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Fall Establishment of Asparagus Using Seedling Transplants

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Abstract. **After the first full growing season, 9- and 11-week-old asparagus (*Asparagus officinalis* L.) seedlings transplanted in fall exhibited superior crown and fern characteristics relative to seedlings of the same ages transplanted in spring. Seedlings overwintered in coldframes and planted in the spring matched or exceeded growth of those transplanted the previous fall. The hybrid 'Jersey Giant' was superior to an improved selection of 'Mary Washington' for all planting dates. Correlations between seedling size at transplanting and after one season's growth were significant for crown weight (r = 0.82), fern weight (r = 0.65), and fern number (r = 0.60). The importance of seedling size is further confirmed by the superior growth of 11-week-old over 9-week-old seedlings up to 18 months after planting.**

The use of asparagus transplants has become an accepted alternative to direct seeding or crown plantings. One obvious drawback to using greenhouse-grown transplants is the requirement for greenhouse space in the early spring, when space is at a premium. Fall transplanting avoids using limited greenhouse space and labor during spring and allows other crop management options for most of the growing season, i.e., early crops, continuous fallow to reduce weeds and pathogens, or other preparation of the planting site.

Previous comparisons of mid- to late-season transplanting in temperate climates are inconclusive. Liptay (1984) found late-August nursery transplant survival and yield equal to that of 1-year-old crowns planted the subsequent spring. Williams (1979) found late-September planting of 22-week-old crowns in England preferable to spring planting, since the plants produced ferns earlier the following spring than those transplanted in spring. He also found that spring plantings of 10-week-old transplants did as well as those twice that age. In New Zealand, 12-week-old summer and fall plantings survived the following winter, but had poor growth the following summer and fall compared with seedlings planted the previous spring and early summer (Bussel, 1983). Loughton and Baker (1984) found yield and survival of fall transplants in Ontario inferior to those transplanted the following spring. Eight-week-old greenhouse seedlings transplanted in mid-September had a very low (27%) survival rate. Nursery-grown 16- and 20-week-old seedlings transplanted in mid-September and mid-October, respectively, performed somewhat better (52% and 59% survival). Eight-week-old seedlings transplanted in June or August outyielded the spring-planted crowns on a per-plant basis. While the field-grown crowns had lower survival rates if transplanted in September or October rather than the following spring, the per-plant yield was greatest for the September planting. No statistical analysis was published with the data.

Our objectives were to shed light on contradictions in the literature, and to determine if fall transplanting is a viable alternative in areas with harsh winters. Cultivar and age of transplants were factors also included in the comparison of fall and spring transplanting dates. As an additional option, a third set of seedlings were overwintered in coldframes and transplanted the following spring. The use of overwintered seedlings in this experiment also allowed us to determine the amount of transplant shock (growth setback due to disturbance during transplanting) and the influence of seedling age by comparing overwintered and fall-planted seedlings.

Two cultivars of asparagus were tested: an improved selection of 'Mary Washington' (open-pollinated) and 'Jersey Giant' (all-male hybrid). The seeds were soaked in distilled water for 48 hr, then two seeds were placed into 0.18-liter round peat pots filled with a medium composed of 1 sand : 1 peat : 1 vermiculite (by volume). Seedlings were watered as needed and thinned to one plant

Table 1. Planting times for asparagus seedlings.

Transplanting regime	Age of seedlings (weeks)	1985 July	Aug.	Sept.	//	1986 Mar.	Apr.	May	June
Fall									
	11	S	C	T[z]					
	9	S	C	T					
Overwinter/coldframe									
	11	S	C		//			T	
	9	S	C		//			T	
Spring									
	11						S	C	T
	9						S	C	T

[z]S = seed sowing, C = coldframe, T = transplanting date.

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Table 2. Effect of transplanting regime on fern and crown characteristics.

