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Introduction of Ornamental *Asparagus* spp. to Semiarid Climates

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ABSTRACT

In recent years there has been a gradual increase in the importance given in ornamental floriculture to so-called cut foliage which is used to improve the appearance of cut flower arrangements. These complementary plants can have very different edaphoclimatic needs and consequently need different cultivation infrastructures. Many areas of the Mediterranean coast have a climatic profile particularly suitable for the production of some of these complementary flowers such as asparagus fern. Any deficiencies in the environment can be resolved by means of auxiliary systems using existing technology. This type of plant needs special thermal and luminous needs to achieve continual production throughout the year. The first need is satisfied by the environment of the cultivations themselves. The plants reduced need for light can be achieved using passive systems of shade. Sandy soils produce optimum growth but corrections can be made in areas where clay soils are a limiting factor. Experiments have been carried out on adapting different species with different morphology of plumes and with greater resistance to the shedding of leaves with the intention of providing a greater diversification of the plants on offer for the market. Other aims of this chapter are to examine technologies of cultivation to: shorten the period until beginning of production; to adapt to integrated production; and to prolong the useful life of the plants.

1. INTRODUCTION

Asparagus grows wild throughout the world. It can be grown for the production of turions (green and white) or for ornamental purposes such as plant pots or cut foliage.

The production of cut green foliage began at the end of the 19th Century with the introduction of ornamental asparagus (*Asparagus* spp.), which was the typical green accompaniment of a bouquet of carnations. Later on, in the mid 20th Century, this form of agriculture peaked with the introduction of leather leaf fern (*Rumorha adiantiformis*), and the application of new farming techniques. At present, asparagus occupies second place in demand for cut foliage in the American market, after leather leaf fern. In Europe it is still one of the must popular green accompaniments but its place is being overtaken by substitute crops, in particular genera such as *Ruscus* or *Euonimus* (López *et al.* 2007).

Commercially, cultivation can last for several years, depending on the types of soil, intensity of production, farming procedures, and principally, the characteristics of the species and the variety that is grown (López *et al.* 2007).

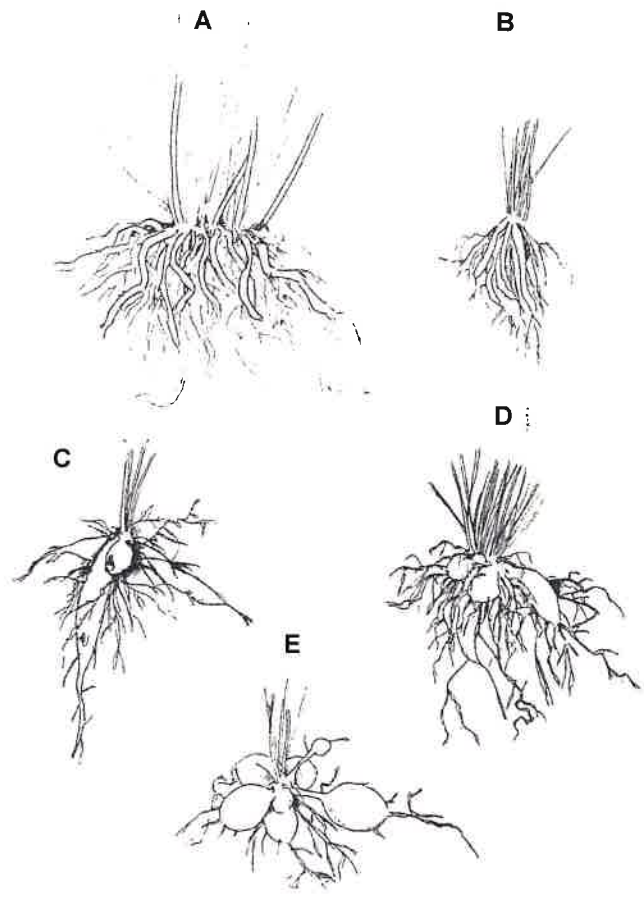

Fig. 1 (**A**) *A. setaceus* cv. 'Nanus'; (**B**) *A. setaceus* cv. 'Pyramidalis'; (**C**) *A. densiflorus* cv. 'Sprengeri'; (D) *A. falcatus*; (**E**) *A. densiflorus* cv. 'Meyeri'.

