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Production and postharvest evaluations of ornamental *Asparagus* spp.

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Abstract: The aim of this work was to investigate the yield and postharvest behaviour of *Asparagus plumosus* Baker and *Asparagus densiflorus* Jessop cv. Myriocladus grown in a soilless growing system. Both species were transplanted with two different planting densities, six and 12 plants per m^2. The results obtained showed that the higher planting density increases the number of stems and total fresh weight in both species. Postharvest behaviour was evaluated in a vase life room characterised by a temperature of 20°C ± 2, RH 60% ± 5, 12 hr of photoperiod and light intensity of 10 µmol m^{-2} s^{-1} PAR. Planting densities did not affect the longevity of cut foliage in either species. Water uptake and weight variations were higher in cut foliage harvested from cultivation with higher planting density. Cut foliage harvested from cv. Myriocladus plants grown at 12 plants per m^2 had higher chlorophyll content. During vase life, the chlorophyll degradation rate was not different in cut foliage harvested from either planting density. Ethylene production was similar in both species and increased at the end of their vase life.

1. Introduction

Asparagus is one of the most widely used cut foliages for enhancing the beauty of cut flower bouquets. *A. plumosus* Baker and *A. densiflorus* Jessop cv. Myriocladus are the two most important species grown for cut foliage production. Little information is available in scientific literature about cultivation systems (Eigemann, 1999) and postharvest behaviour of asparagus cut stems. In the past, preharvest research was focused on mineral nutrition and the effect of nutrient concentrations on the quality and yield of asparagus foliage grown in soil (Magnifico *et al.*, 1986). Postharvest research has concentrated on testing the effects of cold storage, biocides, ethylene inhibitors, sucrose and other compounds on the vase life of the cut foliage. The most recent study showed that a mixed solution of 8-hydroxyquinoline sulphate (8-HQS), aminooxyacetic acid hemihydrochloride (AOA) and 3,4,5-trichlorophenol was able to double the longevity of cut asparagus foliage (Dolci *et al.*, 1989). A positive effect was also found from treatments with 5 or 10 ppm BA which significantly extended the vase life of the cut foliage (Nowak, 1985). Recutting the stems under water was found to have a positive effect on the vase life of cut *Asparagus retro - fractus*, increasing their vase life from 10.3 to 25.5 days (Fujino *et al.*, 1981). Finally, wet cold storage was better than dry storage for maintaining quality and longevity of cut asparagus (Barendse, 1979).

The aim of the present work was to evaluate the effect of plant density on the productivity and postharvest performance of two asparagus species grown in a soilless system.

2. Materials and Methods

Plant material and growing system

Experiments were carried out on two species, *Asparagus plumosus* Baker and *A. densiflorus* Jessop cv. Myriocladus, at the Istituto Sperimentale per la

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Floricoltura section of Pescia (PT). Production and postharvest behaviour of both species were evaluated in a soilless growing system without recycling of the nutrient solution. Two planting densities, six and 12 plants per m^2 were compared for both species. Mineral nutrients were supplied daily with 300 ml of nutrient solution delivered by fertigation. The amount of nutrients supplied did not change during the cultivation period (Table 1). The substrate used comprised 80% pumice and 20% peat placed together in plastic boxes (40 x 60 x 20 cm). The greenhouse temperature was constantly controlled and kept above 4°C during winter time. Cut foliage was harvested twice, in December (winter) and in July (summer). The yield was assessed as the number of stems and total fresh weight of foliage harvested per plant and per m^2.

Table 1 - Nutrient solution and mineral concentrations delivered to plants during the cultivation period

Nutrients	Concentrations (mg l^{-1})	Nutrients delivered per plant	
		mg d^{-1} $plant^{-1}$	mg $year^{-1}$ $plant^{-1}$
$N\text{-}NO_3$	150	45	16425
$N\text{-}NO_4$	15	4.5	1642.5
P	40	12	4380
K	100	30	10950
Ca	100	30	10950
Mg	25	7.5	2737.5
Fe	4	1.2	438
S	25	7.5	2737.5
Mn	0.27	0.081	29.565
B	0.32	0.096	35.04
Cu	0.27	0.081	29.565
Zn	0.11	0.033	12.045
Mo	0.05	0.015	5.475

