# Plant Form In Relation To Root Spread[1]

**Edward F. Gilman**[2]
*Ornamental Horticulture Department*
*University of Florida, Gainesville, FL 32611*

## Abstract

Four *Juniperus chinensis* cultivars, 'Torulosa', 'Sylvestris', 'Pfitzeriana' and 'Hetzii' had mean and maximum root spreads of 1.6m (4.8 ft) and 2.2 m (6.6 ft) resp, 12 months after planting. Despite large differences in plant form, root spread on all four cultivars was equal. The columnar cultivar 'Torulosa' had significantly less root length within the drip-line than the more spreading cultivars 'Pfitzeriana' and 'Hetzii'. Percentage of total root length within the dripline was correlated (r = −.72) with the ratio of plant height to spread.

**Index words:** landscape planting, transplanting
**Species used in this test:** Torulosa juniper, Sylvestris juniper, Pfitzeriana juniper, Hetzii juniper, *Juniperus chinensis L.*

## Introduction

Root development following transplanting varies with species, environmental conditions, physiological status, time of year, cultural practices and type of root system (2, 6, 11, 16). Soil amendments in the backfill were ineffective for enhancing root weight, plant survival or shoot growth in soils ranging from silt loam (14) to fine sand (10, 19). Root number, trunk caliper and top weight of container-grown and field-grown transplanted pecan trees were similar after five years (12). Other establishment techniques tested have included variations of root ball slicing, teasing roots away from the periphery of the root ball and striking the root ball a number of times against a concrete structure to loosen the roots from the medium (3, 17). None of these techniques have improved woody plants long-term root growth after transplanting in the landscape.

Stout (15) found hardwood species in a forest had roots well beyond the drip-line with root spread of established trees linearly correlated with trunk diameter and branch crown spread. Longleaf pine roots extended at least 2 times the branch spread for a variety of tree ages (9). A number of tree species planted as windbreaks in Oklahoma had root systems which were related to the size of the crown (4). Many roots were found beyond the dripline. The literature contains citations expressing root spread with respect to tree height. American elm (*Ulmus americana*) growing from seed at the edge of a woodlot had a shallow root system extending over a radius greater than the height of the tree (5).

Gilman (7) found roots spread 1.7 to 3.7 times the drip-line, depending on species. A portion of this variability is probably attributable to genetic differences between taxa. Some of the variability in root spread relative to branch spread may be due to differences in plant form, i.e., columnar formed plants may have the same root spread morphology as broad-spreading formed plants so that less roots are found within the dripline on columnar formed plants because of the narrower crown.

The objective of this study was to relate root spread morphology to crown form of recently planted culivars of *Juniperus chinensis*. This study also measured root establishment rate into landscape soil during the first year following planting.

[1]Received for publication October 7, 1988; in revised form March 20, 1989. Florida Agricultural Experiment Station Journal No. *8921*.

[2]Assistant Professor.

## Materials and Methods

The study was conducted on an Arrendondo fine sand (loamy, siliceous, hyperthermic Grossarenic *Paleudults*) with pH of 6.1. Container size No. 3 'Pfitzeriana', 'Hetzii', 'Sylvestris' (on its own roots) and 'Torulosa' Chinese junipers representing spreading, upright spreading, fastigiate and columnar forms, were planted Sept 19, 1986. Plants were placed in 4 blocks (1 rep of each cultivar to a block) on 6 m (20 ft) centers. A 10 cm (4 in) thick layer of coarse hardwood chip mulch was spread on a square 1.8 $m^2$ (20 $ft^2$) area around each plant to simulate a landscape planting. A 30 cm (12 in) wide weed-free zone was maintained around the edge of the mulch with glyphosate. Ammonium nitrate at 2.7 kg N/93 $m^2$ (6 lb/1000 $ft^2$)/yr. in 3 equal applications (Oct. 13, 1986, & Apr. and July 1, 1987), was applied to the surface of the mulch. Overhead irrigation was provided to insure that at least 2.5 cm (1 in) of water was applied each week during the growing season. Final branch crown spread was recorded as the mean of the largest crown diameter and three other equally spaced diameters. Final plant heights were recorded on Sept. 22, 1987 according to AAN standards (1) at which time root systems were excavated by hand. Root location was mapped to scale onto graph paper. Mean root spread was calculated by averaging 4 equa-spaced root spread diameters including the North-South transect.