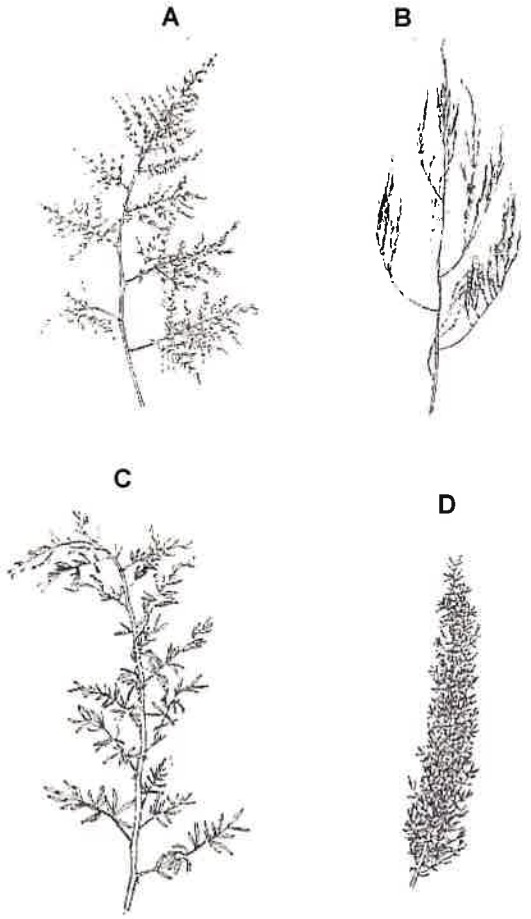

Fig. 2 (A) *A. setaceus* cv. 'Nanus'; (B) *A. setaceus* cv. 'Pyramidalis'; (C) *A. densiflorus* cv. 'Sprengeri'; (D) *A. densiflorus* cv. 'Meyeri'.

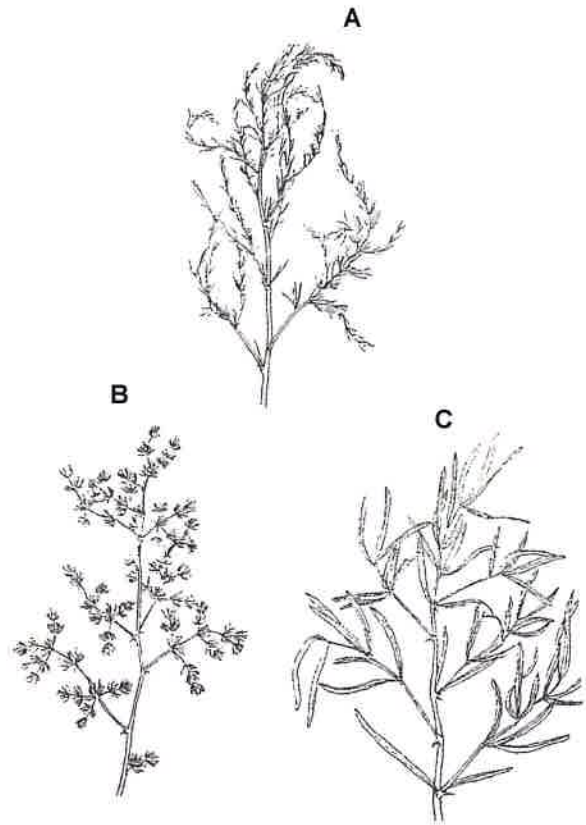

Fig. 3 (A) *A. verticillatus*; (B) *A. myriocladus*; (C) *A. falcatus*.

2. MORPHOLOGICAL ASPECTS

The hypogeal part of the asparagus has a subterranean organ which is used for storing reserves and for propagation (**Fig. 1**).

