

Response of *Gaillardia aristata* Pursh to salinity

N.K. Rao* and Mohammed Shahid

International Center for Biosaline Agriculture (ICBA), P.O. Box 14660, Dubai, UAE. *E-mail: n.rao@biosaline.org.ae

Abstract

The performance of *Gaillardia aristata* Pursh, irrigated with saline water was studied with the objective to identify herbaceous ornamentals for saline landscapes. Seeds were sown directly into field plots of sandy soil and irrigated with saline water at electrical conductivity (EC_w) of 2 (control), 5, 10 and 15 dSm^{-1} . Increase in salinity reduced the plant stand by 38% at 5 dSm^{-1} , 50% at 10 dSm^{-1} and 67% at 15 dSm^{-1} , in comparison with the control. Increased salinity also decreased the mean height, number of branches and dry weight of the plants, but the differences among treatments lower than 15 dSm^{-1} salinity were statistically insignificant ($P>0.05$). Compared with the control, the number of flowers per plant declined by 57% at 5 dSm^{-1} , 61% at 10 dSm^{-1} and 67% at 15 dSm^{-1} . The differences in flower production among 5, 10 and 15 dSm^{-1} treatments were not significant ($P>0.05$). The flower diameter was significantly reduced at 15 dSm^{-1} , but was not affected at the lower salinities. The results show that *G. aristata* could be successfully cultivated upto irrigation water salinity level 10 dSm^{-1} in sandy soils.

Key words: Blanket flower, *Gaillardia aristata* Pursh, ornamental plants, salinity tolerance, sandy soil, urban greenery

Introduction

The demand for landscaping is increasing in several countries due to rapid development in urban and suburban areas. In the arid regions, the availability of good quality water for the gardens and landscapes is becoming increasingly restricted due to the rising demand for domestic use. Consequently, landscape architects are forced to use marginal quality water such as brackish or treated sewage water for irrigation. Although many floral crops are known to be tolerant to salinity (Carter and Grieve, 2006), only limited systematic studies have been done to evaluate the performance of herbaceous ornamental and groundcover plants at different levels of salinity. Such information would be extremely useful for the selection of appropriate species that match the quality of water available for landscape irrigation.

The International Center for Biosaline Agriculture (ICBA) in Dubai (UAE) has been studying several exotic herbaceous ornamentals for salinity tolerance with the objective to introduce them into the saline landscapes. Recently, in a preliminary study, a salt tolerant wildflower mix containing ten herbaceous ornamental species native to the USA was assessed for adaptation to the local growing conditions and three species that appeared promising, namely *Lobularia maritima* (L.) Desv. (Sweet alyssum) *Dimorphotheca aurantiaca* DC. (African daisy) and *Gaillardia aristata* Pursh (Blanket flower), were selected for further investigations. While *L. maritima* and *D. aurantiaca* are annuals suitable for winter planting, *G. aristata*, the subject of the present study is a hardy perennial that flowers throughout the year and requires very low maintenance.

G. aristata, commonly known as blanket flower, is native to northern and western USA, where it often grows wild, but is also widely cultivated as a garden flower. Previous studies also showed that *G. aristata* has some degree of tolerance to salinity (Niu and Rodriguez, 2006; Niu *et al.*, 2007). However, they were conducted under greenhouse conditions or in raised loamy sand soil beds with synthesized saline solutions at electrical

conductivity (EC) ranging from 0.8 to 5.4 dSm^{-1} . The objective of the present study was to evaluate the response of *G. aristata* to higher levels of water salinity in sandy soils under open field conditions to find out its suitability for landscapes in hot and arid desert environments, where the ground water salinity is high and the soils are poorly developed.

