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INTRODUCING AND GROWING SOME FRUITING COLUMNAR CACTI IN A NEW ARID ENVIRONMENT

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ABSTRACT

One of the most important ways of coping with increasingly frequent water shortages is improving the efficiency of water use. Planting drought-resistant crops is a promising way of reducing the demand for water. Columnar cacti are especially drought-tolerant and highly productive even though they consume very little water. In the United Arab Emirates, seven columnar fruiting cacti were evaluated in terms of their capacity for vegetative growth in a new arid environment. The cacti evaluated were: *Carnegiea gigantea*, *Myrtillocactus geometrizans*, *Pachycereus pecten-aboriginum*, *P. pringlii*, *Stenocereus griseus*, *S. stellatus* and *S. thurberi*. Plants were propagated from cuttings in a greenhouse. Roots developed within two to four weeks of planting. The plants were acclimatized and transplanted in an orchard in the desert. Although the cacti varied widely in terms of growth, most of them are promising species for cultivation in desert environments.

Keywords: arid environment, cactus, fruits, new crops, water use efficiency

INTRODUCTION

One-third of the world's population faces water shortages, and this is expected to rise to two-thirds by the year 2025 (U.N. Report, 2000). Government-sponsored investments have increased urban landscaping and agriculture activities, which has resulted in severe over-use of water resources beyond the natural renewal capacity (Wilhite, 2000). The first major step in coping with imminent water shortages is the formulation and implementation of a comprehensive water management plan that reduces the imbalance between supply and demands. A well-designed plan will focus primarily on wise water management and on curbing rising demand (Rogers, 1994).

There is a growing need for new approaches to water management in arid and semi-arid environments, as were as in other environments were rainfall is unreliable. A search for highly productive, drought-resistant fruit crops is underway to address the needs of farmers living in drought-prone areas.

Columnar cacti are among the drought resistant plants under consideration. Many columnar cacti produce unique fruits which can be eaten fresh or dried, or be processed into juice. Some cacti promise to be profitable commercial crops (Casas et al., 1997).

The Cactaceae are a large family of succulents whose natural range is almost entirely restricted to the New World (Anderson, 2001). They have evolved physiological and morphological adaptations which enable them to grow in habitats far too dry for other plants (Mauseth, 2000). They also tolerate high temperatures and poor soils, which makes them highly adaptable to new environments. Cacti can grow in dry, infertile marginal land where common crops cannot grow. As succulents, cacti can survive long periods of drought by living off water stored in their tissues. Water taken up into the stem is incorporated in a mucilaginous substance that does not evaporate as readily as water (Saag et al., 1975). Cacti are not only resistant to desiccation, but are also extremely tolerant of desiccation when it occurs (Sowell, 2001). However, they are extremely susceptible to root rot when they are grown in waterlogged soil. Large columnar cacti consisting of only a few cylinders transpire less and are more drought resistant than smaller cacti with more segments. Cactus spines create a microclimate around the stem, which is covered with a waxy cuticle.

Among the adaptations which enable cacti to tolerate harsh conditions are: a stem capable of storing water; the reduction or absence of leaves; a waxy cuticle (Sowell, 2001); opening of the tissues during the night to facilitate the uptake of carbon dioxide; and Crassulacean Acid Metabolism (CAM) (Malda et al., 1999). Two cactus structures, ribs and tubercles, enable the stem to expand and contract in response to changes in water availability. Cactus roots are usually shallow and non-succulent, and require little water. When the soil dries, the fine lateral roots generally die, while the larger roots become covered with a corky layer (periderm) (Sowell, 2001). Water conductivity in the roots decreases dramatically during soil drying, which reduces water loss from the plant tissues to the soil (Huang and Nobel, 1994; Nobel and Cui, 1992).

The aim of this study was to evaluate the capacity of seven species of fruiting columnar cacti for vegetative growth in a new arid environment in Al-Oha, United Arab Emirates.

MATERIAL AND METHODS

Plant material and propagation

Cacti can be propagated either from seed or cuttings (Lopez-Gomez et al., 2000). Asexual propagation produces daughter plants which are genetically identical to the parent plant. This allows a superior genotype to be perpetuated without losing any desirable traits (ElObeidy, 2001).

Cuttings of seven fruiting cacti were obtained from private nurseries in Brazil, Mexico and the United States. The cacti evaluated were: *Carnegiea gigantea*, *Myrtillocactus geometrizans*, *Pachycereus pecten-aboriginum*, *P. pringlii*, *Stenocereus griseus*, *S. stellatus* and *S. thurberi*.

The cuttings were allowed to dry in a warm, dry area for ten days to permit the cut surface to heal and develop callus. The callus helps prevent rotting when the cutting is placed in a rooting material. The larger the cutting, the longer it should be dried.

