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Full Length Research Paper

Growth of *Capparis spinosa* var. *Inermis* under different irrigation levels

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Due to their importance in enhancing greenery activities in Kuwait, ornamental plants from diverse origins are being introduced and evaluated for their suitability to the harsh climatic conditions of the country. Introduction of multipurpose plants such as *Capparis spinosa* provides an invaluable opportunity to enhance greenery in Kuwait, while at the same time, exploring other applications, such as fruit and feed production. The objective of this study was to conduct field trials to evaluate the adaptation and performance of *Capparis spinosa*, as well as identify irrigation water requirements for water conservation aspects. Hardened Caper seedlings were drip irrigated at 100, 75 and 50% of the daily water requirements. Irrespective of the treatments, the survival of the plants recorded 100%. Though the canopy growth rate was highest in plants with 100% irrigation, no significant variation in canopy was observed in plants with 50 and 100% irrigation. The results signify that caper plants can be grown and sustained successfully with 50% of its daily water requirement. Caper plant is a potential candidate for introduction into greenery projects as a ground cover because of its ability to grow under conditions of aridity.

Keywords: *Capparis spinosa*, greenery activity, ornamental plants, field trials, water conservation.

INTRODUCTION

Water-efficient plants play an important role in the world's arid regions. Water conservation is a vital issue not only restricted to desert countries but also on the international level. In spite of the limiting obstacles, the arid ecosystems of the world can support plants with minimum water requirements that are drought and salt tolerant, for use in afforestation, landscaping and gardening projects, as drought has always been a normal recurrent event in arid and semi-arid lands (Le Houérou, 1996). It is also of extreme importance to create water efficient gardens to enhance the individual's life quality and create pleasant public spaces. The composition of urban vegetation is often more complex than that of surrounding environments (Rebele, 1994) and humans are the primary agents that create new plant communities in urbanized landscapes (Anderson, 1956; Whitney and Adams, 1980; Araujo, 2003). The main aspect of plant introduction is knowledge of and access to appropriate plant materials, which is an important consideration in the implementation of urban design projects in desert areas (Suleiman and Grina, 2003).

Harsh weather conditions, scarce rainfall, use of saline water for irrigation, soil salinity and low soil fertility are the main constraints in greenery development in Kuwait. Although water resources are scarce, consistant use of water-thirsty ornamental plants is still being used in Kuwait. Implementing low-water-use landscape along with drought tolerant plants is the best measure to conserve precious water (Suleiman et. al, 2007). For the successful introduction of new ornamental plants, selection of heat and drought tolerant plants adaptable to arid conditions is essential. Several plants were introduced from different sources with similar climatic conditions and screened for important parameters such as adaptability, potential use in arid environment and salt and drought tolerance (Suleiman et al., 2003). Evaluating economically important dual/multi purpose plants for their potentially to survive

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the local arid environment and produce greenery impact will further benefit Kuwait's greenery development program. Caper plant is a highly potential candidate for survival, adaptation and acclimatization in Kuwait for greenery and culinary values.

Capparis spinosa, a shrub native to Mediterranean countries grows wild on walls or in rocky coastal areas. It is a deciduous dicotyledonous plant with a very deep root system (Alkire, 1998). It prefers dry heat and intense sun-light, and can easily survive summer-time temperatures higher than 40°C (104° F). Caper is a cold tender plant with temperature hardiness range similar to the olive tree (-8°C). It is a salt and drought tolerant plant and has few disease or insect problems (Alkire, 1998). The caper's ve-getative canopy covers soil surfaces which help to con-serve soil water reserves. Growth of *Capparis spinosa* is related with an endogenous rhythm dependent on photo-period and temperature. Research results from irrigated plants under controlled environment showed that leaf ex-tension and growth ceases when temperature falls below a certain threshold (Rhizopoulou et al., 1997). *Capparis spinosa* L. is one of the few species that grow and flower entirely in summer, though very little is known about its life cycle related physiological characteristics (Rhizopoulou et al., 1997).Caper plant is a multipurpose crop that can be used for culinary, pharmaceutical and medicinal purposes. Caper plants are best known for the edible bud and fruit (*caper berry*) which are usually consumed as pickle (Pascual et al., 2003). They are also used in manufacturing cosmetics and medicines. As ornamental shrub, Caper plant is used for the prevention of soil ero-sion in sloppy areas (Barbera et al. 1991; Soyler and Ars-lan 2000).