Transplanting regime	Cultivar	Seedling age (weeks)	Fall 1986 Dry weight (g) Crown	Fern	Buds (no.)	June 1987 Stalk index[z]
Fall	MW[y]	9	16 de[x]	19 de	32.4 cde	699 e
		11	42 a	57 a	43.8 ab	1280 ab
	JG	9	40 a	48 a	48.7 a	1340 ab
		11	26 b	32 bc	48.5 a	1070 bcd
Overwinter/coldframe	MW	9	23 bcd	27 bcd	43.9 ab	928 cde
		11	17 cde	24 cde	33.8 cde	872 cde
	JG	9	27 b	35 b	36.0 cd	1090 bc
		11	42 a	52 a	49.9 a	1570 a
Spring	MW	9	14 e	17 e	27.5 e	780 cde
		11	22 bcd	28 bcd	37.9 bc	803 cde
	JG	9	25 bc	26 bcde	35.7 cd	912 cde
		11	18 cde	21 de	29.7 de	797 cde

[z]Stalk index = fern no. × fern diameter squared.
[y]MW = 'Mary Washington', JG = 'Jersey Giant'.
[x]Mean separation within columns by LSD test, $P = 0.05$.

Table 3. Effect of cultivar, planting date, and transplant age on crown and fern characteristics, table of significance, Fall 1986.

Treatment	Crown dry wt (g)	Number Bud	Fern	Fern Dry wt (g)	Height (cm)	Stalk index[z]
Main effects						
Cultivar (C)	*	*	**	**	NS	*
Transplanting regime (T)	***	***	***	***	***	***
Age (A)	*	*	**	***	*	NS
Interactions						
C × T	**	*	NS	***	*	NS
T × A	NS	NS	NS	NS	NS	NS
C × A	***	NS	NS	***	***	NS
C × T × A	***	***	***	***	***	***

[z]Fern number × fern diameter squared, June 1987.
NS,*,**,***Nonsignificant or significant at the 5%, 1%, or 0.1% levels, respectively.

per pot after emergence. Plants were fertilized weekly with 100 ppm 20N–10P–20K. After hardening in an open coldframe, the seedlings were transplanted into field plots at the Univ. of Minnesota, St. Paul.

Three planting regimes were tested: 1) fall planting of 9- and 11-week-old seedlings, transplanted mid-Sept. 1985; 2) spring planting of 9- and 11-week-old seedlings, transplanted early June 1986; and 3) overwintered seedlings, placed in coldframes in mid-September at 5 and 7 weeks of age, covered with 20 cm of straw after the first killing frost, and transplanted May 1986 (Table 1).

The experimental design was a split-plot, with cultivar as the main plot treatment. Transplant date and seedling age were the split-plot treatments, with four replications of 100 crowns each. Treatment subplots consisted of two 15-m rows, with 0.3-m in-row and 1.5-m between-row spacings. The peat pots were set into 20-cm-deep furrows and covered with 2 to 3 cm of soil. The furrows were filled in gradually over the following summer.

The plants were irrigated when necessary to supplement rainfall to provide ≈2.5 cm of water per week. Glyphosate (10%) was applied between rows, and linuron was applied mid-July 1986 at 2.24 $kg \cdot ha^{-1}$ to control weeds. Malathion (1%) was applied twice to control European asparagus aphid and spotted and common asparagus beetles.

Measurements taken at the time of transplanting included: shoot number, height, fresh and dry weight; bud number; and root dry weight. Ten samples were taken from each treatment. These measurements were repeated in Oct. 1986 on eight crowns selected randomly and dug from each field plot. Fern height and number and percent survival were assessed mid-Summer 1986. Fern number and the diameter of the largest stalk per plant were recorded June 1987, and a stalk index calculated (Scheer and Ellison, 1960) as a final vigor assessment.

