Post-Transplant Root System Expansion in *Juniperus chinensis* L. as Influenced by Production System, Mechanical Root Disruption and Soil Type[1]

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Abstract

Juniperus chinensis (L.) 'Sea Green' from 3.8 l (#1) containers (CG) and comparably sized field grown plants balled and burlapped (B&B) were planted in clay and loam soil in mid-June. Prior to transplanting, root balls of the CG plants were either mechanically disrupted by vertical cuts (D/CG) or left undisturbed (CG). Root growth beyond the original root ball and shoot extension growth in loam soil were determined at 8 and 12 weeks, while similar data were collected from loam and clay soils at 16 wks. B&B plants and D/CG plants produced greater dry weight of new roots, but less shoot growth at 8 wks than CG plants with an undisturbed root ball. By 16 wks, B&B plants had produced greater new root dry weight than either CG treatment and shoot growth was not different among treatments. In clay soil B&B plants produced greater dry weight of new roots than CG plants. Root ball disruption reduced new root growth in the heavy soil compared to CG plants. Shoot growth was not different among treatments in the heavy soil, but was significantly diminished compared to shoot growth on the lighter, loam soil.

Index words: transplanting, root regeneration, container plants, balled and burlapped

Introduction

The survival of transplanted woody plants is dependent upon rapid root system expansion. This is especially true for nursery stock placed into an urban landscape. In the urban setting, environmental stress often reaches severe proportions and maintenance, especially irrigation, may be infrequent or lacking. Under such conditions, adequate root system size may be critical to plant survival.

Woody nursery stock has historically been handled as balled and burlapped (B&B), but container grown (CG) plants are a significant part of the current nursery industry (4). When a tree is moved B&B less than 5% of its root system may be retained (11) while the entire root system of a transplanted CG plant remains intact and undisturbed. Logic suggests that CG plants should transplant more successfully. However, CG plants often establish poorly when moved to the landscape (3, 4, 7). This has been partly attributed to the tendency for roots of CG plants to continue to grow in a circular fashion after transplanting, while only slowly expanding radially into the soil (6, 9). The longer a plant is held in a container, the more pronounced encircling roots become. Container grown plants are also produced in a minimal stress controlled environment including frequent irrigation and fertilization which results in a finely fibrous root system. The use of light, soilless mixes in containers may also create a media interface problem when a plant is transplanted into heavier soil (4, 10).

Several cultural practices have evolved to help alleviate some of the problems associated with CG plants. Use of amended backfill for transplants is common although several studies have shown no consistent improvement in plant re-establishment and growth from the use of soil amendments (2, 8, 9). Mechanical disruption of the root ball before planting is recommended to encourage rapid root development in a radial configuration and to help prevent girdling roots. Mechanical disruption is usually advocated as a standard practice for all CG plants, whether they are pot-bound or not (5, 6, 7). Data are scarce and inconclusive to either support or oppose this practice (2). The objectives of this research were: 1) to characterize and evaluate post-transplant root system expansion of B&B and CG plants in different soil types; and, 2) to evaluate the effect of mechanical root ball disruption of CG plants (D/CG) on root and shoot growth.

Materials and Methods

Plants of *Juniperus chinensis* 'Sea Green' produced in 3.8 l (#1) containers and similarly sized B&B plants were obtained in June, 1985 from two nurseries in Indianapolis, Indiana. The CG plants were growing in a soilless medium consisting of pine bark, hardwood bark and sand (5:2:1 by vol). The B&B plants were grown in a Brookston silty loam field soil. Spread of both CG and B&B plants was classified by their suppliers as 30-38 cm (12-15 in) at the time of planting. The B&B plants tended toward the upper end of the range while the CG plants tended toward the lower end. The root balls of the CG plants averaged 15 cm (5.9 in) in diameter and 18 cm (7.1 in) in depth. The B&B root balls were within industry (AAN) standards (1) and averaged 26 cm (10.2 in) in diameter and depth.

Treatments for both experiments were B&B, CG with an undisturbed root ball, and CG with a mechanically disrupted root ball (D/CG). Mechanical disruption consisted of five vertical slashes to a depth of 2.5 cm (1 in) evenly spaced around the root ball.

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Experiment 1 involved two sets of 30 plants each, with each set consisting of 10 replicates of the three treatments planted in a well-drained Fox loam soil at West Lafayette, Indiana. Treatments were grouped into sets by harvest date for ease of harvest and randomized within each harvest date. Both sets were planted in mid-June, and harvested after 8 or 12 wks.