When the vegetative material has a rhizome, the principle roots grow from the base of the rhizome. From these roots grow secondary roots which are smaller but with a great capacity to absorb water and nutrients. The rhizome grows horizontally, forming a base or platform with great vegetative activity at the ends and little in the centre.

The upper part of the subterranean organ presents several buds from which sprout the annual shoots. The shoots are relatively short with a dense coverage of leaves. The leaves (cladodes) are generally filiform (needle shaped), although in certain species and cultivars they may be ribbon-like, as in the case of *Asparagus falcatus* and the Sprengeri cultivar, *Asparagus densiflorus*. The vegetative materials produced in this form of production are the ferns. These are formed by branching stems and leaves whose appearance varies according to the species and cultivar (**Figs. 2, 3**).

The fruit, which does not usually accompany the ornamental asparagus, is usually quite small. It is round and green at first but finally takes on a reddish colour or becomes dark when it ripens, although this varies with different cultivars. Its presence is undesirable in commercial ferns.

3. THE GROWTH CYCLE

The asparagus is a rustic, relatively herbaceous plant. It is long-lasting with a useful life of between 5 and 12 years. During this period the plant undergoes three phases of growth. The first phase, which lasts for two to three years, is when the plant is establishing itself. The ferns should not be picked during this period. The second phase is when the plant is in full production. In the last phase there is a decrease in yield and quality of the ferns. During this stage the plant is usually uprooted and the subterranean organs are extracted for replanting if this is considered convenient (López *et al.* 2007).

The growth cycle begins annually with the sprouting of the upper part of the repose organ. This is achieved at the expense of the reserves it has accumulated. The shoots initially form the turiones (the edible stalks in *Aparagus officinalis*) which, if they are not cut, grow into ferns (the ornamental part). This constitutes the leaf area in which sugar synthesis takes place and which supplies the different demands of the plant. The production of carbohydrates in the ferns enables fattening and renovation of the repose organ, which in the case of a rhizome grows outwards. That is to say, as the repose organ is a reserve for nutrients, it is very important for the production of the first shoots. The growth of the aerial part of the plant, the production of the ornamental ferns, depends on the control exerted by the plant of the same substances stored in the hypogeal part of the plant (González *et al.* 1998).

Finally, after a long or short interval the ferns bear flowers which mature, are fertilized and produce fruit.

Table 1 Ornamental *Asparagus*.

Scientific names (Bailey *et al.* 1976; Huxley 1992)		Common name(s)	
Name and authority	**Synonyms**	**Floral industry**	**Other**
A. africanus Lam.	*A. cooperi* Bak.		climbing asparagus
A. crispus Lam.		basket asparagus	thornless sprengeri
A. densiflorus (Kunth) Jessop. 'Myers'	*Asparagus meyerii* Hort.	foxtail, foxtail "fern"	meyeri
A. densiflorus 'Sprengeri'	*A. sprengeri* Reg.	sprengeri, sprengeri "fern"	emerald "fern", asparagus "fern"
A. falcatus L.		bamboo "fern"	Sickle thorn
A. officinalis L. subsp. *prostrata*			prostrate edible asparagus
A. pseudoscaber (Asch. & Gräbb.)	*A. officinalis* var. *pseudoscaber*	Lace Veil, Lace Veil asparagus	
A. retrofractus L.	*A. macowanii* Bak.	ming "fern"	
A. setaceus (Kunth) Jessop.	*A. plumosus* Bak.	plumosus, plumosa "fern", wedding "fern"	asparagus "fern", lace fern
A. virgatus Bak.		tree "fern"	broom "fern"

4. SPECIES AND CULTIVARS

The *Asparagus* genus belongs to the lily family (Liliaceae). Many of these species, which originate from the warm regions of Africa and Asia, are cultivated as ornamental plants for their ornamental foliage (**Table 1**). A large number of species and cultivars are used for the production of cut foliage, and in most cases they are often grown as pot plants as well. Of these the most prominent for their commercial value are:

4.1. *Asparagus setaceus* (*Asparagus plumosus*)

Cultivar 'Nanus' – Originating from South Africa, this variety has the longest tradition of cultivation. It is very prized for its delicate flat foliage which resembles fern fronds. For this reason it is sometimes called asparagus fern.