Evaluation of plant growth at all stages of development is critical to assure successful introduction. The study of plants responses to water stress has been a central fea-ture of environmental physiologists' attempts to under-stand how plants function in their natural environment. Plants either avoid or tolerate periods of drought, often accompanied by high temperature and excessive irra-diance levels (Ehleringer and Cooper, 1992), through phenollogical, morphological and physiological adjust-ments (Turner, 1986). Previous research findings indicate that, *Capparis spinosa* is a stenohydric plant, which during the summer is largely free of competition for water with other species of the Mediterranean region (Rhizo-poulou et al., 1997). The objective of the current study was to conduct field trials to evaluate the adaptation and performance, as well as identify irrigation water require-ments of caper for water conservation aspects. Accord-ingly, reliable Caper germplasm was resourced. The irri-gation trials on hardened seedlings of *Capparis spinosa* were designed based on the daily water requirements of the plant during its establishment period in the field to withstand the harsh climatic conditions.

MATERIALS AND METHODS

Seedling source

To evaluate the potentials for large-scale plantation, three year old seedlings of *Capparis spinosa* var. *Inermis* were imported from a commercial source (Caperplants Company, Australia) in June, 2007 and were initially maintained in the greenhouse. Hardened seedlings were transplanted to the field in November, 2007 for further establishment.

Experimental design

Upon plant establishment in the field, irrigation trials were initiated in March 2008 and data were recorded till September 2008. Three irrigation treatments with five replications consisting of 10 plants in each replication were evaluated. The irrigation daily requirements were calculated based on the scheduled irrigation requirements of ornamental plants (groundcover category) established by the National Greenery Plan (KISR, 1996). Plants were irrigated utilizing a drip system scheduled to provide 100% (control), 75% and 50% of water demands, equivalent to 4, 3 and 2 gallons per hour (GPH); respectively. Emitters were adjusted according to required quantities. During the summer season, irrigation was made available for 30 minutes twice daily, whereas; during the winter season, irrigation was administered once daily for the same period. The results were evaluated according to the response of the plant to the water availability.

Soil and water sample analysis.

Soil samples were collected and analyzed at the time of planting to measure various soil properties to modify fertilizer application schedule for plant growth and development. The chemical analysis included plant nutrient contents, salinity, and organic matter content in the soil. The physical analysis included soil water tension and bulk density.

Cultural practices.

Cultural practices like cleaning of basins, application of NPK 15:15:15 fertilizer (approx 2 grams per plant) to fortify the soil once in two months, and leaching of salts were carried out. To enable the Caper plant to withstand the cold weather, mulching with dried Vetiver straws was performed.

Parameters measured.

Parameters recorded (March 2008-September 2008) at bimonthly interval were survival rate, plant height, plant canopy, chlorophyll index, shoot number and phenological observations. Leaf chlorophyll index was determined instantly and non-destructively on an intact leaf sample using chlorophyll meter.

Data on plant height, canopy, chlorophyll index and number of shoots were collected periodically and analyzed using one-way analysis of variance (ANOVA) and the 'R' procedure to ascertain treatment significance (Crawley, 2005). Significant treatment means were separated using the Duncan's Multiple Range Test (Little and Hills, 1978).

RESULTS

Analysis of soil and water sample revealed that both were saline in nature with high levels of sodium and chlorine, and low levels of potassium and phosphate. Organic matter content in soil was also nominal (Table 1).

Average plant height recorded at 0, 30, 60, 90, 120 days after initiation of irrigation trial is detailed in Table 2. Growth rate in height was highest in plants irrigated with 100% of daily water requirement, at the end of the field

Table 1. Results of Chemical Analysis for Soil and Water Samples of KISR Waterfront Site

Sample ID *	pHs	Ece (mS/cm)	Cations (meq/kg)				Anions (meq/kg)			(mg/kg)		Organic Matter %	SAR	Particle density	Bulk Density gm/cm3	Porosity %
			Ca^{+2}	Mg^{+2}	K^{+}	Na^{+}	Cl^{-1}	CO_3^{--}	HCO_3^{-}	PO_4-P	NO_3-N					
Soil 1	7.46	9.08	10.31	4.54	0.28	10.12	13.68	0.11	0.395	0.11	22.64	0.20	3.71	2.65	1.55	41.7
Soil 2	7.32	4.67	6.60	2.73	0.22	4.38	3.49	0.33	0.80	0.33	6.67	0.38	2.03	2.59	1.60	38.0
Soil 3	7.21	6.88	6.72	1.88	0.23	8.70	10.57	0.33	0.41	0.70	2.07	0.49	4.19	2.54	1.51	40.3
Water	7.64	4.94	20.68	10.53	0.50	31.62	31.14	<.01	1.60	<.01	56.93	-	8.01	-	-	-

* Soil 1-3 = Soil samples from three selected sites for implementation of irrigation trials.