After drying, each cutting was placed in the center of a 60 cm flowerpot one-third filled with a potting mix of one part peat and two parts soil. The flowerpots were then filled to the two-thirds level with the same potting mix and kept in a greenhouse.

Orchard and transplantation

The orchard used in this study was located in the Al-Oha area, United Arab Emirates. The soil is sandy and has a salinity of 2200 ppm. The chief salt in the soil is sodium chloride. An underground aquifer is the only source of irrigation water, which has a salinity of up to 2800 ppm. Local temperatures can reach 49°C during the summer. The average annual rainfall is 77 mm.

In the autumn, plants were taken out of the greenhouse, acclimated for ten days in the shade, and planted in the orchard.

The cacti were carefully slipped out of the flowerpots and planted in holes which were about 15 cm wider and a few centimeters deeper than the flowerpots. Heavy gloves and 30 cm forceps were used to avoid injuring the technicians and plants. The soil was lightly firmed around the plants. The plants were then watered thoroughly.

A drip irrigation system was used in the orchard. Fertilizer (12:4:24) was applied one month after transplanting, and once a month after that.

Data analysis

Data were collected in two successive seasons (2001/2002 and 2002/2003). The data recorded included: percentage of surviving plants; growth rate (stem length and diameter); number of ribs; number, length and distribution of spines; and root development. Other observations on growth behavior were also recorded. Thirty plants of each species were evaluated. Thirty more plants of *Pachycereus pecten-aboriginum* were evaluated to determine the effect of planting time on growth and development (Tab. 2).

Means were compared using Duncan's multiple range t-test at P = 0.05.

RESULTS AND DISCUSSION

Seven species of columnar fruiting cacti were evaluated in terms of their capacity for vegetative growth in a new arid environment in Al-Oha, United Arab Emirates.

Most of the cacti adapted well to the new environment. In the local climate, the growing season lasted from the middle of September until the middle of June. No growth or development was observed during the hot summer months.

After being planted in the orchard, *Myrtillocactus geometrizans* showed yellowing in response to stress. The stems were blue-green with four to six ribs, and grew 3.3 cm/month in height and 0.7 cm/month in diameter (Tab. 1). Numerous up-curving branches began to develop a month after transplanting (Fig. 1 and Tab. 3). Each areole consisted of a 3.0 cm long central spine surrounded by five 1.0 to 1.5 cm long peripheral spines. New spines were reddish, and old spines were lead-colored. On the older parts of the stem, the spines had fallen off and smaller, 0.1 to 0.3 cm long spines had developed in their place.

Native to Central Mexico and Guatemala, *M. geometrizans* produces berry-like fruits in large numbers along the rib edges. The fruits have commercial potential and can be found in local markets in central Mexico (Reynoso et al., 1997).

With *M. geometrizans* and some of the other cacti evaluated, excessive irrigation caused stem cracking (Fig. 2). Prolonged over-watering caused wilting and, eventually, death.

Pachycereus pringlii also showed some yellowing after planting, but only on the side facing the sun. New growth was pink (Fig. 3). The stems had thirteen ribs and grew 3.7 cm/month in height and 0.8 cm/month in diameter. Each areole consisted of fourteen 1.0 to 3.0 cm long spines, one to three of which were central spines. All spines on the new growth were red and turned white with age.

Pachycereus pecten-aboriginum had stems which had eight to ten ribs and which grew 3.9 cm/month in height and 0.7 cm/month in diameter. Spines on the new growth were bright reddish-brown and turned white with age (Fig. 4). Each areole consisted of one 3.3 cm long central spine surrounded seven or eight 1.0 cm long peripheral spines.

Neither species of *Pachycereus* developed branches or sprouts during the first two seasons. However, in their natural habitat, *Pachycereus* species develop erect branches close to the ground which grow almost straight up. The branches are almost as big as the main stem (Anderson, 2001).

Both species of *Pachycereus* produce edible fruits with sweet, juicy, pink or red flesh and small black seeds (Felger and Moser 1974; 1976).

The stems of *Stenocereus stellatus* showed reddening on the side facing the sun (Fig. 5). The stems had eight ribs and grew 3.8 cm/month in height and 0.6 cm/month in diameter (Tab. 1). Spines on the new growth were reddish-brown. Each areole consisted of a 2.0 to 3.0 cm long central spine surrounded by seven or eight 0.5 to 2.0 cm long peripheral spines.

