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Introducing *Cereus* into an Arid Region as a New Fruit Crop

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Abstract

Introducing new crops with high water use efficiency in the Middle East and North Africa will participate in curb rising demand of water. *Cereus* species characteristics fit with most of the requirements of a drought tolerant crop with very high water-use efficiency. *Cereus hexagonus*, *C. peruvianus*, *C. peruvianus monstrose*, *C. validus* were introduced as fruiting cacti into an arid desert, characterized with high temperatures and rare rainfall. *C. pachanoi* was introduced as a rootstock for other species. Cuttings were obtained from private nurseries in California. *C. peruvianus* cuttings survived storage up to eight months. Horizontal position of the cuttings during storage of *C. peruvianus* encouraged the development of lateral branches. Plants were propagated, acclimatized and then transplanted into the field in the desert. Growth and development of the introduced cacti were assessed under the new environment. All the introduced species grew successfully except *C. validus* that was eliminated during the first summer. *C. peruvianus monstrose* characterized with dramatic contraction of the stem in the very dry condition. The main stem of *C. peruvianus*, *C. peruvianus monstrose*, *C. hexagonus* and *C. pachanoi* grew 9.2, 10.2, 8.1 and 15 cm/month, respectively. *C. peruvianus* developed the highest number of sprouts. *C. peruvianus* and *C. peruvianus monstrose* were the most promising in the new environment in terms of its high adaptability and healthy growth. The introduced species could be ideal for establishing crop plantations in the arid deserts.
Keywords: Drought resistance; fruits; water shortage; water use efficiency.

Introduction

The water shortage problem is close to crisis levels in most countries of the Middle East and North Africa region, senior vice president of the World Bank warned at a conference on the sidelines of the annual World Bank and International Monetary

Fund meetings in Dubai, September, 2003. Water has been a scarce resource in the Middle East since early civilizations (ASANO and MILLS 1990). Most crops grown in the area however, have a high water requirement. Introducing new crops with high water use efficiency in the Middle East and North Africa will participate in curb rising demand of water.

Cereus species characteristics fit with most of the requirements of a drought tolerant crop with very high water-use efficiency. *Cereus* cacti have physiological and morphological methods of exploiting environments that would soon desiccate other plants. In addition, *Cereus* is characterizes with crassulacean acid metabolism pathway (MALDA *et al.* 1999). Crassulacean acid metabolism, a key adaptation of photosynthetic carbon fixation to limited water availability, is characterized by nocturnal CO_2 fixation and daytime CO_2 re-assimilation. Generally crassulacean acid metabolism pathway results in improved water-use efficiency (CUSHMAN and BORLAND 2002).

Cereus is a popular group of cacti from South America consists of about 60 species. These vigorous-growing cacti are easy to grow in marginal, infertile, dry lands where common crops fail (FELGER and MOSER 1976).

Cereus produces unique fruits that are thornless and vary in skin color from violet-red to yellow. The flesh, which is the edible part of the fruit, is white and contains small, edible, and crunchy seeds (FELGER and MOSER 1976). *Cereus* fruits may be eaten fresh, dried, or can be made into a juice (SCHEINVAR 1985).

Cereus fruits can offer commercial opportunities (FELGER and MOSER 1976). However, *Cereus* is an unexplored, underutilized fruit tree (MORTON 1987).

The aim of this study was to introduce several *cereus* fruiting cacti into an arid desert. Growth and development of the introduced cacti were assessed under the new environment.

Materials and Methods

Sources of the plant material

Cuttings from four fruiting *Cereus* species were obtained from private nurseries in California, USA. The introduced species are *C. hexagonus*, *C. pachanoi*, *C. peruvianus* and *C. validus*. *C. peruvianus monstrose* was also introduced as a sport of the species *peruvianus*.

Healing and storage of cuttings

Cuttings were allowed to heal in a dry area at 30°C for ten days. Other cuttings of *C. peruvianus* and *C. peruvianus monstrose* were stored at 35°C up to eight months.

Propagation

Pots of 60 cm in diameter were filled to about one-third full of potting mix consists of 1 part peat moss: 2 parts sand. Each cutting was stand in the center of a pot. Pots were completed to two-third full with the potting mix. Pots were kept in the greenhouse.

Orchard and transplantation

Soil and irrigation water samples were taken to determine salinity. In the fall, plants were taken out the greenhouse in the shade for ten days for acclimatization. The plants were then transplanted into the orchard in Al-Foha area, UAE.

Hole was dug about 15 cm wider than the container and a couple inches deeper. The plant was slip carefully out of its container. Heavy gloves and 30 cm forceps were used to avoid injuring the technicians or plants. The cactus was ease into the hole and soil was firmed lightly around. Plants were watered thoroughly.

