage of maturity is the most important feature in the ornamental species. In *solidago*, spikes are harvested at bud stage when the basal florets just start to change color. The right stage, proper method, and time of harvesting is an important factor to ensure their long vase life. Nearly 20 to 40 percent of losses in the production of flower crops due to improper postharvest handling [1].

For the exporting of cut flowers, quality and shelf life are the predominant factor. In floriculture industries, post-harvest losses are the major problem due to its highly perishable nature and it ultimately affects the quality and vase life of flowers. Vase life is determined based on attributes such as, rate of water uptake and transpirational loss, changes in fresh weight, water

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balance, diameter or length of stem, senescence pattern, colour of petals, total longevity and flower freshness. To overcome these issues proper postharvest practices are the essential criteria. In the cut flower industries, various techniques of postharvest handling are carried out to maintain the flower freshness and natural color of the flowers, for a maximum period of time after harvesting from the mother plant. Senescence is the terminal stage of plant development that follows the physiological maturity consequently leading to the death of cells, organ or the whole plant [2]. Floral senescence is the most serious problem regarding the postharvest management of cut flowers. Flowers are attracted by their appearance, quality and freshness. The longevity of cut flowers is also an essential factor that makes sure that the customers will be attracted and satisfied to purchase more flowers [3]. Hence keeping the above points in view, the present work has been carried out with preservative chemicals to evaluate the postharvest life as well as quality by using chemicals.

## MATERIALS AND METHODS

The present experiment was carried out in the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar during 2018-2020. The experiment was repeated three times with five replicates in completely randomized design. Uniform sized spikes of goldenrod (*Solidago canadensis*) cv. Tara Gold free from mechanical injury, diseases and insect injuries were obtained from "Grace and flora" wholesale distributer in Hosur, Tamil Nadu were used for the experimentation. The selected flowers were harvested at proper maturity stage, the flowers were carefully brought to the laboratory without causing any damage and they were kept in clean water. The preservative chemicals used in the study viz., Sucrose, citric acid, 8-hydroxy quinoline sulphate (8-HQS), Silver thiosulphate (STS), Aluminium Sulphate ($Al_2(SO_4)_3$) and Gibberellic acid (GA). The required quantity of sucrose were initially dissolved in distilled water, 8-HQS, STS, GA and citric acid was dissolved in absolute ethyl alcohol and then transferred to the flask containing sucrose solution.

In this experiment, flowers were held in the laboratory at 85-90 per cent relative humidity with ambient room temperature under 40 W cool white fluorescent lights to maintain 12 hours of photoperiod. Distilled water was used to reduce experimental variability; therefore, all the solutions were prepared with distilled water and such freshly prepared solutions were used for the experimentation. The spikes were trimmed to 60 cm under water. In each glass bottle one flower was placed and considered as one replication. After recording fresh weight, the individual flower spikes were placed randomly in the glass bottles containing 200 ml of aqueous test solutions of different treatments. The weight of each container and solution/distilled water with and without flower spikes were recorded once in two days, while recording weights recutting the base of floral stems of about 0.5 cm was done. The details of various treatments used in the experiment are described here:

| | | |
|---|---|---|
| $T_1$ | - | 8-HQS @ 200 ppm |
| $T_2$ | - | 8-HQS @ 200 ppm + sucrose 4% |
| $T_3$ | - | Citric acid @ 200 ppm |
| $T_4$ | - | Citric acid @ 200 ppm + sucrose 4% |
| $T_5$ | - | $Al_2$ (SO4)3 @ 200 ppm |
| $T_6$ | - | $Al_2$ (SO4)3 @ 200 ppm + sucrose 4% |
| $T_7$ | - | GA @ 200 ppm |
| $T_8$ | - | GA @ 200 ppm + sucrose 4% |
| $T_9$ | - | STS @ 200 ppm |
| $T_{10}$ | - | STS @ 200 ppm + sucrose 4% |
| $T_{11}$ | - | control (distilled water) |

