Root Regeneration of Shade Trees Following Transplanting[1]

Gary W. Watson and E.B. Himelick[2]

Transplanting shock, the term used to describe physiological disorders of transplanted trees, is often considered to be a primary cause of poor success rates in planting programs. The above ground symptoms of leaf scorch and dying back of twigs are usually typical of decline and results from an excess or deficiency of soil moisture and death of the fine root system. These symptoms frequently occur on transplanted trees and are caused by an imbalance of the absorptive root system with the aerial portion of the tree. Immediate and rapid root regeneration is the most important factor for the successful establishment of transplanted trees and other woody species.

Root Distribution in the Nursery

Our studies of nursery grown trees and that of others (Stout, 1956) has shown that the root systems of most trees extend a considerable distance beyond the dripline of the trees. When a tree is dug for transplanting, only a very small percentage of the original root system is moved with the tree. Our field data indicate that when transplanting trees with a tree spade of maximum recommended size for the equipment, as little as 2 percent of the root system is dug with the ball to support the tree in its new location. Fig. 1 represents a model of a typical nursery-grown tree root system and was constructed using actual field data obtained from our nursery tree studies (Watson and Himelick, 1982) and in conjunction with field observations of root excavations

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[2]Specialist, Michigan State University, East Lansing, MI 48824, and Plant Pathologist, Illinois Natural History Survey, Champaign, IL 61801, resp.

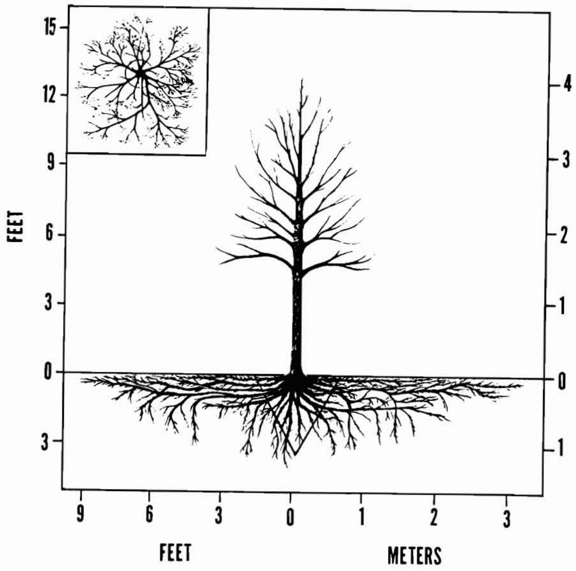

Fig. 1 Illustration or model of a typical root system developed from field data obtained from trees growing in a nursery situation. The shaded area represents a tree-spade soil ball 112 cm (44 in) in diameter and 102 cm (40 in) deep. The tree illustrated has a trunk diameter of 4 inches measured at 6 inches above ground level.

of numerous trees planted along streets. The triangular shaped area outlined in the center of the root system represents the small root area included in the root ball. Other important features of this model root system are the extensive lateral extension of the root system, which has been mentioned above, the vertical distribution of the fine root system, and the presence of sinker roots. The highest densities of fine roots, which are the primary structures for absorbing water and nutrients, are just under the surface of the soil (top 4 inches). These roots become less dense at greater soil depths. Many of these fine roots or rootlets are terminal branches of roots which actually grow toward the surface from their point of origin on larger roots that occur up to 15 cm (6 in) below the soil surface. Sinker roots are roots of various sizes that grow nearly straight down and arise from larger roots growing horizontally. They function to anchor the plant and to absorb available water and nutrients from deeper soil depths. The actual depth of penetration of the root system is dependent on the composition of the soil profile.

Site of Root Regeneration

Observation of excavated root systems of recently transplanted trees showed that the majority of all root regeneration is initiated from the callus layer formed near the severed end of the roots cut during the digging operation. This observation does not support the commonly held belief that root pruning of nursery trees will stimulate extensive lateral root formation and result in a dense compact root system. To the contrary, root pruning results only in the formation of new roots near the cut ends. These new roots have been observed to develop in excess of a meter (3.3 ft) in length within one year. It is therefore impossible for a significant portion of these new roots to be included in the root ball, even if the diameter of the root ball is slightly larger than the original point of root pruning. The most probable result of root pruning would be to reduce the vigor of the tree and induce a stressed condition until the root-shoot balance of the tree is restored.

Root Regeneration in the Field

Root regeneration data collected from field experiments in which three species of commonly used street trees (Norway maple, green ash and ginkgo) were transplanted with a Vermer 44 tree spade, at four different periods over the course of a growing season, is represented in Fig. 2. These data show that the density of fine roots varies with each species, both in the undisturbed root systems used as controls, and in regenerated root systems. Fine roots were concentrated near the soil surface with decreasing at greater soil depths.

Where heavy turf was present, the root density in the upper 10 cm (4 in) of soil was reduced. This can be attributed to the inability of the tree roots to successfully compete with the extensive grass root system.