Drip irrigation system was used in the orchard. Fertilizer 12:4:24 was applied one month after transplanting into orchard, then every tow month during the growing season.

Data collection and analysis

Data were collected in two successive seasons (2001/2002 and 2002/2003) on survival, stem length and diameter and sprout or lateral branch development during the growing season (October – May). Other observations on growth behavior were recorded. Thirty cuttings from each species were planted. Thirty more cuttings of *C. peruvianus* and C. peruvianus monstrose were used in the storage experiment. Cutting were weighed at the end of each month of storage.

For statistical analysis a completely randomized design was used, and mean comparisons were made using Duncan's Multiple Range test at 5% significant level (DUNCAN 1955).

Results and Discussion

Four *cereus* species were introduced into the desert in Al-Ain, UAE. Al-Ain is characterized with high temperatures and rare rainfall. Maximum temperature reaches 49°C during the summer and average annual rainfall is 77mm. Orchard soil is sandy with 2200 ppm salinity. The source of irrigation is the underground aquifer that is also saline. Salt concentration in irrigation water reached 2000 ppm.

Cuttings of the introduced species 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 during propagation.

The introduced species grew successfully except *C. validus* that was eliminated during the first summer. All the plants of *C. peruvianus* and *C. peruvianus* *monstrose* survived the new environment. The main stem of *C. peruvianus* showed 9.2 cm increase in height (Fig 1) and 0.9 cm increase in diameter (Fig 2) per month. Five sprouts were developed per plant (Figs 3 and 4). *C. peruvianus*, found in southeastern coast of South America, already attracted attention in the US as a potential fruit-crop (BACKEBERG 1984). The fruit is smooth and spineless and varies from yellow to deep red (WEISS *et al.* 1993). *C. peruvianus* was found to be very promising columnar cactus (MORTON 1987).

C. peruvianus cuttings survived storage up to eight months. Cuttings lost about 50% of the original weight at the end of the storage period (Fig 5). Horizontal position of the cuttings during storage encouraged the development of lateral branches (Fig 6). Lateral branching averaged at four branches per cutting.

C. peruvianus monstrose cuttings did not survive more than three months of storage (Fig 5). In the field, the main stem of *C. peruvianus monstrose* increased 10.2 cm in length and 1.1 cm in diameter per month (Figs 1 and 2). Four sprouts were developed per plant. *C. peruvianus monstrose* characterized with dramatic expansion and contraction of the stem as water availability changes (Fig 7). Such mechanism enables the stem to conserve water and survive dry, hot conditions. Over millions of years, through natural selection, only the most adapted species survived desert environment (JOHN 2001). Generally, the family of Cactaceae, contained many plants that are highly adaptable to a new environment and able to tolerate drought, heat and saline soil. *Cereus* as a member in the family Cactaceae has devolved to be well adapted to extremely xeric conditions (MAUSETH 2000; JOHN 2001). The pathway of photosynthesis in *Cereus* is the crassulacean acid metabolism. Crassulacean acid metabolism is the process in which stomata open at night (when evaporation rates are usually lower) and are usually closed during the day. The CO_2 is converted to an acid and stored during the night. During the day, the acid is broken down and the CO_2 is released to RUBISCO for photosynthesis. When conditions are extremely arid, *Cereus* plants can just leave their stomata closed night and day. Oxygen given off in photosynthesis is used for respiration and CO_2 given off in respiration is used for photosynthesis. This is a little like a perpetual energy machine (WINTER and SMITH 1996). Importance of crassulacean acid metabolism species increases in the face of expansion of desertification around the world (CUSHMAN and BORLAND 2002).

C. hexagonus is another introduced *Cereus* species with 73% of survival in the new arid environment. The main stem growth rate of *C. hexagonus* was 8.1 and 0.8 cm/month in height and diameter, respectively (Figs 1 and 2). *C. hexagonus* stem developed two sprouts during the first two seasons (Fig 3). *C. hexagonus* gives ovoid red fruits with numerous edible small black seeds, pulp soft and juicy, white to pinkish. *C. hexagonus* is originated in Brazil (ANDERSON 2001).

All *C. pachanoi* plants survived the new environment. *C. pachanoi* grew very fast, averaging up to a fifteen centimeter a month of new growth (Fig 1). Its stem diameter increases 1.1 cm per month (Fig 2). Three sprouts were developed per plant (Fig 3). *C. pachanoi* was introduced as a rootstock for grafting other species. *C. pachanoi* is popular as grafting stock for smaller, slower growing cacti (OSTOLAZA 1984). Grafting in cactus is really best used as a technique for jump starting seedlings, saving a dying cactus from certain death, speeding up breeding programs or growing less hardy species outdoors on a cold hardy stock.