4.2. *Asparagus densiflorus*

Cultivar 'Sprengeri' – This asparagus originates from Africa. It has a bush-like appearance with thorny, much-branched stems which tend to hang slightly (**Fig. 2C**). The leaves are light green in colour, ribbon-shaped and small, approximately 3 cm long and 0.5 cm wide.

Cultivar 'Meyeri' – Originally from East Africa it is notable for its small fine cladodes which form stems resembling a cypress sapling (**Fig. 2D**). It has a slow rate of growth which delays onset of full production phase.

4.3. *Asparagus myriocladus* (*Asparagus umbellatus*)

This variety produces bright highly prized ferns (**Fig. 3B**), fetching the highest price on the market of all the ornamental asparagus species.

4.4. *Asparagus falcatus*

Originating in Sri Lanka and Africa, it is very resilient and can attain great dimensions. It sends forth straight woody stems with strong sharp-pointed thorns (**Fig. 3C**). The main morphological feature of this asparagus is its ribboned leaves.

5. PROPAGATION

5.1. Procedure

Growers of ornamental asparagus usually start their plantations with seedlings derived from seed. The growth habit of asparagus plants varies by the sex of the plant. Female plants produce larger spears than male plants, but the male plants produce larger total yields. In field plantings the ratio of female to male plants is about 50/50. It is not economical to select for gender, however, because it takes two years for sex expression to occur. The use of tissue culture to propagate plants from vigorous stock plants of the desired sex offers tremendous potential to the asparagus industry. Labor costs associated with both planting and harvesting nursery grown crowns has resulted in a shift to the use of hybrid seed and transplants (at the seedling stage) which allows mechanization of both planting and harvesting (González *et al.* 2001).

However, once the useful life of a plantation is over, the subterranean part of the plant (**Fig. 1**) is normally dug up. It is then cleaned and divided to obtain new 'rhizomes' for replanting. In addition to the low cost of acquisition of vegetative material which only involves extraction and preparation, the main advantage for this type of new plantation with 'rhizomes' is a reduction in the time period before the plant begins production. This is important in the majority of the species and particularly those that are slow in coming into production such as *Asparagus myriocladus*.

5.2. Production of seedlings

By means of the germination of seeds, seedlings are obtained which are finally transplanted to plots.

An example of the composition of suitable substrate can be: enriched commercial substrate (51%), black peat (31%), and vermiculite (16%). The vermiculite is usually spread onto the superficial part of the alveolus with the aim of stopping the formation of a crust and to maintain soil humidity (González *et al.* 2001).

Once sowing has taken place, the trays are placed in a climatic chamber in the dark where they remain under the appropriate ambient conditions until germination begins, marked by appearance of the plumule. Temperature has a great effect on the rate of germination, the most advisable being 20-25°C. With these temperatures and a relatively high humidity, the seeds start germinating in approximately a week.

Sowing is usually carried out at the end of winter and the beginning of spring, It takes between one month and one and a half months to form a seedling ready for transplanting, marked by the appearance of a small fern some 10 cm high and a second less developed fern at the base (González *et al.* 2001).

5.3. Other techniques

Asparagus fern seedlings can also be produced by *in vitro* cultivation. Ghosh and Sen (1994) proposed that the stable regeneration of *Asparagus setaceus* depended on the type of explants, level of illumination and vegetative hormones. Pindel and Pindel (1992) studying the micropropagation of *Aparagus densiflorus* cv. 'Sprengeri' found that indolacetic acid and benzyladenine (BA) promoted multiplication of shoots, although separate shoots did not develop roots until callus had been formed.

Alternatively, the first planting with the vegetative material can be undertaken using rhizomes. This, however, is not normal practice with ornamental asparagus, particularly at the beginning of planting.

