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Effect of Saline Water and GA_3 on Flowering Parameters and Yield of Goldenrod (*Solidago canadensis* L.)

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Abstract
The present experiment was carried out at Hi-Tech Horticulture Park, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh to study the flowering behavior of goldenrod under salinity stress and GA_3 foliar spray. Twenty treatment combinations comprising of five levels of saline irrigation water viz., S_0(control), S_1(3.0dSm^{-1}), S_2(6.0dSm^{-1}), S_3(9.0dSm^{-1}) and S_4(12.0dSm^{-1}) and four levels of foliar application of GA_3 viz., G_0(control), G_1(100ppm), G_2(200 ppm) and G_3(300ppm) were allocated in Completely Randomized Design with Factorial concept in three repetitions. The results revealed that flowering parameters like length of panicle, number of panicle per plant and estimated yield of panicle per hectare are significantly affected by interaction of both the factors, i.e. saline irrigation water and foliar application of GA_3. All the combinations of GA_3 treatment with S_0 treatment water gave good results for all the above mentioned parameters while combinations of GA_3 treatment with S_1 treatment water also gave better results. The results of S_1G_2 and S_1G_3 were statically at par with each other hence S_1G_2 can be recommended in saline prone areas for better production of goldenrod.

Keywords: Goldenrod, saline irrigation water, pot culture, foliar application of GA_3.

Introduction
Goldenrod (*Solidago* sp.) belong to asteraceae family, is an invasive plant species in many countries. *Solidago canadensis* L. is an erect growing; hardy, perennial plant, grows well in almost all types of climate and soils ranging from light to heavy types of soils. The inflorescence of goldenrod is very complex in nature. The panicles are harvested when about 25% of the flowers had opened and placed in a container of freshwater. Goldenrod is neglected as commercial cultivation for longer period often unfairly blamed for causing hay fever in humans but later found that the pollens of ragweed (*Ambrosia* sp.), blooming at the same time as the goldenrod caused this allergy, as goldenrod pollen is too heavy and sticky to be blown far from the flowers, and is thus mainly pollinated by insects (Anon., 2005) [2]. The herb is a sign of good luck and fortune in many cultures. Other than that, it is one among the popular commercial cut flowers and used as filler material in flower arrangement, bouquets, corsages, boutonniere, car decoration, *mandap* decoration etc. It is a very good potential flower for dry flower industry. The native Americans used this plant to treat arthritis, emphysema, nephritis and peridontal disease. The commercial cultivation of goldenrod has not yet been exploited throughout India, even though it is cultivated in small scale by many farmers. They are marketed at various places in Gujarat e.g. Ahmedabad, Baroda, Surat, Rajkot, etc. There is a great demand of goldenrod panicles in other large cities of India and also in other countries.

Material and Methods
The present experiment was carried out at Hi-Tech Horticulture Park, Department of Horticulture, College of Agriculture, Junagadh Agricultural University, Junagadh; which is located at 21°30'6.4296'' N latitude and 70°26'58.2504'' E longitude and at an altitude of 61 m above mean sea level. The 'Junagadh region' is included in the 'West-Coast-Kathiawar Peninsula' of Gujarat state and under the South Saurashtra Agro Climatic Zone-VII of Gujarat state. The medium to shallow black soils of this region is classified as Vertic-Ustochrepts. Soil properties of the experimental soil are EC- 1.12 and pH- 6.46 and the experiment was laid out with factorial concept in Completely Randomized Design (FCRD) with 20 treatment

combinations arising from five levels of saline irrigation water (S_0= tap water, S_1= 3.0 dSm^{-1}, S_2= 6.0 dSm^{-1}, S_3=9.0 dSm^{-1} and S_4= 12.0 dSm^{-1}) and four levels of foliar application of GA_3 (G_0=no spray, G_1=100 ppm, G_2= 200 ppm and G_3= 300 ppm) with three replications. The earthen pots (37X30 cm) were used for growing of goldenrod plants which was covered with polythene sheets to avoid any leaching of salt. In each pot filled with media, one healthy sucker of goldenrod was transplanted on 1stOctober 2014. After the establishment of plants in the pots, the pots were irrigated with equal quantities of different levels of saline water, whereas, control was irrigated with tap water. The desired salinity levels of irrigation water were prepared by dilution of sea water (EC of 37.5 dSm^{-1}) in measured quantity of water (i.e. on the basis of measured EC of tap water). At initial stage normal tap water was given till the plants get established. The saline irrigation water was applied as per the treatments from 20 December, 2014 onwards. The crop was irrigated twice in a week in winter season and thrice in summer season. The first foliar spray of GA_3 treatment was done 15 days after treatment water applied and second spray was practiced after 15 days of the first spray. The various observations on growth and floral parameters were recorded on five plants randomly selected from each treatment and tagged. The data collected for all the characters studied were subjected to stastical analysis by adopting 'Analysis of Variance' (ANOVA) technique for factorial completely randomized design method given by Panse and Sukhatme (1967) [12].

Table 1: Required quantity of sea water (EC 37.5 dSm^{-1}) and tap water (EC 1.2 dSm^{-1}) for preparing 10 litre of different levels of saline water.