Cultivar, planting date, and transplant age were all found to have significant influence on nearly every growth parameter investigated (Tables 2 and 3). Mean separation by least significant difference at $P = 0.05$, with age and cultivar averaged over planting date, showed that the fall (F) and overwintered (OW) plantings did not differ significantly from each other. These results are similar to the findings of Liptay (1984) with field seedlings dug and transplanted in August. Williams (1979), however, found transplanting in late September to be preferable to planting overwintered crowns the following spring, presumably because the transplant shock occurred at the end of the season rather than at the start. Our use of younger plants and of peat pots greatly reduced transplant shock, so there was little difference whether transplanting occurred in the fall or the following spring. Late-fall and early spring growth of the OW seedlings in the coldframes gave an average increase of 33% in crown dry weight and 75% in bud number from September to May. There were fewer but larger ferns in May, and fern weight was equal to or greater than in September. The increased OW fern size probably offset the effects of any transplant shock in the spring, as these ferns were more resistant to subsequent field stresses. Winter survival was greater in the field (96%) than in the coldframe (81%); however, we believe that coldframe losses were due to poor drainage and uneven insulation. The 1985–86 winter was typical for Minnesota, with very cold temperatures and generally good snow cover.

The 9- and 11-week-old spring (S) transplants were inferior to the F and OW treatments in all characteristics examined at the end of the first growing season—crown and fern dry weights, fern height, and fern and bud numbers. Spring transplants were significantly smaller than the F and OW seedlings at the time of transplanting (Table 4), probably due to more overcast skies in the spring as compared to late summer, resulting in cooler greenhouse temperatures, as well as lower light intensities. Average crown dry weight of S was 0.17 g, 0.28 g for OW, and 0.31 g for F seedlings. Similarly, fern dry weight of S was 0.08 g, 0.21 g for OW, and 0.23 g for F. Bud and fern numbers did not follow this trend. Significant correlations were found between initial (at time of transplanting) and Fall 1986 fern number ($r = 0.597^*$), fern weight ($r = 0.652^*$), and crown dry weight ($r = 0.818^{***}$), but not for fern height.

The effect of transplant size on field performance is further confirmed by the significant difference in plant growth resulting from just a 2-week difference in age at transplanting. These differences continued to exist, in many cases, 12 and 18 months after planting (Table 2). This finding contradicts previous research concluding that transplant age has no effect on field performance. Williams (1979) found that even a 10-week age difference did not lead to yield differences. Likewise, a 4-week spread (6- vs. 10-week-old transplants) showed a difference only in fern weight 3 months after transplanting (Dufault and Waters, 1984). Occasionally, greenhouse seedling size is the reverse of that expected, i.e., older plants are smaller than plants 2 to 3 weeks younger. This situation occurred with the fall-planted 'Jersey Giant' and was previously reported by Dufault and Waters (1984). The reasons for these anomalies are, as yet, unclear, but are probably due to environmental variations at some crucial point of growth, perhaps even before emergence. The relatively small differences in size at the time of transplanting between the various ages tested by Dufault and Waters (1984) probably explains their failure to find a transplant age effect in the field.

Ombrello and Garrison (1978) measured only fern number and height during the fall after transplanting. It is possible they would have seen differences in their 9- and 12-week

Table 4. Initial asparagus fern and crown dry weights and number of ferns and buds.

Transplanting regime	Cultivar[z]	Seedling age (weeks)	Dry weight (g)[y] Crown	Dry weight (g)[y] Fern	Number[y] Ferns	Number[y] Buds
Fall	MW	9	0.14 de	0.12 cd	2.0 efg	1.6 de
		11	0.31 c	0.10 cde	2.4 abc	1.8 cde
	JG	9	0.45 b	0.46 a	3.3 a	2.2 bcd
		11	0.35 bc	0.23 b	2.9 ab	2.4 bc
Overwinter/ coldframe	MW	9	0.16 de	0.10 cde	1.6 g	1.9 cde
		11	0.18 de	0.16 bc	1.6 g	2.7 b
	JG	9	0.18 de	0.14 cd	1.7 fg	1.8 cde
		11	0.60 a	0.43 a	2.1 def	4.0 a
Spring	MW	9	0.074 e	0.027 e	1.6 g	1.5 e
		11	0.23 cd	0.13 cd	2.7 bc	2.3 bc
	JG	9	0.13 de	0.060 de	2.0 efg	1.4 e
		11	0.24 cd	0.087 cde	2.5 bcd	1.9 cde