Somatic embryogenesis (SE) in Asparagus has been reported previously (Wilma and Hellendoorn 1968; Reuther 1977; Levi and Sink 1991; Saito *et al.* 1991; Odake *et al.* 1993; Nakashima 1995; Roger and Sink 1995; Kunitake *et al.* 1997). However, SE has been induced via callus either originated from apical meristems, protoplasts or spear explants using 2,4-D as a trigger substance, and due to still unsolved problems (abnormal embryo formation and low frequency of germination), these efforts have not yet given a serious impact on the commercial propagation in *Asparagus*.

In contrast, Schröder and Eimert (2000) describe the development of a liquid culture system (temporary immersion) which produces SE from internodal explants without using 2,4-D and the results is no abnormal developments (except the formation of tetraploids which are caused by the polysomatic status of the internodal explants).

Bioreactors provide a rapid and efficient plant propagation system for asparagus utilizing liquid media to avoid intensive manual handling. Micropropagation in bioreactors for optimal plant production will depend on a better understanding of plant responses to signals from the microenvironment and on specific culture manipulation to control the morphogenesis of plants in liquid cultures (Ziv 2005).

6. ENVIRONMENTAL REQUIREMENTS

6.1. Soil

The asparagus prefers cool deep sandy soils rich in organic material, particularly those in which it can develop and an extensive root system. The pH should be neutral in heavier soils and slightly acid in sandy soils. The presence of large amounts of active limestone in the soil can provoke the typical chlorotic symptoms in the leaves, which are not excessively harmful to the production of turions but is detrimental to the marketability of the ferns (Romero and García 2003).

6.2. Light

When the asparagus fern is grown for the production of cut foliage particular attention must be paid to the level of illumination that the plantation receives. An excess can yellow the leaves, damaging one of the principle quality parameters of this plant. The literature advises that the plant receives no more than 70 $\mu mol \cdot mol^{-2} \cdot s^{-1}$ (González *et al.* 1998). This means that in regions with a Mediterranean climate greenhouses should be shaded from May to September.

However, in actual fact, shade net is permanent feature on the greenhouse all year round. It has been shown that a reduction of 65-70% is adequate for the climate of south-eastern Spain.

6.3. Temperature

The rustic quality of the ornamental asparagus means that they are quite resistant to low temperatures. Therefore, this species can be cultivated perfectly well in shade in warm regions such as the littoral of Murcia, Spain, without the need for plastic covering to obtain a good winter harvest. Nonetheless, thermal requirements vary from species to species; *Asparagus setaceus* cv. 'Nanus' and *Asparagus densiflorous* demand higher temperatures (Romero and García 2003).

Some researchers suggest ideal winter temperatures of 12-15°C (Hanselmann 1991).

These plants require a relatively high humidity of between 85 and 90% (Romero and García 2003).

6.4. Planting

Transplanting should be carried out from the end of spring to the beginning of autumn, as the seedlings need a high soil temperature to take good root. This is less important in the case of rhizomes which can be planted in spring (Fernandez-Rufete 1996).

The density of the plantation should be between 4 and 9 plants/m² of shade. Depending on the species to be cultivated the following densities are recommended (plants/m² of umbrage). Some researchers as Hanselmann (1991), recommend higher densities of plantation, proposing the following number of plants/m² of bed:

A. setaceus cv. 'Nanus' (20 plants/m²) (12-20 plants/m² recommend by Gonzalez *et al.* 1998).

A. densiflorus cv. 'Sprengeri' (20 plants/m²) (10-16 plants/m² recommend by Gonzalez *et al.* 1998).

A. densiflorus cv. 'Meyeri' (20 plants/m²) (10-16 plants/m² recommend by Gonzalez *et al.* 1998).

A. falcatus (16 plants/m²) (10-16 plants/m² recommend by Gonzalez *et al.* 1998).

Cut foliage harvested from asparagus plants grown at 12 plants per m² had higher chlorophyll content. During vase life, the chlorophyll degradation rate was not different in cut foliage harvested from either planting density (Marino *et al.* 2003).

6.5. Irrigation

In general the ornamental asparagus does not consume great quantities of water.

The monthly dosage of water is between 650 and 700 m³ in summer and 50-200 m³ in winter per hectare of plantation. If a summer rest period of two months is taken into account, annual water consumption amounts to between 3,500 and 4,000 m³/ha.