Postharvest evaluations

Postharvest studies were carried out on cut foliage harvested in the summer because they had shorter vase life than foliage harvested in winter. Foliage was harvested at the commercial stage. Immediately after harvest, cut foliage was transferred to the postharvest evaluation room with a temperature of 20°C ± 2, RH 60% ± 5, 12 hr photoperiod and light intensity of 10 µmol m^{-2} s^{-1} PAR. Shelf life, growth, water uptake, chlorophyll content and ethylene production were measured. Postharvest life was considered ended when cut foliage began to show the first signs of yellowing. The gravimetric method was used to determine daily weight variations and water uptake. Vase life was considered ended when cut foliage started to yellow and lose cladodes. Ethylene production was measured by gas chromatography (model HP5890; Hewlett-Packard) using a flame ionisation detector (FID) and metal column (150 x 0.4 cm, packed with Hysep T). Column and detector temperatures were 70° and 350°C, respectively. Nitrogen was the carrier gas (40 ml min^{-1}). Apical portions of about 10 cm in length from plants grown in higher planting densities were enclosed in airtight containers for measuring ethylene production. Gas samples (2 ml) were then taken from the headspace of the containers after 1 hr of incubation at room temperature (20°C ± 2) with a hypodermic syringe. Quantification was against an external standard and results were expressed in fresh weight (nl h^{-1} g^{-1} F.W.).

Total chlorophyll was extracted using methanol 99.9% as solvent. Samples were kept in dark cold room at 4°C for 24 hr. Quantitative chlorophyll determinations were carried out immediately after extraction by measuring absorbance with a spectrophotometer. Chlorophyll contents were calculated by Lichtenthaler's formula (1987) and are expressed as µg mg^{-1} of fresh weight.

Statistical analysis

Data analysed and shown are from a two-year trial. Production and vase life were analysed by ANOVA and differences among the means were calculated by the Student-Newman-Keuls test. Means and standard errors were calculated for chlorophyll content, weight variations, water uptake and ethylene production.

3. Results

Cut foliage yield

A. plumosus production was statistically different in the two different planting densities. In particular, the yield per plant was higher in the cultivation with lower planting density. In the soilless growing system the yield was 30.3 stems per plant with a thickness of

12 plants per m^2 and 43.5 stems per plant with six plants per m^2. Also the total production expressed as number of stems per m^2 was different between the two planting densities (Table 2).

In the 'Myriocladus' cultivation the yield per plant was not statistically different between the two planting densities. Consequently, the total production per m^2 was double at the higher planting density (Table 2).

cut *A. plumosus* foliage grown at the higher planting density (Fig. 4). After five days in the vase there was no further variation in weight until the very end of vase life (Figs. 4 and 5). When the cut foliage showed the first symptoms of senescence the weight decreased slightly.

Table 2 - Yield of *A. plumosus* and *A. densiflorus* Jessop cv. Myriocladus expressed as number of stems and fresh weight of cut foliage

	Planting density (plant per m^2)	Stems (no. per plant^{-1})	Fresh weight (g per plant^{-1})	Stems (no. per m^2)	Fresh weight (g per m^2)
A. plumosus	12	30.3 a	98.5 a	364.8 a	1187.9 a
	6	43.5 b	131.8 b	261.4 b	791.1 b
A. densiflorus 'Myriocladus'	12	9.9 a	67.3 a	119.2 a	798.7 a
	6	12.8 a	93.8 a	77.2 b	558.4 b

Values with the same letter within each species are not significantly different (P<0.05).

Postharvest life

Cut asparagus foliage did not show any significant difference in vase life regardless of species or plant density. Longevity ranged from 22 to 27 days (Fig. 1).

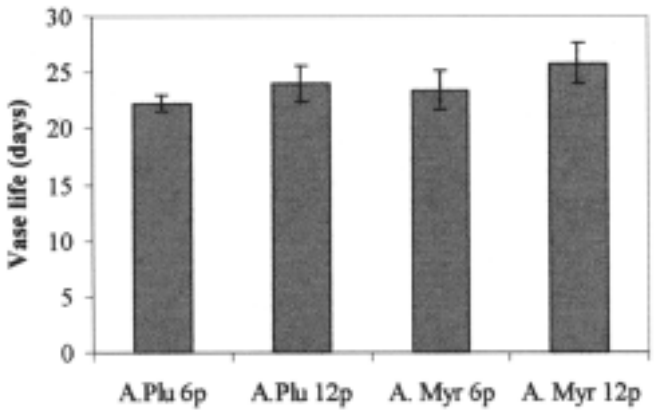

Fig. 1 - Vase life of cut *Asparagus plumosus* foliage grown at two planting densities, six plants per m^2 (A.Plu 6p) and 12 plants per m^2 (A.Plu 12p); and vase life of cut 'Myriocladus' foliage grown at 6 plants per m^2 (A.Myr 6p) and 12 plants per m^2 (A.Myr 12p). Values are means ± standard errors.