The rib edges of *Stenocereus griseus* showed reddening on the side facing the sun (Fig. 6). The stems had

T a b l e 1 . Growth rate as an increase in stem length and diameter in fruiting columnar cacti

Species	Increase in length [cm/month]	Increase in diameter [cm/month]
Carnegiea gigantea	0.3	0.3
Myrtillocactus geometrizans	3.3	0.7
Pachycereus pecten-aboriginum	3.9	0.7
P. pringlii,	3.7	0.8
Stenocereus griseus	3.7	0.8
S. stellatus	3.8	0.6
S. thurberi	2.1	0.8

T a b l e 2 . Effect of transplanting date on growth rate and survival of *Pachycereus pecten-aboriginum* in the orchard

Date of transplanting	Increase in length [cm/month]	Increase in diameter [cm/month]	Percentage survival
August 15th	3.3 b	0.6 b	95
September 15th	3.6 b	0.6 b	100
October 15th	4.1 a	0.7 a	100
February 15th	3.1 bc	0.5 c	95
March 15th	2.1 d	0.4 d	75

*Results followed by the same letter do not differ significantly at P = 0.05 according to Duncan's t-test

T a b l e 3 . Number of branches or sprouts per plant in fruiting columnar cacti

Species	Number of branches or sprouts per plant
Carnegiea gigantea	0
Myrtillocactus geometrizans	5
Pachycereus pecten-aboriginum	0
P. pringlii	0
Stenocereus griseus	2
S. stellatus	2
S. thurberi	0

Figure 1. *Myrtillocactus geometrizans*

Figure 2. Cracked stem as affected by excessive irrigation

Figure 3. *Pachycereus pringlii*

Figure 4. *Pachycereus pecten-aboriginum*

Figure 5. *Stenocereus stellatus*

Figure 6. *Stenocereus griseus*

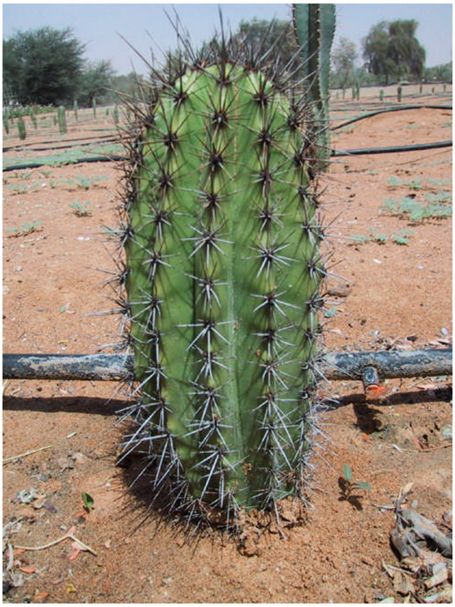

Figure 7. *Stenocereus thurberi*

Figure 8. *Carnegiea gigantea*

seven ribs and grew 3.7 cm/month in height and 0.8 cm/month in diameter. Each plant developed two sprouts during the first growing season. Each areole had one 2.0 to 4.0 cm long central spine surrounded by seven or eight 1.0 to 2.0 cm long peripheral spines.

In Mexico. the most important species of *Stenocereus* are *S. griseus* and *S. stellatus*. Pulp color differs from clone to clone, and may be white, orange, pink, or red. The skin of the fruit is usually green, but sometimes various shades of red are also seen (Casas et al., 1999; Gibson, 1991; Silivius, 1995; Pimienta-Barrios and Nobel, 1994).

Stenocereus thurberi developed purple areoles after being planted in the orchard (Fig. 7). The stems grew 2.1 cm/month in height and 0.8 cm/month in diameter.

S. thurberi grows wild in Arizona and Northwestern Mexico, and produces red fruits that split when mature to reveal red flesh inside (Anderson, 2001).

Carnegiea gigantea grew very slowly. The stems had thirteen or fourteen ribs and grew only 0.3 cm/month in height and 0.3 cm/month in diameter (Tab. 1, Fig. 8). Each areole consisted of two or three 2.0 cm long central spines surrounded by fourteen to sixteen 1.0 to 1.5 cm long peripheral spines. The spines were reddish-brown on new growth and turned gray with age.

Although *C. gigantea* bears edible fruits, it has little agricultural potential. The fruits are usually collected from wild plants (Crosswhite, 1980).

One of the most important ways of coping with increasingly frequent water shortages is improving the efficiency of water use. Planting drought-resistant crops is a promising way of reducing the demand for water. Columnar cacti are especially drought-tolerant and highly productive even though they consume very little water.

The fruiting cacti evaluated in this trial can be used to establish new successful plantations in other arid areas. Cacti can also play an important ecological role in combating desertification.

REFERENCES

Anderson E.F. 2001. The cactus family. Oregon, USA: Timber Press. 776 p.

Casas A., Caballero J., Valient-Banuet A., Soriano J.A., Davilla P. 1999. Morphological variation and the process of domestication of *Stenocereus stellatus* (Cactaceae). AMER. J. BOTANY 86: 522-533.