6.6. Fertilization

For a thorough application of mineral fertilizer, a suitable composition could be: 4g/m² of N (ammonium sulphate, 21%), 14 g/m² of P_2O_5 (superphosphate of lime, 18%), 27 g/m² of K_2O (potassium sulphate, 50%) and 2 g/m² of MgO (magnesium sulphate, 16%).

7. POSTHARVEST

7.1. Preservation

To obtain good preservation of cut ferns they should be kept in water at a temperature of 2-4°C. It is not advisable to add preserving agents, as they are ineffective and can even damage the leaves (Nowak and Rudnicki 1990).

A foliar application of 100 mg BA/L once-a-day for 3 days inhibited yellowing and abscission and maintained relatively high chlorophyll and protein content. The vase life of asparagus was extended twice longer than the control under 15-30°C, BA spray treatment. In addition, vase life was longest at 15°C and shortest at 30°C. *A. densiflorus* showed a longer vase life than *A. sprengeri* [~*A. densiflorus*] (Lee *et al.* 2003).

Stems are harvested by pulling by hand (*A. densiflorus* 'Myers' and 'Sprengeri', *A. officinalis* subsp. *prostrata*) or cutting using clippers and bunched into five or ten-stem groups. Stem lengths generally ranged from 60-76 cm (~24-30 inches) (Gonzalez *et al.* 1998).

Table 2 Vase life of *Asparagus* after storage for 2 weeks at 4°C. Data from Nowak and Rudniki 1990.

Species/Cv.	Vase life (days)
A. africanus	14.8
A. crispus	7.0
A. densiflorus 'Myers'	24.4
A. densiflorus 'Sprengeri'	7.6
A. falcatus	11.7
A. officinalis	7.2
A. pseudoscaber	6.2
A. retrofractus	8.4
A. setaceus	15.9
A. virgatus	10.2

In a study carried out by Stamps *et al.* (2005) bunches were submerged in deionized water for 3 min and immediately placed into 30 cm × 76 cm (12" × 30") plastic bags. Bags were sealed and placed in waxed fiberboard boxes and stored in a cooler at 4°C (40°F) (Nowak and Rudnicki 1990) for two weeks. After 14 d in storage, stem bases were re-cut using hand clippers to remove about 2.5 cm (1 inch). Cladophylls at base of the stems were stripped off by hand. Stems were then placed in 900-mL glass jars, filled with deionized water, located in an acclimatization room. Only the stems of one species or cultivar were placed in a jar. Conditions in the rooms simulated home/office conditions with light levels of 17 $\mu mol \cdot m^{-2} \cdot s^{-1}$ (107 ft-candles) provided for 12 h per day using cool white fluorescent lamps, temperatures of 23 ± 2°C (74 ± 4°F) and relative humidities of 45 ± 15%. Vase life of stems were terminated when they began to exhibit chlorosis (yellowing), necrosis (brown or black tissue), desiccation (graying, curling, wilting) or cladophyll drop (abscission) affecting about 5% or more of the cladophylls or cladophyll surface area. The remaining Asparagus, with average overall vase lives greater than one week but less than two, are intermediate between the better and worst performing plants (**Table 2**). Of these Asparagus, vase lives found are consistent with those reported earlier for *A. falcatus* (Dolci *et al.* 1989) and *A. virgatus* (Barendse 1979; Stamps and Rock 2000) but shorter than previously reported for *A. retrofractus* (Barendse 1979; Broschat and Donselman 1987).

Chlorosis was by far the most common reason vase lives were terminated. Depending on asparagus type, from 78% to 98% of stems exhibited this symptom (Stamp *et al.* 2005). The other significant characteristic ending vase lives was cladophyll drop. Both of these symptoms are typical for ornamental Asparagus (Barendse 1979; Dolci *et al.* 1989; Lee *et al.* 2003) and are likely related to the known ethylene sensitivity of these crops (Nowak 1985; Dolci *et al.* 1989; Lee *et al.* 2003).

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