Electrical Conductivity (EC)		Required quantity of Water (liter)	
dSm^{-1}	Symbol	Sea Water	Tap Water
1.2 EC (Control)	S_1	-	10
3.0	S_2	0.8	10
6.0	S_3	1.6	10
9.0	S_4	2.4	10
12.0	S_5	3.2	10

Results and Discussion

A perusal of the results clearly indicated that the various levels of saline irrigation water treatment and foliar spray of GA_3 significantly influenced flowering parameters and yield of goldenrod. The important attributes related to the flowering of goldenrod, viz., days taken for first flowering and complete flower opening, length of panicle and rachis, number of panicles per plant and estimated yield of panicles per hectare, longevity of panicle *in situ*, fresh and dry weight of panicle were significantly influenced by saline irrigation water. The minimum number of days taken to first flower opening (110.41 days) and complete flower opening (114.62 days) was recorded at S_0 (1.23 dSm^{-1}) level i.e. control which was found at par with S_1 (3.0 dSm^{-1}) level of saline irrigation water treatment. Significantly highest length of panicle and rachis (31.76 cm and 24.60 cm) was recorded at S_0 (1.23 dSm^{-1}) level i.e. control. The significant drop in length of panicle and rachis of goldenrod plant (19.52 cm and11.89 cm) was recorded from S_1 (3.0 dSm^{-1}) level, followed by S_2 (6.0 dSm^{-1}) level (13.17 cm and 7.42 cm). The maximum number of panicles per plant and estimated yield of panicle per hectare (3.42 and 3.79 lakh) was found to be with S_0 (1.23 dSm^{-1}) i.e. control. The significant drop in the number of panicles per plant of goldenrod was recorded from S_1 (3.0 dSm^{-1}) level (2.88 and 3.19 lakh) to S_2 (6.0 dSm^{-1}) level (2.04 and 2.26 lakh). The maximum (16.10 days) longevity of panicle *in situ* was reported in S_0 (1.23 dSm^{-1}) which was followed by S_1 (3.0 dSm^{-1}) level (16.08 days) but significant decrease was noted when salinity levels raises from S_1 (16.08 days) to S_2 (14.43 days) in survived plants. The significant highest fresh and dry weight of panicle (65.95 g and 21.99 g) was recorded at S_0 (1.23 dSm^{-1}) level i.e. control. The drop in fresh and dry weight of goldenrod panicle was recorded from S_1 (3.0 dSm^{-1}) level (51.74 g and 17.24 g) to S_2 (6.0 dSm^{-1}) level (41.25 g and 13.76 g). Caia *et al*. (2014) [4] reported that under salt stress the uptake of water and some mineral nutrients were restricted and, hence, plant growth and development were inhibited, as well as a series of metabolic functions. The present findings are also in conformity with those reported by Ishida *et al*. (1979) [7] in carnation; Devitt and Morris (1987) [5] in ten flowering annuals including marigold; Huang and Cox (1987) [6] in marigold; Khimani and Patil (1994) [8] in gaillardia; Mantur *et al*. (1996) [9] in China aster and Nawab *et al*. (2002) [10] in marigold and gaillardia.

Significantly maximum panicle and rachis length of plant (13.39 cm and 9.27 cm) was recorded at G_2 (200 ppm) level, which was followed by G_3 (13.32 cm 9.12 cm). The maximum number of panicles per plant and per hectare (1.71 and 1.89 lakh) was found to be with G_3 (300 ppm), which was followed by G_2 (1.70 and 1.88 lakh) and G_1 (1.65 and 1.83 lakh). The maximum fresh and dry weight of panicle of goldenrod (33.04 g and 11.01 g) was recorded at G_3 (300 ppm) level which was at par with G_2 (32.75 g and 10.92 g) and G_1 (31.45 g and 10.48 g). The increase in growth by GA_3 was due to its effect on stem elongation by increasing cell elongation in sub-apical meristem. The rapid growth is a result of both, new number of cells formed and increased elongation of the individual cell. Improvement in plant vegetative and flowering parameters as a consequence of GA_3 treatments has also been reported by Patil *et al*. (1996) [14], Pavagadhi (2001) [15] and Patel (2004) [13] in goldenrod, Pandya (2000) [11] in marigold, Rakesh *et al*. (2003) [16] in chrysanthemum.