Roots were collected from 4 overlapping zones around the plant: a) within the branch dripline; b) outside the drip-line; c) within a 1 m (3 ft) diameter circle, centered at the trunk; and d) outside a 1 m (3 ft) diameter circle. After washing soil from roots, Newman's line-intersection method was used for estimating the total length of roots in each zone for individual plants (13).

## Results and Discussion

The 4 juniper cultivars had similar root spreads (1.48–1.71 m (4.8–5.6 ft) 12 months after planting (Table 1), despite large difference in plant form. Maximum root spread (Table 1) was also similar for the four cultivars (2.09–2.36 m (6.8–7.7 ft) and was only 25% greater than mean root spread, indicating a somewhat symmetrical root system (Figure 1).

Branch spread and plant height differed among cultivars, as expected, since each cultivar was selected for their unique plant form (Table 1). Roots spread 3.2 times branch spread

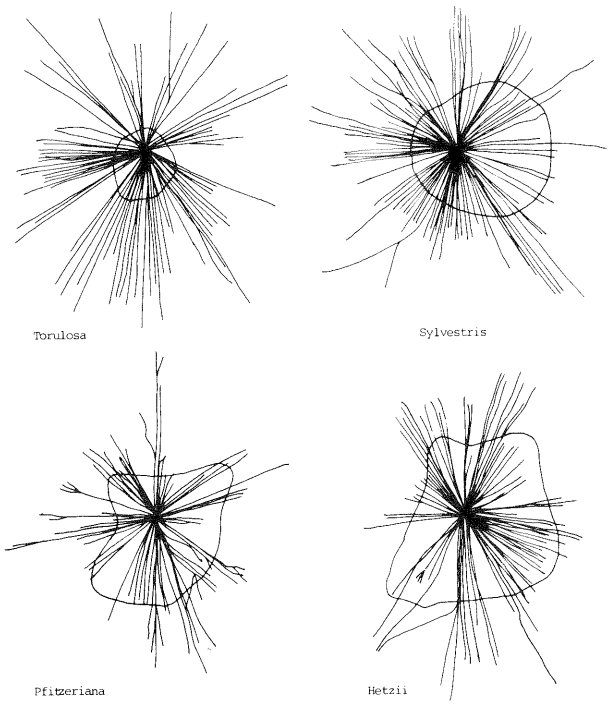


**Fig. 1. Plan view of one root system on 4 juniper cutivars. Solid circular line indicates the branch dripline.**

for columnar plants, but only 1.5 times branch spread for spreading cultivars. This range of root spread to crown spread ratios is similar to ratios calculated for tree species excavated three years after planting (7) and for established trees growing in a forest (15). This implies these four Juniper cultivars, may have reached their characteristic root spread to branch spread ratio sometime within 12 months of planting. Further study is needed to test this.

Total root length was significantly less for 'Torulosa' than the other cultivars, yet caliper increase was similar for all four cultivars (Table 2). Perhaps 'Torulosa' can support top growth with a more efficiant, smaller root system. Ratios of percentage of root length within a 1 m (3 ft) diameter circle (76.7%) to root length outside of this area (23.3%) were similar for all four cultivars reflecting the similarity among root systems. However the correlation between ratio of plant height to spread and percentage of root length within the dripline (figure 2) indicates that columnar formed plants have a smaller portion of the root system within the dripline (39.6%) than broad spreading plants. Many landscape maintenance firms apply fertilizer to an area beneath the dripline or just beyond. Only a small portion of the root system may be fertilized following this practice for upright, fastigiate and columnar formed plants. However if these plants are growing in turf, ground cover or a shrub bed which is maintained on a fertility program, the entire root system is likely to be fertilized.