Table 2. Average Plant Height of *Capparis spinosa* in Different Irrigation Trials (Initiated in March 2008)

Treatment	Average plant height (cm)					
	Initial	30 DAI[i]	60 DAI	90 DAI	120 DAI	Growth rate (%)
Irrigation 100%	3.96 ± 0.26	4.16 ± 0.22	5.18 ± 0.30	10.00 ± 0.30c[ii]	13.56 ± 0.48b	242
Irrigation 75%	3.76 ± 0.20	3.54 ± 0.10	4.48 ± 03	7.62 ± 0.62a	10.18 ± 0.78a	171
Irrigation 50%	3.74 ± 0.28	3.68 ± 0.23	4.66 ± 0.22	8.66 ± 0.11b	12.58 ± 0.68b	236
Significance	NS[iii]	NS	NS	***	***	

[i] DAI – Days after initiation of irrigation trials
[ii] The means followed by the same letter are not statistically different at $P \leq 0.001$
[iii] NS- Not Significant

trial. There was significant variation in plant height between the treatments, 90 days after the initiation of irrigation trials. During the initial 60 days there was no significant difference in plant height among the treatments. As Caper plant has trailing habit, plant canopy is an important parameter of vegetative growth. There was significant variation in plant canopy between the treatments 30 days after the initiation of irrigation trials (Table 3). Growth rate in canopy was found to be highest in plants irrigated with 100 % of its daily water requirement followed by 75% and 50% irrigation.

Average chlorophyll index recorded at 0, 30, 60, 90, 120 days after the initiation of irrigation trials indicate that chlorophyll index increases till the beginning of reproductive stage in all the treatments and reaches its maximum at the end of vegetative stage. There was a significant variation in chlorophyll index from 30 days to 90 days after initiation of irrigation trials (Table 4). After that there was no significant variation between the treatments.

Number of shoots was high in plants irrigated with 100% of daily water requirement followed by 50 % and 75 % irrigation (Table 5). Except at 30 days after the initiation of irrigation trials, there was no significant variation in number of shoots produced among the treatments. During the first week of May, 2008 (90 days after initiation of irrigation trials) flowering was observed in 28% of control plants (100 % of daily water requirement). In plants irrigated with 50 % and 75 % of its daily water requirement, flowering was recorded in 20% and 4 % of the total plants respectively. Though control plants started to flower early, at the end of June, 2008, 96 % of plants with 50 % irrigation flowered compared to 94% and 92 % of plants with 100 % (control) and 75 % irrigation.

DISCUSSION

Irrespective of the irrigation treatment, all the plants survived both during winter (December – February) and summer (May- August) seasons. Though there was a cessation of growth during winter, it was compensated by the sudden spurt in growth during summer. These facts suggest that Caper plant can be successfully introduced in Kuwait. The daily requirement of irrigation water was established based

Table 3. Average Plant Canopy of *Capparis spinosa* in Different Irrigation Trials (Initiated in March 2008)

Treatment	Average plant canopy (cm)					Growth rate (%)
	Initial	30 DAI[i]	60 DAI	90 DAI	120 DAI	
Irrigation 100%	14.40 ± 0.51	24.46 ± 0.86 b[ii]	47.74 ± 0.95c	80.22 ± 1.7 b	110.62 ± 5.13b	668.19
Irrigation 75%	13.40 ± 1.4	15.94 ± 2.00 a	29.52 ± 3.59a	56.30 ± 4.62a	92.66 ± 7.71a	591.49
Irrigation 50%	15.32 ± 1.22	21.86 ± 2.18 b	40.58 ± 1.86b	74.02 ± 4.61b	105.02 ± 2.5b	585.51
Significance	NS[iii]	***	***	***	**	

[i] DAI – Days after initiation of irrigation trials
[ii] The treatment means followed by the same letter are not statistically different at P ≤, 0.01, 0.001 levels.
[iii] NS- Not Significant