Experiment 2 consisted of two similar sets of plants as Experiment 1, in a split plot design. Main plots were soil type with root conditions as subplots. One set of 30 plants was planted in the same Fox loam soil and another set in a Brookston silty clay soil also at West Lafayette, Indiana. Both sets were hand planted in mid-June, but not harvested until after 16 wks. Subplot treatments were randomized within each main plot.

Planting sites were prepared by incorporating 25 kg/100 M^2 (50 lbs/1000 ft^2) of 8.0N-10.3P-19.9K (8-24-24) using a Howard rotovator. Plants were spaced in rows 3.5 m (10 ft) apart with 1.5 m (5 ft) between plants. Before planting the diameter and depth of the B&B root balls were measured. Three shoots were chosen at random on each B&B and CG plant, measured in length (cm) and marked so that the same shoot could be measured later. Weeds were controlled by hand. Plants were watered at planting time and natural rainfall was supplemented by overhead irrigation to a level of 2.5 cm (1 in) water/per week throughout the summer.

To maintain an essentially intact root system, plants were harvested using a backhoe with a 90 cm (36 in) bucket. New shoot extension growth of the three previously identified branches was measured. Average root spread was measured as the mean of the longest root spread dimension (tip to tip) and the root spread dimension measured perpendicular to the longest. This mean value was then used as the diameter of a circle approximating the horizontal root expansion of the plant. The net area of new root spread was calculated by subtracting the area occupied by the root ball from the total area. New root extension growth outside the original root ball is the difference between the mean diameter of root spread and the diameter of the root ball. Roots were shaved at the original root ball surface, washed and dried at 70°C (158°F) to obtain new root dry weight.

Data from each set of 30 plants, in Experiment 1 were analyzed separately as a completely random design. Mean separation was done by Duncan's multiple range test for treatments within harvest date. Experiment 2 was analyzed as a split plot design.

Results and Discussion

Experiment 1. After 8 wks of growth both B&B and D/CG plants had more root dry weight than did CG plants, but after 12 wks there was no difference in root dry weight accumulation between CG and D/CG treatments (Table 1). B&B plants had significantly more root dry weight ($P < .01$) after 12 wks than did either CG or D/CG treatments.

New root extension growth was not significantly different among treatments for either harvest date. The root extension growth data showed excessive variability, particularly for CG and D/CG treatments, perhaps preventing resolution of small differences between treatments.

At 8 wks new shoot extension growth was greatest for CG plants, suggesting that shoot growth in the first several weeks is inversely related to root growth. The differences in shoot growth diminished through the season and, as seen in Experiment 2, after 16 wks there were no significant differences among treatments (Table 2). Root ball disruption apparently caused a greater proportion of photosynthate to be directed to root system expansion rather than shoot growth immediately post-disruption, but did not result in greater root dry weight by season's end.

Net area of root spread as calculated here results from root extension growth minus the original root ball size. If the original root balls of all treatments were the same diameter then net root spread would be directly correlated to root extension growth. This is the case between the two CG treatments. However, the B&B treatment did show significantly greater new root spread after 8 and 12 wks due in part to the larger root ball provided by AAN standards. A B&B plant with a 25 cm (9.8 in) diameter explores 58% more soil area than a #1 CG plant (15 cm (5.9 in) diameter) does when both produce 5 cm of root extension growth. The inherent advantage to the B&B plants with respect to net root spread decreases with additional root growth. This is reflected by the lack of significant differences in net root spread between CG and B&B treatments after 16 wks in Experiment 2.

Table 1. Eight and twelve week new root and shoot growth of *Juniperus chinensis* 'Sea Green' following transplanting into loam soil from field or containers.

	8 Weeks				12 Weeks			
Treatment[y]	Root dry wt. (gms)	Root ext. growth (cm)	Net root spread (cm^2)	Shoot growth (cm)	Root dry wt. (gms)	Root ext. growth (cm)	Net root spread (cm^2)	Shoot growth (cm)
B&B	1.35 a[z]	8.1 a	1007 a	1.3 a	4.32 a	15.5 a	2164 a	4.3 a
CG	.58 b	5.3 a	359 b	3.8 b	2.30 b	12.4 a	1188 b	3.6 a
D/CG	1.32 a	7.4 a	580 b	1.2 a	2.38 b	10.8 a	1114 b	2.3 b

[z]Means within a column followed by the same letter are not significantly different at the 1% level as measured by Duncan's multiple range test.

[y]Root condition treatments were: B&B, field grown balled and burlapped; CG, container grown; D/CG, container grown with root system disruption by five vertical slashes.