Materials and methods

The study was carried out at ICBA research station (25°05'49" N and 55°23'25"E) in Dubai, United Arab Emirates, during the year 2009. The soil at the experimental site was sandy and moderately alkaline (pH 8.2) with very low organic matter (<0.5%). The seeds of *G. aristata* used in the study were obtained from Applewood Seed Co., USA. Four salinity treatments with electrical conductivities (EC_w) of 2 (control), 5, 10 and 15 dSm^{-1} were used to assess the performance. Saline ground water (~20 dSm^{-1}) was blended with fresh water (2 dSm^{-1}) to obtain the desired salinities for irrigation. Seeds were sown in mid-January 2009 directly in the field in rows on plots of size 5 x 5 m. Each plot consisted of ten rows, 50 cm apart. The spacing between plots was 20 m. Within each row, depending on germination, thinning and/or transplanting of seedlings was undertaken to maintain a distance of 25 cm between plants. The plots were irrigated with a drip system using water at the chosen level of salinity. Water was applied once every day for 20 min at the rate of 4 L h^{-1} plant⁻¹ until April and two times a day thereafter. Prior to sowing, the fertility of soil was improved by incorporating organic fertilizer (compost) at the rate of 40 t ha^{-1} . One month after planting, NPK (20:20:20) was applied at the rate of 50 kg ha^{-1} by banding alongside the rows. Soil samples were taken at the end of the experiment from three locations in each plot and analyzed through saturated extraction at ICBA's Central Analytical Laboratory (CAL).

The traits studied to evaluate the effect of salinity are presented in Table 1. Except for the number of days to first flowering, all other observations were made ten months after sowing when the second cycle of flowering was nearly over and the majority of the

Table 1. Effect of irrigation water salinity on growth and floral characteristics of *G. aristata*

Salinity	Plant stand (per m ²)	Plant height (cm)	Number of branches	Fresh weight (g plant ⁻¹)	Dry weight (g plant ⁻¹)	Days to first flowering	Number of flowers	Flower diameter (cm)	Seeds per head	100 seed weight (g)
Control	11.3	96.8	17.8	737	189	85	296	6.4	75.8	0.25
5 dSm ⁻¹	7.0	93.8	14.8	604	168	90	126	6.4	65.8	0.30
10 dSm ⁻¹	5.7	83.0	14.6	456	136	99	115	5.6	56.8	0.28
15 dSm ⁻¹	3.7	39.4	9.4	172	50	114	99	5.1	52.2	0.21
LSD (<i>P</i> =0.05)	2.1	19.7	5.4	247	79		97	1.1	9.8	

seed heads were mature for harvest. Plant stand was expressed as the mean number of individuals per 1 x 1 m quadrat, estimated from three randomly chosen quadrats within each treatment. Observations on plant height, number of branches, number of flowers, and fresh and dry weight of plants were based on five plants, randomly selected from each treatment. Flower diameter and number of seeds per head represent the mean of 10 inflorescences picked at random from each treatment. The significance of the salinity treatments on growth and development was assessed by analysis of variance (ANOVA) using GenStat software.

Results and discussion

The effect of salinity on plant establishment, growth and floral characteristics of *G. aristata* is shown in Table 1. Compared to the control, plant stand was reduced by 38% at 5 dSm⁻¹, 50% at 10 dSm⁻¹ and 67% at 15 dSm⁻¹. Increase in salinity resulted in a decrease of plant height, number of branches and dry weight of plants (Table 1). For all these parameters, significant reduction was observed at 15 dSm⁻¹, while differences among the control, 5 and 10 dSm⁻¹ treatments were only marginal. Although the fresh weight of the plants decreased with increase in salinity, differences between the control and 5 dSm⁻¹ treatments and between the 10 and 15 dSm⁻¹ treatments were found to be insignificant (*P*>0.05).

Initiation of flowering was delayed with an increase in salinity of the irrigation water (Table 1). Thus, flowering, which commenced at 85 days after sowing in the control, was delayed by 5, 14 and 29 days at 5, 10 and 15 dSm⁻¹ salinities, respectively. Flowering continued throughout the year, irrespective of the salinity level of irrigation water. Increased salinity also resulted in marked decrease in flower production. Compared with the control, the number of flower heads per plant decreased by 57% at 5 dSm⁻¹, 61% at 10 dSm⁻¹ and 67% at 15 dSm⁻¹. The differences among 5, 10 and 15 dSm⁻¹ treatments were observed to be insignificant (*P*>0.05). Flower size (diameter) was significantly reduced at 15 dSm⁻¹, but the differences among the control, 5 and 10 dSm⁻¹ treatments were only small (*P*>0.05). Increase in salinity also led to a decrease in seed set. The differences in the number of seeds produced per head were found to be marginal between the control and 5 dSm⁻¹ treatments and between the 10 and 15 dSm⁻¹ treatments.