Table 4. Average Chlorophyll Index of *Capparis spinosa* in Different Irrigation Trials (Initiated in March 2008)

Treatment	Average chlorophyll index				
	Initial	30 DAI[i]	60 DAI	90 DAI	120 DAI
Irrigation 100%	2.76 ± 0.40	41.81± 3.97c[ii]	29.54 ± 3.64b	44.07 ± 0.95a	39.16 ± 1.25
Irrigation 75%	1.47 ± 0.30	12.84 ± 2.99a	18.97 ± 4.28a	41.94 ± 1.40a	37.73 ± 1.41
Irrigation 50%	2.20 ± 0.13ab	27.37 ± 4.20b	28.35 ± 2.88b	48.68 ± 2.15b	41.23 ± 2.21
Significance	NS[iii]	***	*	**	NS

[i] DAI – Days after initiation of irrigation trials
[ii] The treatment means followed by the same letter are not statistically different at P ≤ 0.05, 0.01, 0.001 levels.
[iii] NS- Not Significant

Table 5. Average Shoot Number of *Capparis spinosa* in Different Irrigation Trials (Initiated in March 2008)

Treatment	Average number of shoots				
	Initial	30 DAI [i]	60 DAI	90 DAI	120 DAI
Irrigation 100%	4.04 ± 0.18	6.42 ± 0.35b[ii]	6.38 ± 0.38	7.02 ± 0.48	7.32 ± 0.52
Irrigation 75%	3.44 ± 0.36	4.62 ± 0.54a	5.58 ± 0.46	6.54 ± 0.59	7.12 ± 0.54
Irrigation 50%	3.86 ± 0.32	5.28 ± 0.35ab	6.16 ± 0.30	6.72 ± 0.38	7.26 ± 0.32
Significance	NS [iii]	*	NS	NS	NS

[i] DAI – Days after initiation of irrigation trials
[ii] The treatment means followed by the same letter are not statistically different at P ≤ 0.05.
[iii] NS- Not Significant

Figure 1. *Capparis spinosa* in the field.

based on the scheduled average daily irrigation plan for groundcovers in Kuwait, and not on the peak daily demands. Irrigation was administered providing 100 %, 75 % and 50 % of the daily water requirements. Data recorded on plant height indicated no significant difference among irrigation treatments during the period of fastest vegetative growth. Though the canopy growth rate was highest in plants with 100 % irrigation, no significant variation in canopy was observed in plants with 50% and 100% irrigation (except during 30-60 Days after initiation of irrigation trials).

There was also no significant variation in plant height between plants with 50% and 100% irrigation except for a short period of time (60- 90 Days after initiation of irrigation trials). This supports the theory that *Capparis spinosa* is a stenohydric plant, as it is tolerant of a wide range of moisture levels. It is also a polymorph shrub and can

can function as a shrub as well as a groundcover. In our study it was used as groundcover (Figure 1) and in such plants heights do not effectively indicate the growth rate. Results signify that caper plants can be grown and sustained successfully with 50% of its daily water requirement. Caper plant is a problem free plant which can adapt to Kuwait's climatic conditions with minimal pest and disease incidence. Further work in this field is required to fully test these hypotheses.

Conclusion

Caper plant is a potential candidate for introduction into greenery projects as a ground cover because of its ability to grow under conditions of aridity. Caper plant species has appealing form, which will be a welcome addition to the list of plants for landscaping and greenery activities. Caper plant can be used as a ground cover to bind the loose soil, improve the micro climate of soil and in soil and water conservation programs. There was no significant difference in plant height at the beginning between the irrigation treatments (100%, 75% and 50% of daily water requirement), indicating that plant height do not play a vital role in determining the growth rate of Caper plant during the period of vegetative growth. Canopy growth rate was highest in plants with 100% irrigation. If instant landscape was not vital, plants irrigated at 50% still developed lusciously, however; at a slower growth rate. Irrespective of the irrigation treatment, all the plants survived both winter and summer. Mass Caper plantations will require average daily demands of irrigation water (12.5 liters) even in summer periods; unlike most acclimatized groundcovers in Kuwait that require peak daily demands (KISR, 1996) of irrigation water (25 liters/day). Caper plant was found to be a problem-free plant which could readily adapt to Kuwait's environmental conditions with no pest and disease incidence and will be an asset to Kuwait's greenery program.

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