Time of transplanting seemed to have a major influence only on the root growth of Norway maples transplanted in March. These trees were in the early stages of shoot elongation at the time of transplanting. During this period carbohydrate reserves are at low levels in the plant. Both the roots and shoots are competing for the available supply, resulting in less of these energy reserves being available for root growth. Root regeneration of these Norway maples was greatly reduced and the trees produced a less extensive regenerated root system during the first year of growth following transplant-

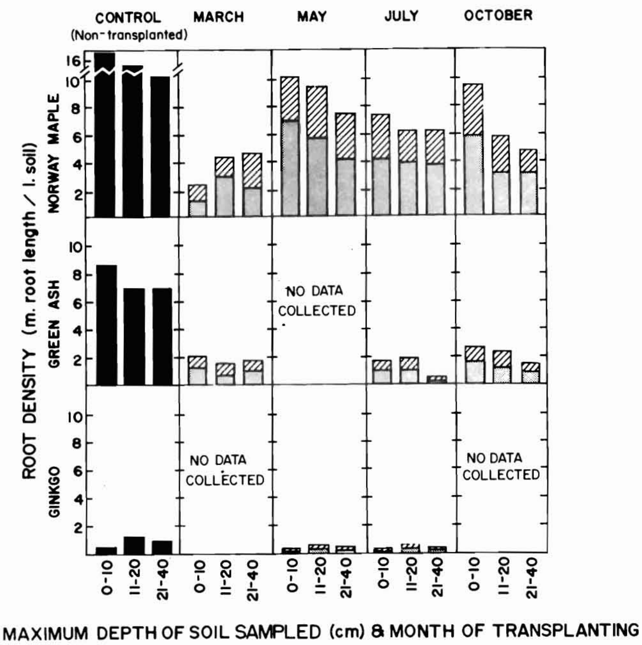

Fig. 2 Root regeneration of transplanted trees after 1 year of growth. (Stippled portions represent inner core samples taken 0 to 7.5 cm (3 in) from the root ball edge.) Slashed areas represent outer core samples taken 7.5 to 15.0 cm (6 in) from the edge of the root ball. Control tree samples were taken at similar distances from the trunk, but were analyzed together.

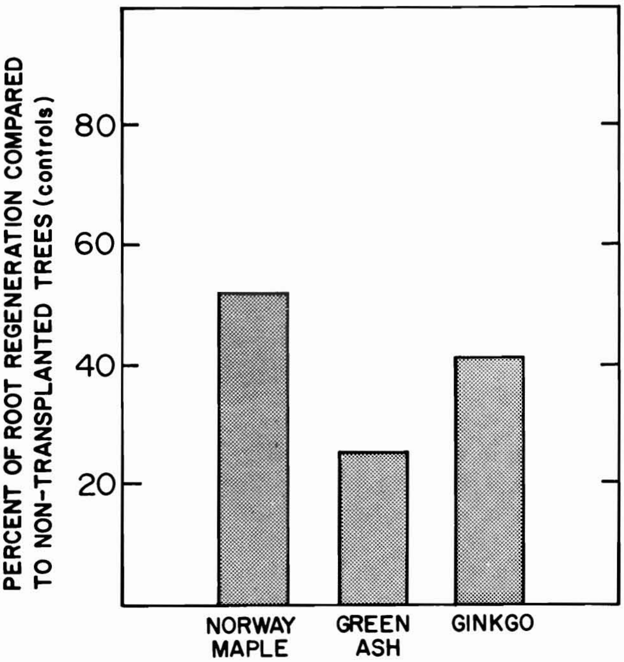

Fig. 3 Relative root regeneration of transplanted trees in relation to fine-root densities of non-transplanted trees.

ing than those transplanted during other seasons. In contrast, the green ash transplanted at the same time had not yet initiated shoot expansion. Roots were not forced to compete with shoots for available carbohydrates and root regeneration during the first year was similar to the ashes transplanted during other seasons. The Norway maples transplanted in May, when shoot elongation was nearly complete and photosynthate production was taking place in the leaves, showed no suppression of root regeneration. When densities of regenerated roots outside of the root ball are compared to undisturbed control root densities, the regenerated root densities, one year after transplanting, are only a fraction of those of non-transplanted root densities. The amount of fine or small root densities of green ash are particularly low when compared to other tree species studied. This may be due to the nature of the green ash root system. The average diameter of green ash roots were larger than the other species. We have observed that green ash roots larger than 1 inch are less likely to initiate new roots than smaller roots. This reduction in root regeneration of large severed roots will result in severe water stress during the first and second growing periods following transplanting. Root initiation occurred much more readily from similar size Norway maple roots when they were severed, but the same trend of poor root initiation from large severed roots was observed.

Conclusion

It is amazing that large transplanted trees survive transplanting at all, since such an extremely small portion of the root system is moved with the tree. Several physiological changes must occur within a recently transplanted tree in order for it to be able to survive until the root system is sufficiently regenerated. Exceptional care must be taken not to damage the root ball or to let it dry out during transit, since this type of injury most certainly will result in substantial damage to the remaining roots within the ball. During transit and after planting, the root ball is subjected to rapid loss of water through root absorption and leaf transpiration. Proper care and maintenance following transplanting must be essential for all transplanting operations. Regeneration originates from the area of callus formed near the severed root ends at the perimeter of the root ball. Care should be taken to keep this area from drying out and causing injury or death of this critical portion of the root system. It should be emphasized that overwatering can also severely injure the young regenerated roots.

Our study and others (Dumbroff and Webb, 1978) have shown that root regeneration is suppressed when transplanting occurs during the period of active shoot elongation. Transplanting during this time should be avoided.

Literature Cited

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