The maximum plant height at first flower appearance, peak flowering and at last harvest was reported with treatment S_0G_3 (49.27, 49.78 and 50.37 cm respectively) which was at par with treatment S_0G_2 (48.42, 48.93 and 49.58 cm), whereas the minimum plant height was reported with treatment S_3G_0 (9.63, 9.98 and 10.52 cm) which was at par with S_3G_1 (11.33, 11.80 and 12.40 cm) at the three stages of flowering respectively. The maximum fresh weight was reported with treatment S_0G_2 (231.80 g) which was at par with treatment S_0G_3 (230.53g). The maximum dry weight was reported with treatment S_0G_2 (77.26 g) which is at par with treatment S_0G_3 (76.84 g). The lowest dry weight of plant (50.21 g) was found to be with the treatment S_3G_0 and it is found to be significantly differ from the other treatment. The maximum length of panicle was reported with treatment S_0G_2 (32.53 cm) which was at par with treatment S_0G_3 (32.40 cm) and S_0G_1 (31.83 cm). No significant effect on panicle numbers when concentration of GA_3 was increased from G_2 to G_3 in all salinity levels. All the GA_3 levels were found ineffective being at par for panicle numbers at S_2 (3.0dSm^{-1}) level of salinity. No significant effect on panicle numbers when concentration of GA_3 was increased from G_2 to G_3 in all salinity levels. All the GA_3 levels were found ineffective being at par for panicle numbers at S_2 (3.0dSm^{-1}) level of salinity. These results are in agreement with the findings of Ashraf *et al.* (2002) [3] that GA_3 in salt stressed plants showed an increased photosynthetic capacity- a vital factor for higher

fresh and dry matter synthesis. Alleviatory effects of salt stress by GA_3 on plant height and fresh and dry weights of rose plants (Ali *et al*., 2014) [1] also supported the results obtained in current investigation.

Conclusion

It can be concluded that under salinity treatments the flowering parameters and yield of goldenrod were hampered. The more pronounced reduction was found to be at 6.0 dSm^{-1} and afterwards. Goldenrod can be grown up to 3.0 dSm^{-1} salt concentration in irrigation water but with about 16 per cent reduction in yield. On the other hand, GA_3 treatments alleviate the negative effects of salinity on the growth and flowering parameters previously mentioned. The best treatment of GA_3 for reclamation of the effects of saline irrigation water on goldenrod was found to be at 200 ppm and 300 ppm. These two treatments were found to be statistically at par for effects on goldenrod; hence, the lower level 200 ppm can be recommended here.

Table 2: Effect of saline irrigation water and GA_3 on flowering parameters of goldenrod

Treatment	Days taken for first flower opening (days)	Days taken to complete flower opening (days)	Length of panicle (cm)	Length of rachis (cm)	Number of panicles per plant	Yield of panicle per hectare (lakh)
Saline irrigation water						
S_0(control, 1.23 dSm^{-1})	110.41	114.62	31.76	24.60	3.42	3.79
S_1(3.0 dSm^{-1})	112.86	117.11	19.52	11.89	2.88	3.19
S_2(6.0 dSm^{-1})	120.13	123.95	13.17	7.42	2.04	2.26
S_3(9.0 dSm^{-1})	-	-	-	-	-	-
S_4(12.0 dSm^{-1})	-	-	-	-	-	-
SEm±	1.45	1.37	0.24	0.23	0.03	0.03
C.D. at 5%	4.15	3.92	0.70	0.67	0.09	0.09
GA_3 foliar spray						
G_0(control)	69.10	71.67	11.74	7.92	1.61	1.78
G_1 (100 ppm)	68.69	71.19	13.11	8.82	1.65	1.83
G_2 (200 ppm)	68.73	70.87	13.39	9.27	1.70	1.88
G_3 (300 ppm)	68.19	70.82	13.32	9.12	1.71	1.89
SEm±	1.30	1.23	0.22	0.21	0.03	0.03
C.D. at 5%	NS	NS	0.63	0.60	0.08	0.08
Interaction(S X G)						
SEm±	2.91	2.74	0.49	0.47	0.06	0.06
C.D. at 5%	NS	NS	1.40	NS	0.17	0.17
C.V. %	7.33	6.67	6.58	9.19	6.34	6.34

Table 3: Effect of saline irrigation water and GA_3 on flowering and yield parameters of goldenrod

Treatment	Longevity of panicle *in situ* (days)	Vase life (days)	Fresh weight of panicle (g)	Dry weight panicle (g)
Saline irrigation water				
S_0 (control, 1.23 dSm^{-1})	16.10	7.25 (2.69)*	65.95	21.99
S_1 (3.0 dSm^{-1})	16.08	7.25(2.70)*	51.74	17.24
S_2 (6.0 dSm^{-1})	14.43	7.25(2.70)*	41.25	13.76
S_3 (9.0 dSm^{-1})	-	0.00(0.71)*	-	-
S_4 (12.0 dSm^{-1})	-	0.00 (0.71)*	-	-
SEm±	0.21	0.16 (0.03)*	0.83	0.28
C.D. at 5%	0.60	0.45(0.08)*	2.37	0.79
GA_3 foliar spray				
G_0 (control)	9.36	4.40(1.91)*	29.90	9.98
G_1 (100 ppm)	9.60	4.27(1.88)*	31.45	10.48
G_2(200 ppm)	9.18	4.40(1.91)*	32.75	10.92
G_3 (300 ppm)	9.14	4.33(1.90)*	33.04	11.01
SEm±	0.19	0.14(0.03)*	0.74	0.25
C.D. at 5%	NS	NS	2.12	0.70
Interaction(S X G)				
SEm±	0.42	0.32(0.06)*	1.66	0.55
C.D. at 5%	NS	NS	NS	NS
C.V. %	7.83	12.59 (5.26)*	9.04	8.99

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