C. validus grows 5.1 cm in height and 0.5 cm in diameter per month during the first season (Figs 1 and 2). However, it could not survive the high temperature during summer months. All plants were dried and finally died during the first summer.

Conclusion

The Middle East is located within the arid region that has limited renewable freshwater supplies (WILHITE 2000). So, a large portion of the Middle East is desert, the majority of which is uninhabitable because of lacking the biological production (AL ALAWI and ABDULRAZZAK 1994). It is vital that the kind of agriculture practiced should use as little water as possible. In addition, agricultural activities should produce materials that can have economic potential. *Cereus* as a plant with numerous and innovative physical and behavioral adaptations for drought, may become the base for small scale industries. *Cereus* can give the inhabitants of the arid and marginal lands a way of making a living.

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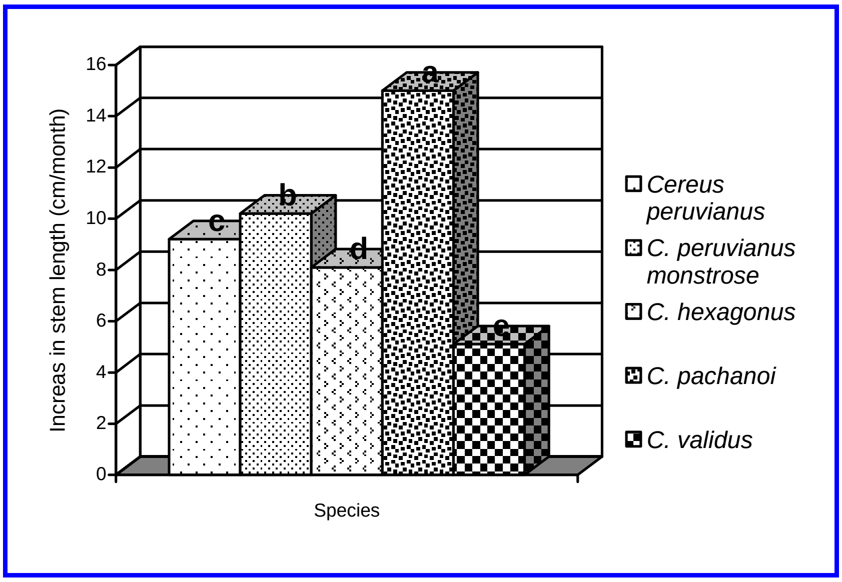

Fig 1. Rate of the increase in main stem length of the introduced *Cereus* species. Columns labeled with the same letter are not significantly different (P>0.05).

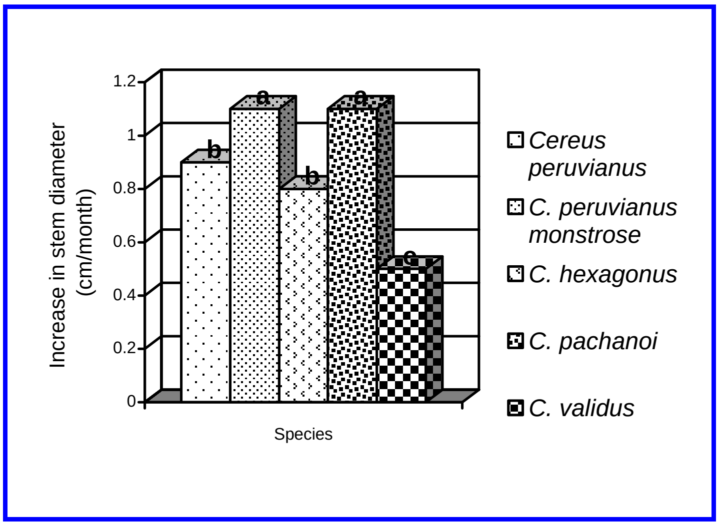

Fig 2. Rate of the increase in main stem diameter of the introduced *Cereus* species. Columns labeled with the same letter are not significantly different (P>0. 05).

