chemicals. In most cases growth will be as large or larger than with plants grown with overhead irrigation.

LITERATURE CITED

1. Auger, E., C. Zafonte, and J. J. McGuire. 1977. Capillary irrigation of container plants. *Proc. Inter. Plant Prop. Soc.* 27:467–473.
2. Bluhm, W., D. Adams, and R. Tickner. 1980. Irrigation water application to Oregon nursery and greenhouse crops. pp. 1—Report to the Ore. Assoc. of Nurserymen.
3. Efford Sandbed Leaflet 847. 1984. Ministry of Agriculture, Fisheries & Food. U.K.
4. Havis, J. and R. Fitzgerald. 1981. Capillary irrigation of containers. Pioneer Valley-Berkshire Region Newsletter. Mass. Coop. Extension Service, April 13, 1981.
5. Smith, E. M. 1982. Utilizing capillary irrigation from propagation bench to harvest. *Proc. Inter. Plant Prop. soc.* 32:564–569.
6. Stanley, J. and I. Baldwin. 1980. Standing grounds—A key to successful container growing. *Amer. Nurs.* 152(1):24–25, 64.

PERLITE: START TO FINISH

GREG MOORE

REDCO II

11831 Vose Street

North Hollywood, California 91605

Few propagation mixes today are devoid of at least some perlite and so this common tie deserves elaboration. We will first identify its origins and processing and then examine how perlite uniquely meets traditional grower applications, with a passing comparison to several other inorganic amendments.

Origins—Perlite is found worldwide as a naturally occurring igneous glassy rock (an amorphous silicate) similar to obsidian and rhyolite. It is distinguished from them by possessing 2 to 6% combined water collected from free surface or atmospheric moisture present as it cooled. The raw rock ranges from translucent to gray or black and is quite friable, with a loose density of 60 to 70 lbs./ft.^{3}.

Perlite ore is generally surface mined via tractor ripping and scraping. The ore is then crushed, dried and screened, to size segregate it, before being transported by truck, railcar, or barge to expansion plants.

Processing—Precision expansion of a variety of finished products is achieved by proper selection of ore size, furnace draft and temperature. Processing consists of heating the ore from between 1100° to 1600°F, so that, while the outer kernel softens, the bound water abruptly flashes to steam and is released from the

mineral, thereby expanding the particle to a lightweight collection of glass-sealed bubbles. Expanded perlite density is geared to end use need, including industrial and construction, and ranges in density between 2 to 12 lbs./ft.^{3}, and in size from −300 mesh to ½ in. Coarser ore produces coarser perlite (and finer by-products) and, everything else being equal, it is generally to the expander's advantage to expand ore at lower density because there is a larger expanded yield per unit of raw ore, e.g. 2,000 lbs. ore expanded at 5 lbs./ft.^{3} yields 400 ft.^{3}, while the same unit of ore expanded at 7 lbs./ft.^{3} yields only 285 ft.^{3}. This is important to the nursery grower since 7 lbs./ft.^{3} perlite is harder, and better maintains its integrity in mixing and long term growing, i.e. without a collapse in air space from soft perlite engendered fines.

Packaging and Delivery—Expanded perlite is packaged in a wide variety of paper, polyethylene, or returnable muslin or dacron bags, ranging in size from less than 1 ft.^{3} to 2 yds.^{3} For those with provisions to receive it (primarily closed systems or plenty of water spray) it is sold in bulk tanks or dumpsters.

Advantage of the increasingly popular returnable (particularly large sized) bags include the minimization or elimination of such hidden costs associated with throw-away paper bag use as: 1) higher intrinsic bag costs, 2) higher handling costs, 3) broken bags due to handling, or the necessity of outdoor storage in inclement weather, 4) loss of material in the vacuum formed in the unbroken, unemptied part of each broken paper bag, 5) trash removal costs, and 6) the difficulty of water treating perlite (one of our routine procedures for dust control) in paper bags (unless more expensive lined paper bags are used.)