In a previous study in Texas (USA), the growth and aesthetic appearance of *G. aristata* were found to be little affected after three months of treatment with saline water at salinity levels up to 5.4 dSm⁻¹ (Niu *et al.*, 2007). In our study, *G. aristata* showed much higher level of tolerance to salinity than the previously reported. This was probably because, the soil at the experimental

site was sandy and there was only a small increase in root zone salinity even after prolonged irrigation with highly saline water. Thus, the soil electrical conductivity at the end of the experiment measured by saturated paste extraction was found to be 1.72, 2.24, 3.42 and 3.78 dSm⁻¹ for the control, 5, 10 and 15 dSm⁻¹ treatments, respectively. In a study at Texas, the soil was loamy sand mixed with sphagnum peat moss (2:1 ratio by volume) and root zone salinity reached up to 6.8 dSm⁻¹ in treatments irrigated with saline water at 5.4 dSm⁻¹ (Niu *et al.*, 2007). It is possible that the irrigation rate and scheduling applied in our study consistently provided the net downward leaching volume to prevent any significant accumulation of salts in the root zone.

In addition to salinity tolerance, the species also showed good adaptation to the harsh growing environment in the Arabian Peninsula, characterized by extremely high summer temperatures. For instance, the daily mean temperatures during the period of study ranged between 19 and 37°C, the maximum temperatures were over 46°C for several days in July and August, much higher than those recorded at Texas (Niu *et al.*, 2007).

The finding that plant height, number of branches and flower size were not significantly affected by irrigation water salinity of up to 10 dSm⁻¹, makes *G. aristata* an excellent choice for moderately saline landscapes and gardens. Other advantages with *Gaillardia* are: it is a perennial, easy to propagate either by seeds or stem cuttings, flowers throughout the year and requires low maintenance. *Gaillardia* is also tolerant to drought, which it avoids by means of deep rooting. Plant resprouts after watering even after dying back when water is limited (Nickolee *et al.*, 2005). In our study, seeds were sown directly in the field and irrigated with high salinity water from day one, which in effect resulted in reduced germination and lower plant stand at higher salinities, compared with the control. Closer plant spacing to make up for the decrease in number of flower heads is expected to improve the aesthetic appearance of the species even at elevated salinities. This could be achieved by either increasing the seeding rate to compensate for poor germination or raising the seedlings with fresh water and transplanting them into the field after hardening with saline water. It should be noted that in this study, the soil of the experimental site was sandy, hence there was only small accumulation of salts in the root zone even after prolonged irrigation with highly saline water. With loamy and clayey soils, if the salinity of irrigation water is high, periodic leaching with low salinity water would be required to prevent salinity buildup and ensure an aesthetically acceptable appearance for landscape performance.

References

- Carter, C.T. and C.M. Grieve, 2006. Salt tolerance of floriculture crops. In: *Ecophysiology of High Salinity Tolerant Plants*, M.A. Khan and D.J. Weber (Eds). Springer, The Netherlands, pp. 279-287.
- Nickolee, Z., R. Kjelgren, T. Cerny-Koenig, R. Koenig and K. Kopp, 2005. Drought responses of ornamental herbaceous perennials. *HortScience*, 40: 1035.
- Niu, G. and D.S. Rodriguez, 2006. Relative salt tolerance of five herbaceous perennials. *HortScience*, 41: 1493-1497.
- Niu, G., D.S. Rodriguez and L. Aguiniga, 2007. Growth and landscape performance of ten herbaceous species in response to saline water irrigation. *J. Environ. Hort.*, 25: 204-210.

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