Table 2. Sixteen week new root and shoot growth of *Juniperus chinensis* 'Sea Green' following transplanting into loam or silty clay soil from field or containers

	Loam soil				Silty clay soil			
Treatment[y]	Root dry wt. (gms)	Root ext. growth (cm)	Net root spread (cm²)	Shoot growth (cm)	Root dry wt. (gms)	Root ext. growth (cm)	Net root spread (cm²)	Shoot growth (cm)
B&B	6.00 a[z]	23.0 a	3691 a	3.7 a	8.00 a	24.4 a	4414 a	1.1 a
CG	3.92 b	20.5 b	2734 b	2.9 b	3.13 b	14.9 b	1686 b	1.0 a
D/CG	4.64 c	24.0 b	3061 b	3.1 a	1.85 c	13.5 b	1306 b	1.3 a

[z]Means within a column followed by the same letter are not significantly different at the 1% level as measured by Duncan's multiple range test.

[y]Root condition treatments were: B&B, field grown balled and burlapped; CG, container grown; D/CG, container grown with root system disruption by five vertical slashes.

Experiment 2. Data for shoot and root growth in loam or silty clay soil after 16 wks (Table 2) indicate that, in the clay, B&B plant values were significantly higher ($P < .05$) for all root growth parameters compared to either CG or D/CG treatments. Shoot growth was uniform in all three treatments. CG plants had significantly greater root dry weight than D/CG plants (P v .05). Even though there were large differences in root dry weight between CG and D/CG plants, there were no differences between these treatments in root extension growth suggesting the difference in dry weight was due to an increased density of roots in the soil area immediately surrounding the root ball, rather than longer roots.

The apparent adverse effect of mechanical root ball disruption when plants are placed in a heavy soil is of special note. Root ball disruption appeared to be detrimental in this study. B&B plants produced the greater root growth in all parameters measured.

Treatment differences are more pronounced when data between the two soil types are compared. D/CG plants produced less root and shoot growth ($P < .01$) when planted in a clay soil. The data for root dry weight are illustrated in Fig. 1. Undisturbed CG plants in clay soil produced similar root dry weight to those grown in loam soil, but showed lower shoot and root extension growth and net root spread in the clay. While these results are consistent with known problems in plant growth associated with heavy soil, the increase in root dry weight of B&B plants in heavy soil was not expected. Shoot growth was significantly greater in the loam soil for all treatments. The overall effect of the heavier soil was to decrease shoot and root growth of CG and D/CG treatments, while B&B plants had less shoot growth, but produced larger root systems.

Significance to the Nursery Industry

The choice of balled and burlapped versus container grown nursery stock is not a simple one. Even though CG plants are less expensive to produce and handle than B&B plants, their use is generally restricted to smaller sized plants that cannot be economically dug B&B. Furthermore, CG plants have often been associated with poor post-transplant growth and survival.

The present study indicates that the recommended practice of mechanically disrupting the root ball of CG plants before planting provides no consistent increase in new root dry weight by the end of the first season and actually decreased root system growth in clay soil. B&B plants, on the other hand, are naturally pre-disposed to wider root system expansion due to industry standards regarding top/ball size. Furthermore, when B&B production fields are in heavy soil, the plants are more likely to be well adapted to heavy soils. Our results suggest that the practice of mechanical disruption of CG root balls before transplanting should not be indiscriminately applied. In heavier soils the extra cost of B&B stock may be warranted.

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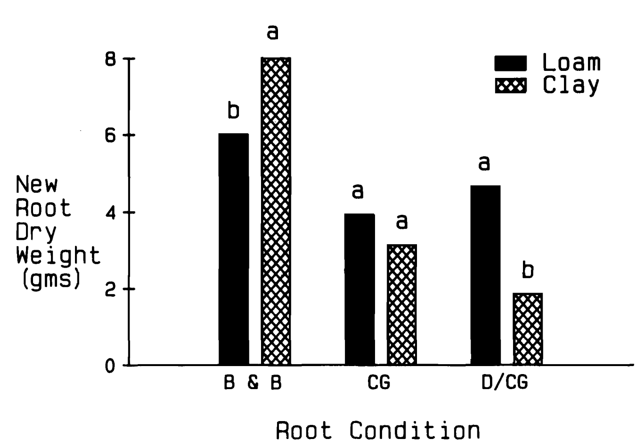

Fig. 1. Dry weight of new root growth of *Juniperus chinensis* 'Sea Green' in silty clay or loam soil after 16 wks. Root condition treatments included field grown balled and burlapped (B&B), container grown (CG) and container grown with root system disruption by five vertical slashes (D/CG). Mean separations within root condition at $P < .01$.