Horticultural properties of perlite.

1) Perlite is readily available in a wide variety of grades, with worldwide reproducibility and excellent compatibility with the full range of organic and inorganic mix ingredients.

2) With its inherent porosity, it is very lightweight, usually 5 to 8 lbs./ft.^{3} (or 80 to 128 Kg/m^3) and it is easy, safe, and inexpensive to handle, transport, and use in mixes. For example, its use minimizes losses when pricking out or transplanting since the lightweight root system remains intact on removal; similarly, it allows new dimensions in hanging baskets and rooftop gardens, vis-a-vis soil-based mixes.

3) It is axiomatic that plant roots need ample oxygen for root respiration, gas exchange, and overall good rooting with minimal damage or disease. Perlite is rightly perceived principally as an aerator; in fact, in Japan perlite is called "Nenisanso", meaning "giving oxygen to the roots". With its inherent sharpness it provides excellent particle interference, thus generating voids or macropore space, which allows excess moisture to drain away. Moreover, perlite creates a very favorable balance between aeration and water

retention because perlite has an immense and unique surface area configuration which adsorbs water and water soluble nutrients in the micropore space, for subsequent easy release. Since particle size distribution affects soil pore size, mixes with coarser perlite generally have a greater air to water ratio than mixes with finer grades, and thus provide greater oxygen availability (even when fully saturated, as at field capacity), oxygen diffusion rate, drainage and leaching of excess soluble salts. The mixture, however, of relatively coarse perlite with fine organic particles can allow interstitial marrying of the two, thus filling to some extent the macropore space, and permitting excessive sogginess. Conversely, *uniformly* fine perlite, if sized with the proper organics, can drain well and provide good oxygen availability. To minimize particle segregation and degradation in mixing, perlite can be mixed slightly wet, with a low shear ribbon or paddle type mixer and with as short a mixing time as possible.

4) Perlite is inorganic, but not a by-product and not artificial and it does not appreciably, even in fumigation, deteriorate, shrink, or compact.

5) Perlite is chemically inert, pH neutral, sterile, odorless, and free of foreign material. With its known low CEC and salinity, it provides an excellent starting point for control of plant nutrition. The corollary is that it is less forgiving of nutrient starvation or excess than soil, and perlite substrates generally require constant liquid feed or slow-release fertilizers. A note regarding fluoride and perlite: Some perlite ores have small amounts of fluoride, and for those few plants sensitive to fluoride, the elimination of superphosphate (which contributes fluoride), or the addition of extra calcium to form a CaFl precipitate, which will leave little soluble fluoride.

6) Perlite imparts excellent soil temperature insulation (with its closed cell structure) by moderating temperature fluctuations—an *especially valuable contribution in seed and cutting propagation.*

7) Perlite acts as a reflector of light from the top of the soil surface up to the foliage underside, which is especially useful in low light areas and in fall and winter.

8) Perlite is easy to wet for dust control and, dry or wet, it is a trouble-free performer in automatic mixing and tray filling equipment.

9) Perlite is often used as a seedcoat ingredient to enhance seed appearance, sowing, and germination.

Specific Usages:

Cutting propagation—Perlite, although used in the full range of propagated plants, finds its best use with semi-hardwood cuttings, where long term misting occurs and high aeration and drainage are required. Typical cutting mixes for semi-hard or hardwood cuttings incorporate 30 to 100% perlite—most commonly 80 to 90% (up to

100% if slightly finer perlite is used to substitute for peat moss). With its optimum balance of air and water, it provides excellent rooting, minimizing compaction, sogginess and decay as well as damping-off risk. Moreover, cuttings are easily removed after rooting without root damage, thus lessening transplant shock and enabling rooted cuttings to get a faster start. In soft stem and leaf cuttings, particularly groundcovers, perlite is used at between 20 to 80% (usually 30 to 60%), most often with peat moss.