Roots grew very rapidly during the first year of landscape establishment. Future studies will determine when and if the initial rate of root growth decreases. This study demonstrates that despite large differences in crown form, root morphology on four cultivars of *Juniperus chinensis* is similar. Prediction of percentage of roots within the dripline among cultivars can be made with the ratio of plant height to spread, not with either parameter alone.

## Significance to the Nursery Industry

Determining the extent of tree root systems can help the landscape maintenance industry develop effective fertiliza-

**Table 1. Mean and maximum root spread and branch spread diameters of four field-grown *Juniperus chinensis* cultivars.**

| Juniper cultivar | Mean root spread diameter[z] (m) | Maximum root spread diameter (m) | Mean branch spread diameter[y] (m) | Plant height (m) | Root spread to branch spread ratio |
|---|---|---|---|---|---|
| Torulosa | 1.48a[x] | 2.09a | .46a | 1.6c | 3.2 |
| Sylvestris | 1.55a | 2.07a | .86b | 1.0b | 1.8 |
| Pfitzeriana | 1.71a | 2.36a | 1.11b | 0.5a | 1.5 |
| Hetzii | 1.64a | 2.28a | 1.09b | 0.8ab | 1.5 |

[z]Mean of 4 equa-spaced diameters, including the N-S transect.

[y]Mean of 4 equa-spaced diameters, including the largest.

[x]Numbers in a column followed by different letters are significantly different at the P<.01 level by Duncan's MRT.

**Table 2. Caliper increase and root length[z] of four field-grown *Juniperus chinensis* cultivars 12 months after planting.**

| Juniper cultivar | Caliper increase (cm) | Mean total root length (m) | Root length within a 1 m diameter circle around trunk (m) | Root length outside a 1 m diameter circle around trunk (m) | Root length within dripline (m) | Root length outside dripline (m) |
|---|---|---|---|---|---|---|
| Torulosa | 1.0a[y] | 156a | 124 (79.5)[x] | 32 (20.5) | 62 (39.2) | 94 (60.4) |
| Sylvestris | .8a | 350b | 293 (83.6) | 57 (16.4) | 252 (72.1) | 98 (27.9) |
| Pfitzeriana | .9a | 301b | 215 (71.4) | 86 (28.6) | 234 (77.9) | 67 (22.1) |
| Hetzii | .7a | 283b | 204 (72.2) | 79 (27.8) | 210 (74.2) | 73 (25.8) |

[z]Length of roots in the field soil beyond original root ball.

[y]Numbers in a column followed by different letters are significantly different at the P<.01 level by Duncan's MRT.

[x]Percentage of total root length in parenthesis.