Casas A., Pickersgill B., Caballero J., Valient-Banuet A. 1997. Ethnobotany and domestication in xoconochtli, *Stenocereus stellatus* (Cactaceae), in the Tehuacan Valley and La Mixteca Baja, Mexico. ECONOMIC BOTANY 51: 279-292.

Crosswhite F.S. 1980. Dry country plants of the south Texas plains. DESERT PLANTS 2: 141-179.

ElObeidy A.A. 2001. In vitro regeneration of carob. BULL. FAC. AGRIC. CAIRO UNIV. 52: 297-308.

Felger R.S., Moser M.B. 1974. Columnar cacti in Seri Indian culture. KIVA 39: 257-275.

Felger, R.S., Moser M.B. 1976. Seri Indian food plants: desert subsistence without agriculture, J. ECOL. FOOD. NUTR. 5: 13-27.

Gibson A.C. 1991. The systematics and evaluation of subtribe *Stenocereus griseus*. CACTUS SUCCULENT J. 63: 92-99.

Huang B., Nobel P.S. 1994. Root hydraulic conductance and its components, with emphasis on desert succulents. AGRON. J. 86: 767-774.

Lopez-Gomez R., Diaz-Perez J.C., Flores-Martinez G. 2000. Vegetative propagation of three species of cacti: pitaya (*Stenocereus griseus*), Tunillo (*Stenocereus stellatus*) and jiotilla (*Escontria chiotilla*). AGROCIENICA 34: 363-367.

Malda G., Backhaus R.A., Martin C. 1999. Alterations in growth and crassulacean acid metabolism (CAM) activity of in vitro cultured cactus. PLANT CELL, TISSUE ORGAN CULTURE 58: 1-9.

Mauseth J.D. 2000. Theoretical aspects of surface-to-volume ratios and water-storage capacities of succulent shoots. AMER. J. BOTANY 88: 1107-1115.

Nobel R.S., Cui M. 1992. Hydraulic conductances of the soil. the root-soil air gap, and the root changes for desert succulents in drying soil. J. EXP. BOTANY 43: 319-326.

Pimienta-Barrios E., Nobel R.S. 1994. Pitaya (*Stenocereus* spp., Cactaceae): An ancient and modern fruit crop of Mexico. ECON. BOT. 48: 76-83.

Reynoso R., Garcia F.A., Morales D., Gonzalez de Mejia E. 1997. Stability of betalain pigments from a Cactaceae fruits. J. AGR. FOOD CHEM. 45: 2884-2889.

Rogers P. 1994. The agenda for the next thirty years. In: P. Rogers and P. Lydon (eds.), Water in the Arab world, perspectives and progress. Division of Applied Sciences, Harvard University.

Saag L.M.K., Sanderson G.R., Moyna P., Ramos G. 1975. Cactaceae mucilage composition. J. SCI. FOOD AGR. 26: 993-1000.

Silivius K.M. 1995. Avian consumers of cardon fruits (*Stenocereus griseus*: Cactaceae) on Margarita Island, Venezuela. BIOTROPICA 27: 96-105.

Sowell J. 2001. Desert ecology. An introduction to life in the arid Southwest. University of Utah Press, Salt Lake City, USA. 192 pp.

Wilhite D.A. 2000. Drought: a global assessment. Natural Hazards and Disasters Series. Routledge Publishers, London, 700 pp.

WZROST I UPRAWA OWOCUJĄCYCH KAKTUSÓW KOLUMNOWYCH W ŚRODOWISKU PUSTYNNYM

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STRESZCZENIE

Jednym z najważniejszych sposobów zapobiegania pogłębiającemu się deficytowi wody jest poprawa skuteczności jej użytkowania. Obiecująco w tym kontekście przedstawia się uprawa roślin przystosowanych do suchego środowiska. Należą do nich kaktusy kolumnowe, które są wyjątkowo odporne na suszę, a przy tym ich produktywność jest wysoka, pomimo że zużywają one bardzo mało wody. Przydatność siedmiu gatunków kolumnowych kaktusów: *Carnegiea gigantea*, *Myrtillocactus geometrizans, Pachycereus pecten-aboriginum, P. pringlii, Stenocereus griseus, S. stellatus* i *S. thurberi* do uprawy w suchym środowisku testowano w Zjednoczonych Emiratach Arabskich. Rośliny rozmnażano z sadzonek zielnych w szklarni. Wytworzyły one korzenia po upływie 2 do 4 tygodni od posadzenia. Ukorzenione rośliny były aklimatyzowane i posadzone w sadzie na pustyni. Jakkolwiek wzrost tych kaktusów był bardzo zróżnicowany, większość z nich nadaje się do uprawy w środowisku pustynnym.

Słowa kluczowe: suche środowisko, kaktusy, owoce, nowe odmiany, deficyt wody