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Response of Bedding Plants and Weeds to Herbicides[1]

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Abstract

Preemergence and postemergence herbicides were evaluated for summer weed control and for phytotoxicity of 6 commonly used annual bedding plant species. Dacthal (dimethyl 2,3,5,6-tetrachloro-1,4-benzenedicarboxylate), Enide (*N,N*-dimethyl-*a*-phenyl benzene acetamide), Devrinol (*N,N*-diethyl-2-(1-naphthalenyloxy) propanamide), Surflan (4-(dipropylamino)-3,5-dinitro-benzenesulfonamide), Ronstar (3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-1(1,1-dimethylethyl)-1,3,4-oxadiazol-2-(3*H*)-one), Kerb (3,5-dichloro(*N*-1,1-dimethyl-2-propynyl)benzamide), and Treflan (2,6-dinitro-*N,N*-dipropyl-4-(trifluoromethyl)benzenamine) at 3.3 kg/ha (3.0 lb/A) applied as preemergence treatments and Poast (2-[1-(ethoxyimino)-butyl]-5-[2-ethylthio)propyl]-3-hydroxy-2-cyclohexen-1-one) and Fusilade (+)-2-[4-[[5-(trifluoromethyl)-2-pyridinyl]oxy]phenoxy] propanoic acid) applied as postemergence treatments effectively controlled large crabgrass [*Digitaria sanguinalis* (L.) Scop.] throughout a two-month period. Effective prostrate pigweed (*Amaranthus blitoides* S. Wats.) control was achieved by use of Dacthal at 14.0 kg/ha (12.5 lb/A), Surflan at 1.1 kg/ha (1.0 lb/A) and Ronstar at 3.3 kg/ha (3.0 lb/A) and postemergence application of Escort (2-[[[[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)amino]carbonyl]-amino]sulfonyl]benzoic acid) at 0.07 kg/ha (0.06 lb/A). SC 1084 (methyl 3-hydroxy-4-[4-[[5-(trifluoromethyl)-2-pyridinyl]-oxy]-phenoxy]-pentanoate at 0.13 kg/ha (0.12 lb/A) was ineffective in controlling either weed. Plant vigor of salvia was reduced by Dacthal at 11.2 kg/ha (12.5 lb/A), while vigor of ageratum and geranium was reduced by Enide at 4.4 kg/ha (4.0 lb/A). The vigor of geranium and salvia was lower than untreated plants when treated with Devrinol at 3.3 kg/ha (3.0 lb/A). The vigor of petunia, marigold, and salvia was also lower than untreated plants when treated with Ronstar at 3.3 kg/ha (3.0 lb/A) while vigor of geranium, salvia, marigold, and zinnia was lower when treated with Surflan at 2.2 kg/ha (2.0 lb/A). Kerb at 1.6 kg/ha (1.5 lb/A) reduced the vigor of geranium, petunia, and salvia when compared with untreated plants. Poast at 0.28 kg/ha (0.25 lb/A) did not injure any of the annuals while marigold and zinnia were injured with Fusilade at 0.2 kg/ha (0.18 lb/A). Escort at 0.07 kg/ha (0.06 lb/A) and Oust (2-[[[[(4,6-dimethyl-2-pyrimidinyl)amino]-carbonyl]amino]sulfonyl]benzoic acid) at 0.07 kg/ha (0.06 lb/A) applied as postemergence applications severely injured all annuals.

Index words: large crabgrass, preemergence, postemergence, prostrate pigweed, weed control, bedding plants, herbicides, annuals

Introduction

Weeds can be a severe problem in newly transplanted flowering annual beds. Freshly tilled soil, high moisture and nutrient levels for growth of the transplants create an ideal environment for invading weed seeds. Herbicides can be effectively used for weed control (3, 4, 5, 7, 8) in such instances, although injury to the transplanted annuals often occurs.

Researchers have reported effective preemergence crabgrass control in summer annuals with Treflan, Dacthal, Enide, Surflan, Ronstar and Devrinol (2, 3, 4, 5, 6, 7) while effective postemergence control was obtained with either Fusilade or Poast (9). In past studies, herbicides generally did not injure petunia, ageratum, marigold, or zinnia, but injury to salvia varied with herbicide application. Salvia was severely injured when treated with Surflan and Ronstar (4), while the injury varied with Treflan from slight (7) to moderate and severe (3, 5). The injury of salvia treated with Dacthal varied from none (4) to moderate and severe (2, 7). Devrinol did not injure salvia in New York (3) but slight injury occurred in an Ohio test (7). Tolerance of geranium from Devrinol in New York varied from none (6) to moderate injury (3). These results indicate that herbicides were effective in controlling crabgrass, but tolerance of selected plant species varied with herbicide rates and locations.

Because additional information on weed control in summer flowering annuals is needed in Georgia and the Southeast, an experiment was initiated to determine the effects of preemergence and postemergence herbicides

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