## RESULTS AND DISCUSSION

In the present study an increase in the rate of water uptake was recorded by goldenrod spikes held in different concentrations of preservative solutions in combination with sucrose. Water uptake decreased from the first day of experimentation till the end of vase life period. Among the preservatives chemicals, goldenrod spikes held in $Al_2(SO_4)_3$ @ 200 ppm + 4% sucrose ($T_6$) recorded the maximum water uptake when compared to other treatments and the lowest water uptake was recorded in control ($T_{11}$). The higher rate of water uptake obtained in goldenrod spikes is due to aluminium sulphate, it acidifies vase solution, reduces bacterial proliferation and enhances the water uptake of cut flowers [4]. Application of sucrose and aluminium sulphate was the major factor to influence the water uptake in rose spikes, because when sucrose or aluminium sulphate were separately applied, the both cases the water uptake was sharply decreased [5]. Diminished water movement from the vase solution to different parts of the flower stem may cause water stress that results in wilting and early senescence [6] in tuberose, [7] in cut calendula flowers, in cut lisianthus [8], in cut roses (*Rosa hybrida* cv. Boeing) [9]. Mineral salts increased the water uptake by reducing physiological stem plugging in cut flowers [10]. Aluminium sulphate acts as a germicide, thereby encouraging continuous water transport through the cut stem by inhibiting the vascular blockage and delaying the increase in membrane permeability.

Figueroa *et al*. [11] confined that use of aluminium sulphate, act as antimicrobial compound to enhance the post-harvest life of cut flowers is recommended [12] treated cut rose cv. Raktagantha flowers with aluminium sulphate + sucrose recorded the greatest water uptake. whereas, [13] reported that use the holding solution with sucrose + aluminium sulphate extended the vase life of cut rose, *Rosa hybrid* Cv. First Red by recorded the highest water uptake. Halvey [14] reported that cut flowers treated with mineral salts can partially substitute for metabolic sugars in expanding cut flower longevity, which indicate some metabolic roles for the applied sugar. Jamil *et al*. [15] revealed that interaction of sucrose and Aluminium Sulphate delays senescence of Hippeastrum flowers (*Hippeastrum hybridum* Hort.) cv. 'Apple Blossom' by increasing water uptake and maintaining a higher fresh weight, leading to enhanced vase life. Similar findings have been reported by [16] in tuberose. Water stress occurs when the rate of transpiration exceeds the rate of water uptake by plants including in cut flowers which causes wilting and termination of vase life [17]. Water deficit have direct effect on turgor of cut flowers, which accelerates wilting and senescence [18]. According to Burdett [19] water loss from flowers were decreased after harvesting due to the closure of stomata which is mostly parallel to the water uptake. To reduce the water stress normal rate of transpiration is essential for extending the vase life of cut flowers.

Among all flower spikes treated, $Al_2(SO_4)_3$ @ 200 ppm + 4% sucrose ($T_6$) recorded lowest transpirational loss of water when compared to control as shown in table 1. The minimum loss of water might be because of sucrose and aluminium sulphate it causes closure of stomata leading to reduction in water loss [20]. Water loss from the flower tissue by transpiration during the experimental period was greatly influenced by sucrose in combination with aluminium sulphate.

Water balance of cut flowers is considered as determining factor for its quality and vase life which is influenced by the uptake and transpiration loss of water [21]. Aluminium sulphate extended the vase life and improved water relation of cut rose flowers by antimicrobial effect [22]. If water loss through transpiration exceeds the water uptake, wilting of the cut flowers will be occurred which terminates the vase life of cut flowers [23]. The use of preservative chemicals in the Vase solution had significant effect on water balance of cut flowers. Higher water balance observed in $Al_2 (SO_4)_3$ @ 200 ppm + 4% sucrose treated goldenrod spikes, while lowest water balance was obtained in control (distilled water). A positive water balance is crucial for longevity of cut shoots. Application of such chemical on vase solutions resulted longer vase life on cut flowers which is generally in line with findings of the present study [24]. Further, certain non-toxic mineral salts can increase the osmotic concentration and the pressure potential of the petal cells, thus improving the water balance and promoting longevity as reported by [25] in cut flowers, [26] in cut carnation and [27] in cut gerbera.