[z]MW = 'Mary Washington' selection, JG = 'Jersey Giant'.
[y]Mean separation within columns by LSD test, $P = 0.05$.

transplants had they measured other crown or fern characteristics. Also, their use of bare-root plants and small containers may have led to greater transplant shock than the seedlings in this study experienced, perhaps, to the extent of offsetting any effects of age difference. Williams (1979) found that a 10-week age difference did not affect yield, but he did not look at earlier growth characteristics. Our data show differences due to transplant age only during the first year; age did not affect plant vigor significantly (as measured by the stalk index) the second season after transplanting (Table 3). It is likely that yield is not affected by transplant age.

'Jersey Giant' was superior to the 'Mary Washington' selection in all factors investigated (Table 2), with the exception of July and fall fern heights. Since 'Jersey Giant' has outyielded most asparagus cultivars tested in many locations across the United States and Canada (Ellison and Kinelski, 1985), it was expected to perform well in this experiment. Much of the cultivar effect we observed was probably due to the larger crown weight of 'Jersey Giant' at the time of field planting. Seedling growth studies by Nichols and Woolley (1985) and Benson and Takatori (1980) suggest that differences in early seedling growth, especially in dry-matter distribution, may account for the greater vigor of hybrids over open-pollinated cultivars.

We found that fall transplanting or overwintering seedlings outdoors before spring transplanting can be as successful as transplanting young seedlings in the spring. We suggest that, in general, larger seedlings (whether older or of a more vigorous cultivar) perform best. Individual growers should consider fall planting as an option, basing their decision on economic, as well as biological, factors.

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Air and Substrate Temperatures For 'Atlas' and 'Monika' Alstroemeria

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Abstract. **'Atlas' and 'Monika' alstroemeria (*Alstroemeria hybrida* L.) were grown in cooled (12 to 16C) and noncooled (15 to 18C) gravel substrate in four temperature-controlled greenhouse compartments having mean day/night air temperatures of: 20/14, 20/13, 22/13, and 24/14C. Total flower production of 'Atlas' in all compartments was 1.6 times greater than for 'Monika'. The greatest production of 'Atlas' occurred with 20C average daytime air temperatures combined with root substrate temperatures 12C to 14C, which favored year-round production. Warmer day temperatures tended to improve flower grade and stem length of 'Monika'; however, the higher yield in cooler air temperatures outweighed the contributions of warmer air temperatures to quality. 'Atlas' stems were significantly longer and of better quality than 'Monika' in all temperature regimes.**

Alstroemeria flowering is influenced by two primary factors: rhizome temperature and photoperiod (Healy and Wilkins, 1982; Healy et al., 1982; Healy and Wilkins, 1986; Heins and Wilkins, 1977; Heins and Wilkins, 1979; Lin, 1984; Lin and Molnar, 1983; Noordegraf, 1975; Robinson and Kanterovitz, 1973; Verboom, 1979–80). Noordegraf (1975) suggested that vegetative shoots are produced at relatively high air temperatures, but a greater percentage of reproductive shoots form under cooler conditions. Constant 15C soil and night-interruption lighting produced a greater percentage of flowering shoots than a 15 and 21C alternating treatment (Heins and Wilkins, 1979). Twelve weeks of soil at 13C caused alstroemeria to bloom continu-

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Table 1. Actual mean air temperatures created to identify temperature treatments.

Compartment	Day heat to/ cool at set points (°C)	Mean day/night air temp (°C)
A	14/20	20/14
B	20/26	22/13
C	23/29	24/14
D	17/23	20/13