Water uptake and weight variations

The ability of cut *A. plumosus* foliage to uptake water declined during vase life; the branches harvested from plants grown at a density of six plants per m^2 showed a more rapid decrease (Fig. 2). However, at the end of the trial water uptake did not differ between cut foliage harvested from the two planting densities. Apart from the first two days, water uptake of cut 'Myriocladus' foliage grown at higher planting density was greater than that of cut foliage harvested from plants grown at lower planting density (Fig. 3).

Cut asparagus foliage showed an increase of fresh weight during the first two days of vase life, except for

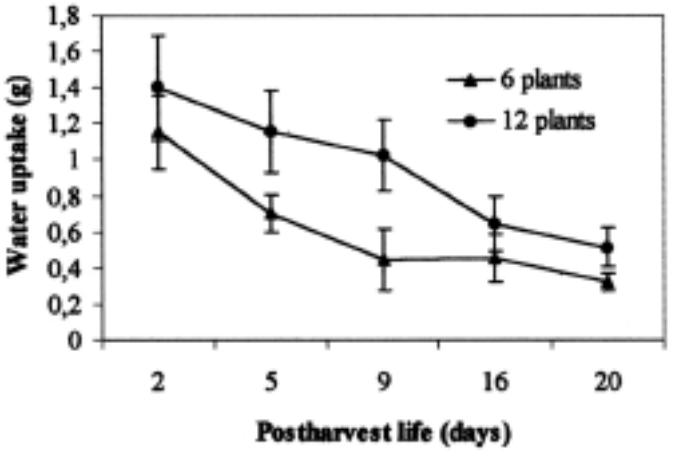

Fig. 2 - Water uptake during postharvest life in cut *Asparagus plumosus* Baker foliage grown at two planting densities, six plants per m^2 and 12 plants per m^2. Values are means ± standard errors.

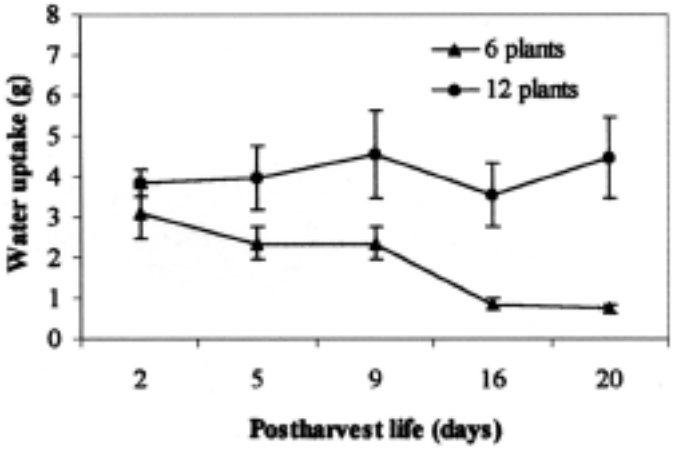

Fig. 3 - Water uptake during postharvest life in cut *A. densiflorus* Jessop cv. Myriocladus foliage grown at two planting densities: 6 plants per m^2 and 12 plants per m^2. Values are means ± standard errors.

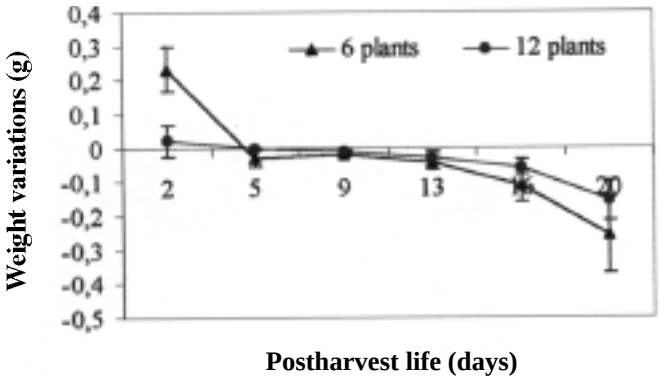

Fig. 4 - Weight variations during postharvest life in cut *Asparagus plumosus* Baker foliage grown at two planting densities: six plants per m^2 and 12 plants per m^2. Values are means ± standard errors.