The ratio between water loss and water uptake is an important factor to determine the water balance so that post-harvest life of cut flowers increased. The goldenrod spikes held in the vase solution containing different floral preservatives, among all the lowest loss of water to water uptake ratio was observed in the treatment containing $Al_2 (SO_4)_3$ @ 200 ppm + 4% sucrose ($T_6$), comparison to other treatments. While, those held in distilled water (control) recorded the highest ratio. Interaction of sucrose and aluminium sulphate significantly influenced the ratio of transpiration loss and water uptake. The present study was accordance with the findings of [28] in cut calendula flowers [29] in cut Hippeastrum flower (*Hippeastrum hybridum*) cv. 'Apple Blossom'.

The goldenrod spikes treated with different concentrations of chemical preservatives along with ideal concentration of sucrose. Among the 11 treatments, $Al_2 (SO_4)_3$ @ 200 ppm + 4% sucrose ($T_6$) recorded the maximum fresh weight than control ($T_{11}$). The fresh weight of the cut flowers has been slightly decreased day by day, this might be attributed to decreased rate of water uptake and increased loss of water due to transpiration. An increase in fresh weight could be attributed to improved water balance in the floral tissue. Beginning of the senescence phase in cut flowers is characterized by decrease in fresh weight [30]. The results revealed that cut flowers treated with different concentrations of mineral salts recorded higher fresh weight. The possible reason for minimum weight loss might be low transpirational loss of water, it is due to the presence of aluminium sulphate in vase solution resulted in partial closure of stomata and hence, reduced transpiration loss of water [31]. The floral preservatives delayed the senescence of cut tulip by maintaining turgidity and improving postharvest physiology of cut tulips. The preservatives improved water uptake and thereby maintained better water balance leading to improved fresh weight and vase life of cut tulips. Fresh weight of the cut flowers is gradually reduced [32], cut flowers treated with aluminium sulphate + sucrose in third day recorded the highest fresh weight among all treatments compared to control. Aluminium sulphate have positive effect on water uptake rate and raising fresh weight [33]. Chemical preservatives in the vase solution significantly enhanced the fresh weight and cumulative physiological loss in weight of goldenrod flowers. Higher fresh weight and lower physiological loss in weight of cut flower were found in the treatment consist of $Al_2 (SO_4)_3$ @ 200 ppm + 4% sucrose, while the lowest fresh weight and higher physiological loss in weight was recorded in control (distilled water). Similarly [34], observed minimum weight loss in cut flower of chrysanthemum cv. Shyamal. Due to its germicidal property, the rate of water uptake and fresh weight of the flowers has been increased that resulted in the lower physiological loss in weight of cut flowers. This could be due to the ability of mineral salt and sugars. $Al_2 (SO_4)_3$ acidify the holding solution whereas sucrose containing carbohydrate, which might have prevented proteolysis, there by resulting in lower physiological loss in weight [35]. Water absorption from the vase solution maintains a better flower freshness which saves from early wilting and reflecting on vase life improvement of cut flowers.

With regard to freshness of flower, the goldenrod cv. Tara Gold held in vase solution containing $Al_2 (SO_4)_3$ @ 200 ppm + 4% sucrose ($T_6$) recorded the maximum days for flower shrivelling followed by STS @ 200ppm + 4% sucrose ($T_{10}$). The maintenance of higher water balance in cut flowers resulted in high degree of freshness of cut flowers for long period. The effect of $Al_2 (SO_4)_3$ @ 200 ppm + 4% sucrose on goldenrod flowers recorded maximum number of days taken for flower discoloration, whereas minimum days required for fading were observed in control (distilled water). This may be due to inhibition of ethylene synthesis, which has become an essential tool for delaying the senescence of cut flowers and also improves the post-harvest quality [36].