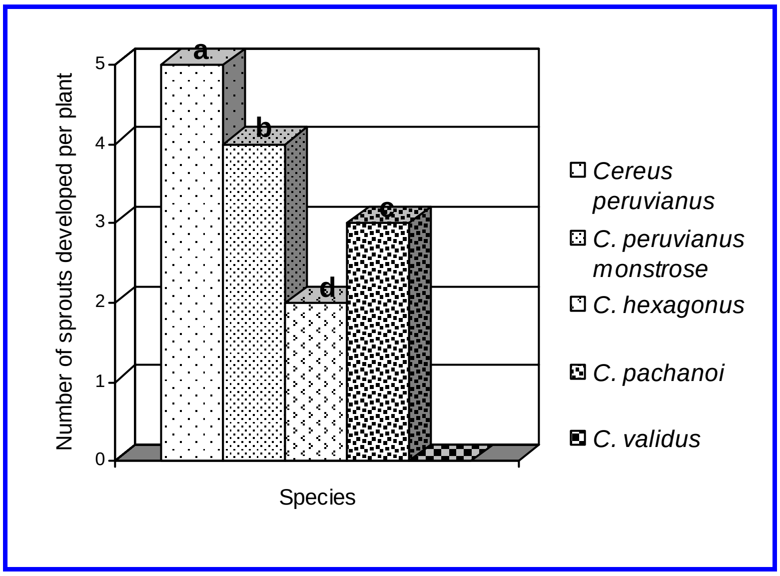

Fig 3. Average number of the developed sprouts per plant during the first two seasons. Columns labeled with the same letter are not significantly different (P>0.05).

Fig 4. Sprouts were ramified from the base of the main stem of *C. peruvianus*.

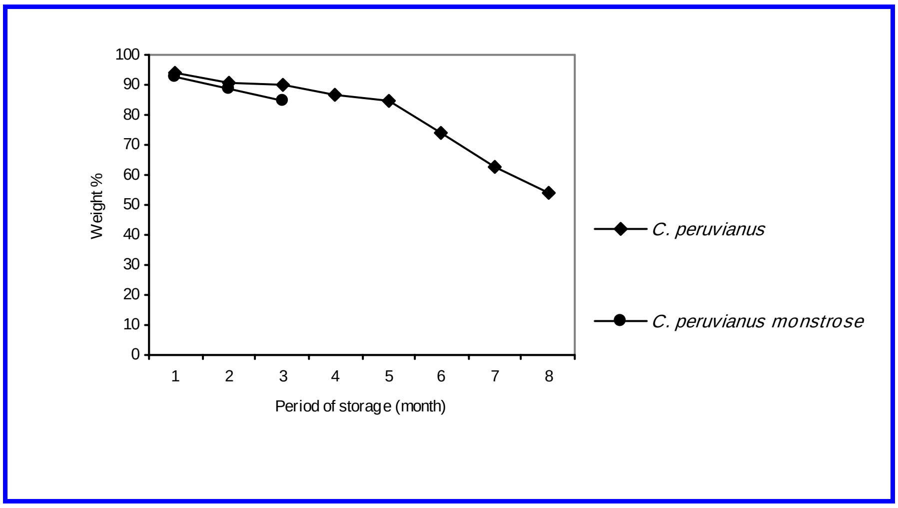

Fig 5. Effect of the storage period on weight of cuttings of *C. peruvianus* and *C. peruvianus monstrose*.

Fig 6. Horizontal position of *C. peruvianus* cuttings during storage encouraged the development of lateral branches**.**

A B

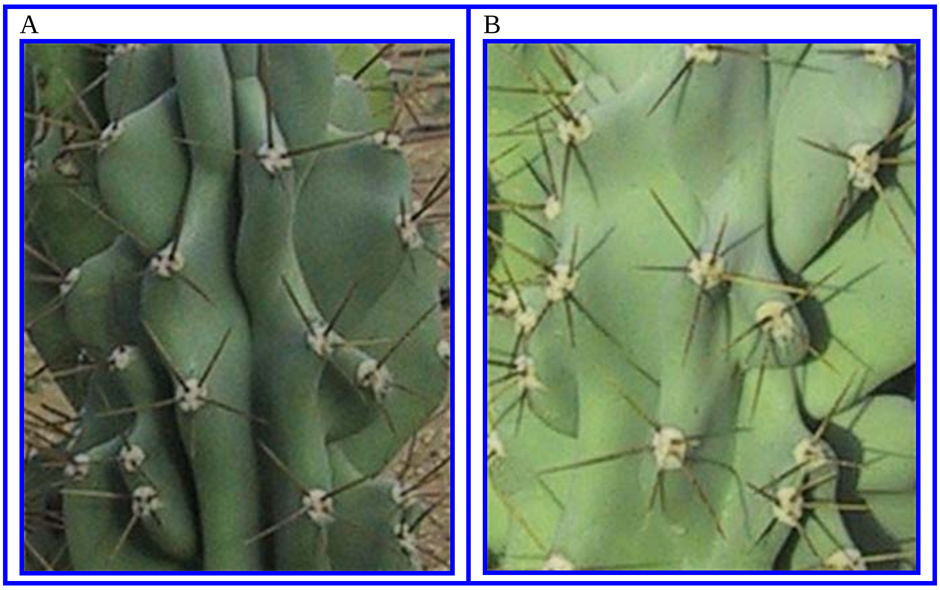

Fig 7. Dramatic contraction and expansion of *C. peruvianus monstrose* stem as water availability changes.