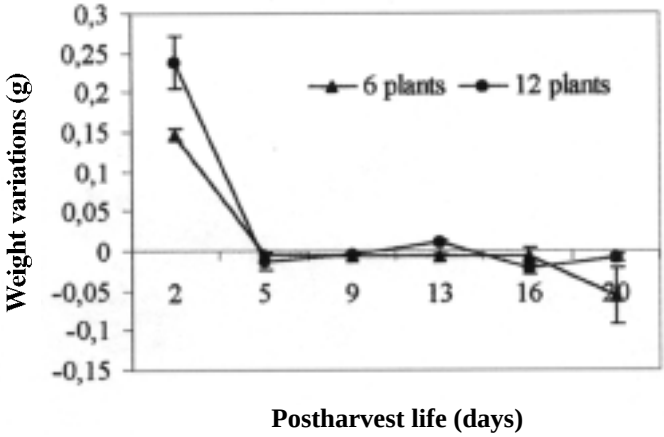

Fig. 5 - Weight variations during postharvest life in cut *A. densiflorus* Jessop cv. Myriocladus foliage grown at two planting densities: six plants per m^2 and 12 plants per m^2. Values are means ± standard errors.

Chlorophyll content and ethylene production

There was no effect from plant density on the chlorophyll content of cut *A. plumosus* foliage during postharvest life. Cut stems showed a declining trend in chlorophyll. At the beginning of the experiment cut foliage chlorophyll content was about 5-6 µg mg^{-1} of fresh weight. At the end of the experiment this value was reduced to 2-3 µg mg^{-1} (Fig. 6). Cut 'Myriocladus' foliage harvested from plants grown at a higher planting density had higher chlorophyll content at the beginning of the experiment. This difference did not persist during vase life both because cut foliage harvested from the lower planting density increased their chlorophyll content slightly and also because cut foliage harvested from higher planting density continuously and constantly lost chlorophyll (Fig. 7). Ethylene production was measured in both species harvested from the higher planting density. Cut *A. plumosus* foliage produced higher ethylene levels at the beginning of the experiment. Ethylene evolution decreased until 17 days of vase life, then increased again until the end of vase life (Fig. 8). Cut 'Myriocladus' foliage produced a lower amount of

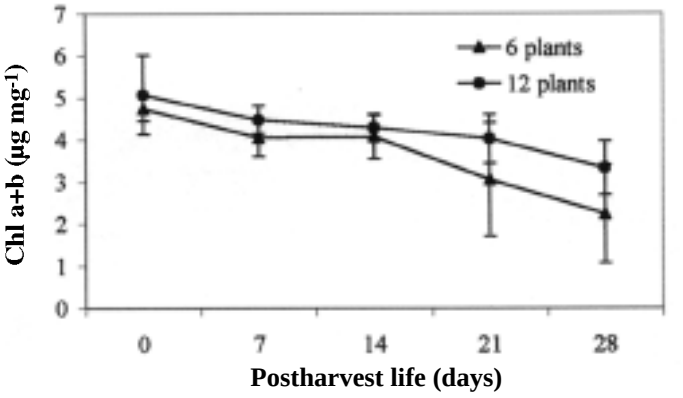

Fig. 6 - Total chlorophyll content during postharvest life in cut *Asparagus plumosus* Baker foliage grown at two planting densities: six plants per m^2 and 12 plants per m^2. Values are means ± standard errors.

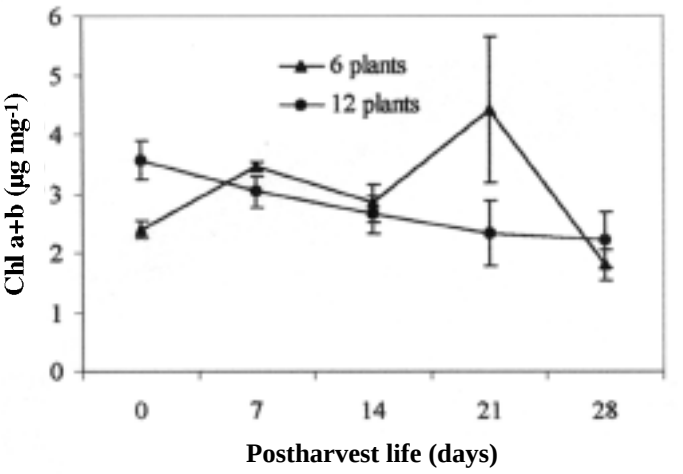

Fig. 7 - Total chlorophyll content during postharvest life in cut *A. densiflorus* Jessop cv. Myriocladus foliage grown at two planting densities: six plants per m^2 and 12 plants per m^2. Values are means ± standard errors.