Table 1 Effect of different preservative chemicals on the postharvest life of goldenrod flowers

| Treatments | Uptake of water (g/flower) | | | | Transpirational loss of water (g/flower) | | | | Ratio between water loss and uptake of water | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2nd day | 4th day | 6th day | 8th day | 2nd day | 4th day | 6th day | 8th day | 2nd day | 4th day | 6th day | 8th day |
| $T_1$ | 12.80 | 10.43 | 8.37 | 7.96 | 13.62 | 11.67 | 8.83 | 8.42 | 1.06 | 1.11 | 1.05 | 1.05 |
| $T_2$ | 16.79 | 13.69 | 9.78 | 9.90 | 16.00 | 14.00 | 9.86 | 9.59 | 0.95 | 1.02 | 1.00 | 0.96 |
| $T_3$ | 10.14 | 8.18 | 6.95 | 6.60 | 12.37 | 10.19 | 7.07 | 6.64 | 1.22 | 1.24 | 1.01 | 1.00 |
| $T_4$ | 15.89 | 12.95 | 10.23 | 9.48 | 15.47 | 13.37 | 10.16 | 9.34 | 0.97 | 1.03 | 0.99 | 0.98 |
| $T_5$ | 11.28 | 9.28 | 7.56 | 7.02 | 12.88 | 10.92 | 8.07 | 7.51 | 1.14 | 1.17 | 1.06 | 1.06 |
| $T_6$ | 18.76 | 15.36 | 11.14 | 10.66 | 17.00 | 14.94 | 10.76 | 10.09 | 0.90 | 0.97 | 0.96 | 0.94 |
| $T_7$ | 12.20 | 10.08 | 8.00 | 7.84 | 13.42 | 11.44 | 8.73 | 8.22 | 1.10 | 1.13 | 1.09 | 1.04 |
| $T_8$ | 14.65 | 12.16 | 9.34 | 8.96 | 14.91 | 12.87 | 9.57 | 9.07 | 1.01 | 1.05 | 1.03 | 1.01 |
| $T_9$ | 13.71 | 11.43 | 8.83 | 8.58 | 14.39 | 12.40 | 9.11 | 8.83 | 1.05 | 1.08 | 1.10 | 1.02 |
| $T_{10}$ | 17.83 | 14.46 | 10.70 | 10.27 | 16.51 | 14.48 | 10.47 | 9.85 | 0.92 | 0.96 | 0.97 | 0.95 |
| $T_{11}$ | 9.06 | 7.24 | 6.42 | 5.78 | 9.78 | 9.37 | 6.74 | 6.26 | 1.07 | 1.29 | 1.04 | 1.08 |
| SED | 0.42 | 0.35 | 0.20 | 0.16 | 0.23 | 0.21 | 0.13 | 0.10 | 0.0045 | 0.006 | 0.003 | 0.004 |
| CD (0.05) | 0.84 | 0.70 | 0.41 | 0.32 | 0.47 | 0.43 | 0.26 | 0.21 | 0.009 | 0.012 | 0.006 | 0.008 |

Vase life or longevity is the period of time the flower remains fresh and its one of the most important characteristics in floriculture industry. Flowers are highly perishable in nature, due to its poor keeping quality and short vase life most of the researches are conducted to improve the vase life of the flowers using different techniques [37]. The present investigation stated that goldenrod flowers remain fresh in vase solution containing different preservative chemicals along with sucrose, out of that

$T_6$ ($Al_2(SO_4)_3$ @ 200 ppm + 4% flowers) recorded the higher vase life period, followed by STS @ 200ppm + 4% sucrose ($T_{10}$), whereas control (distilled water) obtained the minimum vase life [38]. Aluminium sulphate increase vase life and keeping quality of cut flowers has been proved in several experiments conducted by different researchers in different crops [39-40].

Post-harvest life of cut flowers can be determined by assessing the effect of various physiological factors that influence the vase life of goldenrod flowers. The increase in vase life might be attributed to interaction of sucrose and aluminium sulphate. $Al_2(SO_4)_3$ is responsible for lowering the pH of petal and acidifying the holding water, this might have reduced the bacterial growth and improved water uptake and it also reduces transpiration by inducing the stomatal closure. This might be due to decreased loss of water as well as loss-uptake ratio, tends to increase the water balance in the spike because of lower range of temperature [41].

