STAKING IN RELATION TO GROWTH AND FORM

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The provision of support for plants in the nursery is a costly and time-consuming process. An examination of present practices may suggest ways of saving work without a significant reduction in quality. With this in mind a survey of some of the principal features leading to establishment of particular forms of growth has been made.

Botanists and foresters have long been concerned with growth and form and their many publications, particularly in the present century, provide an immense amount of information from which only those findings considered relevant to nursery work will be mentioned here.

TREE RESPONSE TO NATURAL FORCES

Light and spacing. Whilst the hereditary disposition to react in certain ways may pattern growth; light, gravity and other physical forces determine or modify the development and direction of branches. The plant's response is also considerably influenced by the "quality" of the site, this site quality may be assessed by the vigor and erectness of leading shoots; on poor soils trees become crooked.

Close spacing, by increasing the competition for light, soil-water and nutrients results in erect, attenuated plants with few or no side shoots. The mutual wind-protection accompanying close spacing precludes the formation of stem-taper and increases the need for prolonged support at planting.

Close tying to a stake reduces light on one side and the tree grows away from the stake, inviting more frequent tying. Experimentally, "see-through" stakes have not only eliminated this tendency but resulted in stiffer trees.

Wide spacing increases lateral branching relative to height and the main stem becomes tapered and the tree more resistant to wind stress.

Light is rarely a limiting factor in the early life of a nursery but may become so as competition develops. In addition, competition for water and nutrients may be so great between close-spaced trees that lateral buds do not develop into shoots; the apical buds seems to require all available water and nutrients.

Pruning and shoot/root ratio. Pruning effects on growth and form vary with species, season and severity of cutting. In general, growth as a whole will be less impeded by pruning when dormant

than when active in full summer. Light cutting back of leading shoots spreads the resulting laterals but more severe heading results in one or more stiffly erect shoots. This vigorous response follows a disturbance of the shoot/root ratio, clearly seen in well established material; it is also in part due to release and development of hitherto dormant vegetative buds.

Anchorage and soil. Unstable or loose soils such as those containing much broken stone or coarse gravel or, at the other extreme, much peat may provide insufficient anchorage when plants are young, especially when newly transplanted, so that the plants lean away from the vertical. Apical growth is resumed in a vertical direction but the plant is permanently "kinked".

A compact root system is formed in a deep organically rich soil. The primary reason for wind-loosening is inadequate cultivation of soils which are impermeable to roots. Shallow cultivation, with or without surface enrichment, attracts roots to the surface where they are vulnerable to environmental hazards and obtain minimal anchorage.

A small increase in rooting depth can produce a considerable increase in resistance to windblow. Drainage not only increases rooting depth but also increases the mechanical strength of the soil.

Gravity. Plants respond to gravity in very definite but differing ways. A root from a seed goes down, the shoot up, regardless of the influence of moisture or light, but quite soon the genotype patterns the reaction to gravity. In many conifers gravity is seemingly all-powerful. If wind, soil erosion, or mechanical damage displace the vertical axis the upright position is restored. The plumbline accuracy of vertical growth is achieved despite wind pressure, side illumination, or unequal development of lateral branches. Leading shoots of some vertical species may not attain an erect posture initially but only at the end of a growth period during which they may grow in a hemispherical arch towards the ground, indicating secondary growth activity and control some distance from the apical growing point.

The horizontal development of fan shoots from main stems, as in beech, despite their emergence from upward-inclined buds, is initially gravity controlled but the effect of the leaves upon them is largely governed by light.

Sensitivity to gravity often declines with age. Nursery trees are usually more erect than older ones. Whilst due mainly to vigour or speed of growth this equates well with the tendency observed in seedlings, and in adventitious or other fast growths (see pruning and shoot/root ratio). Examples are seen in hollies where shoots from trunk sphaeroblasts grow straight up through the head of the tree regardless of any superior horizontal lighting,

displaying the over-riding directional influence of gravity.

Pendulous growths, as in weeping ash and willow, appear to give way to gravity. By freely dangling there is no need for shoots to thicken to achieve support, they need only to conduct; the thickening and tapering of stems to resist mechanical stress incidentally provides excessive means of conduction (see interplay of forces and trunk motion).