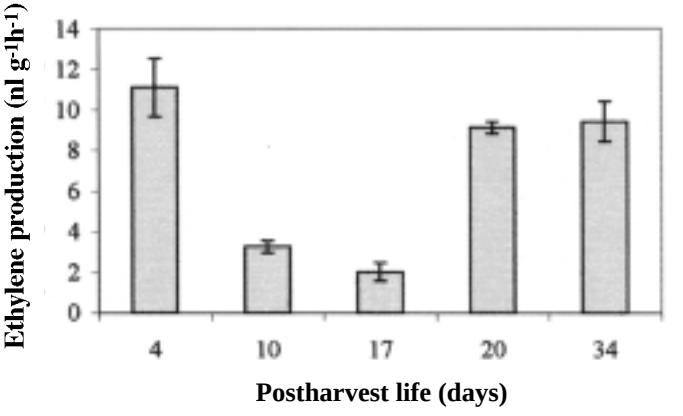

Fig. 8 - Ethylene production from cut *Asparagus plumosus* Baker foliage grown at 12 plants per m^2 planting density. Values are means ± standard errors.

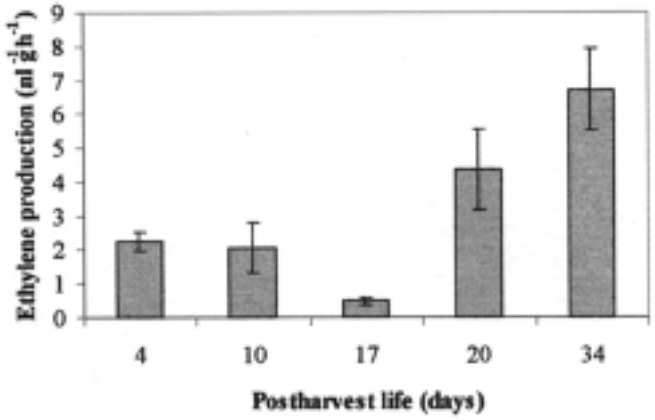

Fig. 9 - Ethylene production from cut *A. densiflorus* Jessop cv. Myriocladus foliage grown at 12 plants per m^2 planting density. Values are means ± standard errors.

ethylene than *A. plumosus*, especially at the beginning of the trial and increased at the end of vase life to reach about 7-8 nl h^{-1} g^{-1} of fresh weight (Fig. 9).

4. Discussion and Conclusions

Even though stem production per plant of *A. plumosus* was higher at the lower planting density, it did not increase the total production compared with higher density. As regards 'Myriocladus', no significant effect was observed between the stem production of each plant cultured at the two densities. The slight response of this species to plant density might be attributed to its slow growth rate and may be correlated with the lower chlorophyll content observed in the plants grown at lower plant density. The higher chlorophyll content found in cut foliage obtained from plants grown at 12 plants per m^2 could be caused by mutual shading. The effect of shading varies from species to species as observed in several woody cut foliage crops (Stamps, 1985).

During vase life both species showed progressive senescence characterised by yellowing and falling of cladodes. The vase life of cut *A. plumosus* ranged between 22 and 24 days and was longer than cut foliage obtained from soil cultivation (Dolci *et al.*, 1989). Also, the vase life of cut 'Myriocladus' was longer in cut foliage harvested from the soilless system than from soil (Borrelli, 2001).

Water uptake of cut 'Myriocladus' foliage was almost double that of cut *A. plumosus* foliage, perhaps due to different morphology of transpiration apparatus. However, these species are both known to be drought resistant with high water use efficiency (Eigenmann, 1999). During vase life chlorophyll content fell in both species, although cut 'Myriocladus' foliage showed an increase of chlorophyll content at the beginning of the postharvest evaluation. Chlorophyll loss may be regulated by ethylene as has been shown in many plant species (Ferrante *et al.*, 2002). Ethylene production progressively increases with senescence and this increase was clearly evident in 'Myriocladus'. Treatment with AOA, an inhibitor of ethylene biosynthesis, has been shown to extend the vase life of cut *A. plumosus* foliage (Dolci *et al.*, 1989). These results suggest that ethylene could be an important factor in the postharvest life of these species. Moreover, harvesting caused a higher ethylene evolution during the first days of vase life of *A. plumosus*.

Further investigations should be carried out using leaf yellowing and ethylene action inhibitors that might efficiently improve the vase life of such cut floral items.

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