Table 1 Effect of different preservative chemicals on the postharvest life of goldenrod flowers

| Treatments | Water balance (g/flower) | | | | Fresh weight (g/flower) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2nd day | 4th day | 6th day | 8th day | 2nd day | 4th day | 6th day | 8th day |
| $T_1$ | -0.82 | -1.00 | -0.46 | -0.46 | 28.72 | 26.65 | 24.34 | 21.93 |
| $T_2$ | 0.79 | -0.15 | -0.08 | 0.31 | 33.61 | 32.02 | 28.42 | 25.32 |
| $T_3$ | -2.23 | -1.68 | -0.12 | -0.04 | 24.75 | 22.69 | 21.09 | 19.55 |
| $T_4$ | 0.42 | -0.42 | 0.07 | 0.14 | 32.28 | 30.69 | 27.38 | 24.53 |
| $T_5$ | -1.60 | -1.44 | -0.51 | -0.49 | 26.06 | 24.42 | 22.43 | 20.32 |
| $T_6$ | 1.76 | 0.42 | 0.38 | 0.57 | 36.00 | 34.44 | 30.22 | 27.00 |
| $T_7$ | -1.22 | -1.95 | -0.73 | -0.38 | 27.67 | 25.85 | 23.57 | 21.34 |
| $T_8$ | 0.26 | -0.69 | -0.23 | -0.11 | 31.28 | 29.48 | 26.47 | 23.51 |
| $T_9$ | -0.68 | -0.96 | -0.28 | -0.25 | 29.87 | 27.85 | 25.58 | 22.71 |
| $T_{10}$ | 1.32 | 0.12 | 0.23 | 0.42 | 34.82 | 33.21 | 29.30 | 26.24 |
| $T_{11}$ | -0.72 | -2.13 | -0.32 | -0.48 | 23.52 | 21.17 | 20.16 | 18.74 |
| SED | 0.13 | 0.07 | 0.05 | 0.04 | 0.55 | 0.56 | 0.42 | 0.36 |
| CD (0.05) | 0.26 | 0.14 | 0.10 | 0.08 | 1.11 | 1.13 | 0.84 | 0.72 |

Table 3 Effect of different preservative chemicals on the postharvest life of goldenrod flowers

| Treatments | Flower freshness (Days) | Flower discoloration (Days) | Vase life (days) | Ornamental value | Cumulative physiological loss in weight (%) |
|---|---|---|---|---|---|
| $T_1$ | 8.42 | 8.27 | 9.28 | 3.84 | 46.96 |
| $T_2$ | 11.34 | 11.05 | 11.67 | 6.94 | 35.82 |
| $T_3$ | 6.48 | 5.75 | 7.27 | 2.07 | 55.41 |
| $T_4$ | 10.63 | 10.44 | 11.04 | 6.34 | 38.42 |
| $T_5$ | 7.04 | 6.87 | 8.10 | 2.66 | 52.80 |
| $T_6$ | 12.49 | 12.37 | 13.17 | 8.21 | 31.26 |
| $T_7$ | 7.85 | 7.69 | 8.68 | 3.29 | 49.73 |
| $T_8$ | 10.04 | 9.42 | 10.43 | 5.76 | 41.07 |
| $T_9$ | 9.03 | 8.87 | 9.84 | 4.95 | 44.34 |
| $T_{10}$ | 11.89 | 11.62 | 12.24 | 7.50 | 35.82 |
| $T_{11}$ | 5.15 | 5.06 | 5.64 | 1.19 | 58.28 |
| SED | 0.25 | 0.26 | 0.26 | 0.25 | 1.28 |
| CD (0.05) | 0.51 | 0.52 | 0.53 | 0.51 | 2.57 |

## CONCLUSION

The results showed that all treatments had improved the keeping quality and vase life of cut flowers when compared to control. Among all the treatments, the results of the experiment revealed that $T_6$ ($Al_2(SO_4)_3$ @ 200ppm + 4% sucrose) obtained higher water uptake, reduced transpirational loss of water, water balance, fresh weight, lowest cumulative physiological loss in weight, flower freshness, flower discolouration, vase life and ornamental value compared to control.

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