General Seeding and Bedding Plant Seeding and Growing. Perlite encourages quicker seed germination and seedling growth with less check in growth upon pricking out or potting on; 20 to 50% perlite is typically incorporated with peat, vermiculite, wood residuals and/or sand, topped with a mulch (of any of these) to provide easy re-wetting without surface capping.

Canning—Perlite has long been a mainstay (used at 20 to 60%) in the production of potted plants, indoor foliage, general ornamental liners, and canned azaleas/camellias to improve and maintain the aeration, drainage, leachability, rewettability, and lightweight of the mix. Coarse perlite is often used here but finer grades can be mixed with soil and/or peat to provide an easy to mix and pot medium that is cohesive and provides good root branching. Care must be taken if finer grades are used in liners, since the extra water retention is multiplied with liners' higher zone of capillarity. Also, care must be taken to avoid liner shift-up from heavy to light mixes since new roots will not easily penetrate the heavier surrounding soil. In the future, perlite may gain wider acceptance in general ornamental nursery stock at 5 to 15% (by volume) to minimize sand compaction and stratification, to facilitate handling in the nursery, and to lower shipping costs, and to increase water retention for warm climate retail outlets.

Soil Conditioners—When incorporated by spading or rototilling, with or without organic matter, perlite aerifies and loosens clay soil and improves the water and nutrient holding ability of sandy soil (finer grades especially). It is particularly valuable in poorly drained or compacted areas such as golf greens and athletic fields where it helps bring marginal sands (i.e., too coarse, fine, or silty) closer to USGA specifications.

In this and in general use, it also promotes easier leaching and adds a measure of drought insurance, while reducing stratification, surface crusting, and traffic-induced compaction. It can be added to all phases of soil preparation, including soil or green reconstruction and sod aerification/plugging—including top dressing, (watered or raked in).

Specialty Applications include:

a) Carrier for wetting agent, fertilizer, pesticides.

b) Bulb, corm or tuber storage.

c) Recirculating and non-recirculating quasi-hypoponic bag systems.

d) In ring culture, capillary benching, growing bags.
e) Mushroom casing additives.
f) Sewage sludge compost additive where it absorbs excess water and improves air flow, thus enhancing composting. It is also useful in the final product as an amendment.

Inorganic Comparisons—No discussion of perlite would be complete without at least passing reference to the other most common inorganic amendments that it is often used in conjunction with or in lieu of. One of the salient features of perlite is its high total porosity, i.e. the total available for occupation by water and air. This is largely so because the inner air space of perlite is not entirely occupied, while the inner air space of sand, pumice and polystyrene (despite their radically different densities) are relatively more solid or occupied. With respect to total porosity, only coarse vermiculite (with 80% + and with air space of 43%) and peat (with 80% +) have more than coarse perlite (with 70% +, and air space of 60%) while sand varies from 30 to 45%. Perlite holds 2 to 4 times its dry weight of water while sand and polystyrene hold considerably less, whereas peat and vermiculite hold far more.

TOP-WORKING (WINTER-FIELD GRAFTING)

F. ALLAN ELLIOTT
Carlton Plants
14301 S. E. Wallace Road
Dayton, Oregon 97114

One of the methods of propagation used at Carlton Plants is that of top-working or winter-field grafting. This technique is used in combination with other methods of propagation to develop a unique style of tree. This style or form is characterized by having a clean straight trunk to a specific height, then a burst of limbs and foliage from that point. A select group of plants lend themselves to top-working, specifically those with a compact globular form and those that are weeping. Other advantages to top-working are to circumvent the problems of poor bud take and slow growth rates of some cultivars.

Cultivars. Current production levels consist of about twenty cultivars totaling 50,000 plants. The majority of this production is in flowering cherries with the remainder being globular and pendulus forms of ornamental tree, (See Table 1).

Materials. The grafting process requires some basic tools and supplies. Those used at Carlton consist of a good knife, sharpening stone, leather strap, hand pruners, and pouch to carry scionwood. Other supplies include 1 in. wide paint brush, tree tar, 1 in. wide