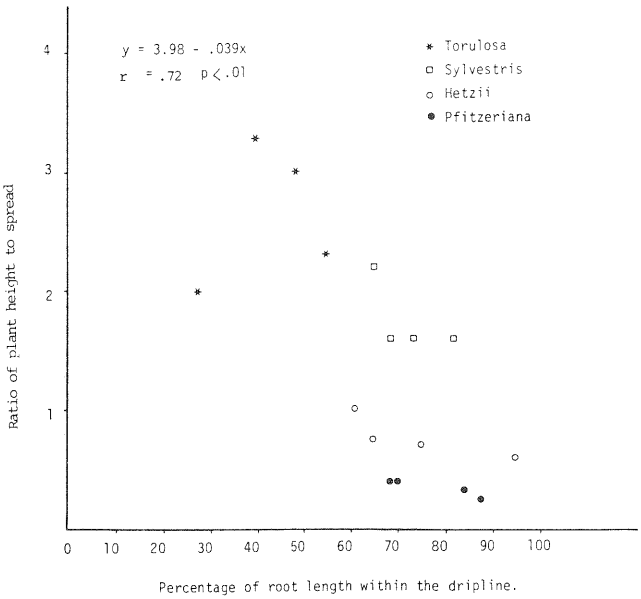


**Fig. 2. Percentage of root length within the dripline relative to plant form.**

tion practices. It can also assist tree managers and regulators develop tree protection measures for construction sites. Recently, a model showing tree roots extending to 3 times the branch dripline has been used to describe landscape tree root growth patterns. Although many tree species probably have roots extending to 3 times the dripline, the current study shows that roots of columnar formed plants extend further from the dripline than those of broad spreading plants. Watson's (18) root extension model is workable for open-grown oval to round shaped trees and has been supported by other studies (7, 8). It can be modified to become more inclusive of all plant forms by stating that columnar formed plants will have roots farther from the tree than 3 times the dripline; whereas, plants with a broad spreading crown are likely to have roots extending to somewhat less than 3 times the dripline. Further study will help quantify these modifications.

This study also shows that the length of roots within the dripline can be reliably predicted by measuring the ratio of plant height to crown width. This gives us one more tool to use in determining root distribution in landscape sites.

## Literature Cited

1. Anonymous. 1986. American standard for nursery stock. American Assoc. Nurserymen, Wash., D.C.

2. Bevington, K.B. and W.S. Castle. 1985. Annual root growth pattern of young citrus trees in relation to shoot growth, soil temperature, and soil water content. J. Amer. Soc. Hort. Sci. 110:840–845.

3. Blessing, S.C. and M.N. Dana. 1988. Post-transplant root system expansion in *Juniperus chinensis* as influenced by production system, mechanical root disruption, and soil type. J. Environ. Hort. 5:155–158.

4. Bunger, M.T. and H.J. Thomson. 1938. Root development as a factor in the success or failure of windbreak trees in the southern high plains J. Forestry 36:78–84.

5. Bushey, D.J. 1937. Root extension of shade trees. Proceedings Intern. Shade Tree Conf. 13:22–30.

6. Fare, D.C., C.H. Gilliam and H.G. Ponder. 1985. Root distribution of two field-grown *Ilex*. HortScience 10:1129–1130.

7. Gilman, E.F. 1988. Predicting root spread from trunk diameter and branch spread. J. Arboriculture 14:85–89.

8. Gilman, E.F., I.A. Leone and F.B. Flower. 1987. Effect of soil compaction and oxygen content on vertical and horizontal root distribution. J. Environ. Hort. 5:33–36.

9. Hodgkins, E.J. and N.G. Nichols. 1977. Extent of main lateral roots in natural long leaf pine as related to position and age of the trees. For. Sci. 23:161–166.

10. Ingram, D.L., R.J. Black and C.R. Johnson. 1981. Effect of backfill composition and fertilization on establishment of container-grown plants in the landscape. Proc. Fla. State Hort. Soc. 94:198–200.

11. Koslowski, T.T. 1986. Soil aeration and growth of forest trees (review article). Scand. J. For. Res. 1:113–123.

12. Laiche, A.J., W.W. Kilby and J.P. Overcash. 1983. Root and shoot growth of field- and container-grown pecan nursery trees five years after transplanting. HortScience 18:328–329.

13. Newman, E.I. 1966. A method of estimating the total length of roots in a sample. J. Appl. Ecol. 3:129–145.

14. Schulte, J.R. and C.E. Whitcomb. 1975. Effects of soil amendments and fertilizer levels on the establishment of silver maple. J. Arboriculture 1:192–195.

15. Stout, B.B. 1956. Studies of the root systems of deciduous trees. Black Forest Bul. 15, Cornwall-on-the-Hudson, N.Y.

16. Struve, D.K. and B.C. Moser. 1984. Root system and root regeneration characteristics of pin oak and scarlet oak. HortScience 19:123–125.

17. Wade, G.L. and G.E. Smith. 1985. Effect of root disturbance on establishment of container-grown *Ilex crenata* 'Compacta' in the landscape. Proc. Southern Nurseryman Assoc. Res. Conf. 30:110–111.

18. Watson, G.W. and E.B. Himelick. 1982. Root distribution of nursery trees and its relationship to transplanting success. J. Arboriculture 8:225–229.

19. Whitcomb, C.E. 1987. Establishment and maintenance of landscape plants. Lacebark Publications, Stillwater, OK.