Wind and shelter. Wood formation in a stem or branch is governed by the need for mechanical strength. The requirement increases in a long stem and is accentuated by exposure to wind. Trees require a degree of stiffness; violent shaking restricts extension growth. A stem, especially in a conifer, less clearly in a broadleaved tree, closely satisfies the requirements of a beam of uniform resistance. Exposure to wind pressure, mainly at the top, develops the necessary taper. Overcrowding checks or completely prevents taper. Compare close-grown oaks (*Quercus robur*) in a forest with those isolated in a field. Excessive protection from wind, which prevents movement, also precludes stem taper.

Trunk motion. Experimental separation of environmental stresses reveals the seemingly automatic reaction of the plant. A stiff rod hinged at one end to a fixed support and attached to a non-staked round-stemmed tree at the other ensures a one-way sway. The trunk develops an oval section with the longer axis in the direction of sway. A well-established tree with large heavy branches is structured to resist stress; its main trunk, or principal vertical branches have a round section and a central pith. The pith position of inclined branches varies in strict accordance with stresses principally imposed by gravity. From a series of cross sections near the bases of branches one can, by noting the pith positions, reconstruct the angles of the tree's limbs.

When a young tree is shaken rapidly to and fro by hand or mechanically, if only for less than a minute a day, it produces fewer nodes and these are closer together, consequently the tree is much shorter than one non-shaken and the main stem is much thicker.

NURSERY STAKING

Soil. On a well drained medium loam, deeply cultivated and not too windswept, staking may be beneficially reduced to the demands of "weepers" and "wobblers." Heavy clays eventually provide excellent anchorage but wind-rocking in the year of lining-out may so pug the soil close around that suffocation occurs. This, and wind-rocking in a loose peat or gravelly soil, is prevented by driving a short stake at planting. The stake can be safely withdrawn as the root system develops. If hard soils are well broken up, and have some organic matter incorporated, then

the roots will provide good anchorage, the basis for a proper development of growth and form.

Shelter. It is appreciated that external windscreens are well worthwhile. Adjustment of spacing between and within rows, in relation to plant character, also considerably influences staking needs. Square plants are theoretically acceptable but impractical. At the other extreme very wide row spacings, along with close spacing in the row, may result in flat trees with oval-section stems, hence a compromise is called for. Spacing in the row should not be so close that the individual plant cannot sway a little up and down the row as well as across, neither so close that more advanced plants suppress others by excluding light.

Trimming. Maiden trees intended for bush forms should, wherever possible, be left free. Low-grafted material can usually be held one season by a very short stake. Short-legged material may be kept clean up to the head to save later trimming but plants for standards should be allowed to feather during their nursery life if not beyond. If feathers are tipped or shortened the remaining leaf area should be left undamaged. Defeathering in summer adversely affects the tree's weight and girth, and its stability. Trees allowed to feather gain more in growth the year after transplanting. Defeathering does not materially strengthen leader growth. Active buds and leaves on laterals start downward waves of thickening which increases taper thus reducing the need for staking.

Degree of support. Artificial support controlling growth and form is required for the production of many cultivars, its provision is not only costly but may seriously interfere with the plant's development. Too much support checks stem thickening and prevents normal tapering and may also by rubbing provide entry for disease.

Rigid support by use of thick stakes not only prevents the formation of taper but by unilateral shading causes the tree to grow away from the vertical, involving more frequent tying. A comparatively thin and flexible stake is far better. Such stakes may be held in line by a single string or wire permitting a modicum of flexing between wire and ground. The stakes should first be fixed to the string or wire and then each tree be tied loosely to its stake, away from the string. Tie intervals should be as far apart as practical.

CONCLUSIONS

The hereditary disposition patterns growth.

Light, gravity, wind and other physical forces — soil-anchorage and mechanics — determine development.

Pruning effects vary with species, season and severity of cutting.

Trunk and branch strengthening is in response to environmental stress.

These observations lead to the recommendation that staking should not be rigid so as to completely remove environmental stress but should be flexible and elastic to permit sufficient exercise.

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