exchange. As no additional nitrogen is added to our pine bark this must be compensated for at the mixing stage of a potting compost. This has the advantage that an early release of nitrogen within the compost will be mopped up by the bark, or leached out because of the free draining properties, preventing scorch occurring. This property is used to full advantage in a propagating mix for rooting cuttings, either as a 50/50 peat/bark mix or 100% bark. Controlled release fertilisers can be used which give a far superior cutting in considerably less time.

No matter how good the compost, growth of the plants is still very dependent on the management and expertise within the nursery. Nevertheless, in order that he may concentrate on growing plants, the nurseryman will want to be assured that the high quality material he buys today can be bought tomorrow and the day after.

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PROGRESS WITH DIRECT STICKING OF CUTTINGS

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Rooting cuttings directly into small containers is not a new technique but with major improvements in propagation techniques in recent years, particularly developments in using fertilized rooting media, it was felt that greater benefits from direct sticking were possible and that the subject needed looking at in greater depth. The work is still in its early stages and the scope of this paper is to preview the background of the improved rooting media, as well as the progress with direct sticking at Efford Experimental Horticulture Station.

Good quality cuttings are an essential start to any production schedule but all too often cuttings, once rooted, become neglected and starved before potting. This results in delayed establishment, slower growth initially, and poorer overall uniformity within a batch of plants which can be reflected in the

final grade-out at sale. A series of trials and observations at Efford between 1980 and 1984 investigated methods of maintaining (and improving) cutting quality prior to potting. Results were impressive and showed that significant improvements could be achieved.

NUTRITION AFTER ROOTING

The standard rooting medium used at Efford for many years was a 75% medium Irish sphagnum peat + 25% lime-free sharp grit. Use of liquid feed as a means of maintaining cutting quality once cuttings had been rooted and weaned was examined over three successive seasons for a range of autumn struck cuttings held until late spring before potting. Treatments included an untreated control (water only), and feeds containing 50 ppm N + 50 ppm K_2O, or 50 ppm N + 50 ppm P_2O_5 + 50 ppm K_2O, applied every 1 or 2 weeks (depending on frequency of watering).

The magnitude of effects varied with species, but in all cases there was a striking improvement in quality of cutting growth where feed had been given after weaning; establishment and early growth following potting was faster and more uniform than where cuttings had been allowed to starve. These effects were still obvious six months after potting. The N:K liquid feed maintained cutting quality without excessive growth, but the inclusion of phosphate promoted growth in the propagation tray. While this made earlier potting desirable to prevent overcrowding, root activity was such that despite the relatively severe tearing apart required by delaying potting, establishment and early growth was rapid.

One of the problems of liquid feeding over winter was the limited requirement for water and it was easy to waterlog cuttings unless frequency of application was reduced, thus limiting the feed applied. This led to investigation of incorporation of long term formulations of resin-coated controlled release fertilizers in the rooting medium.

NUTRITION DURING ROOTING

1. *Controlled-Release Fertilizers in Peat:Grit Rooting Media.*

The first observation incorporated 1 kg/m^3 of Osmocote 18:11:10 (8-9 months) in a 75:25 peat:grit mix for *Hydrangea* cuttings rooted under mist in the spring. Results were striking — cuttings in the fertilized medium rooting rapidly and foliage remained a dark green with active axillary bud growth compared with the well-rooted but starved, hard cuttings in the unfertilized medium. Work was repeated with summer struck, mist-propagated Japanese azaleas, this time with a 12-14

month formulation of Ficote (Nutricote) 16:10:10 (140).

Results were again impressive with no adverse effects on rooting from inclusion of the fertilizer but a marked improvement in cutting quality by the time they were potted six months after striking. While up to 1 kg/m^3 of either 8-9 or 12-14 month formulations of Osmocote or Ficote proved successful in a peat:grit medium for propagation under mist, caution is needed in their use under polythene covers where leaching is minimal and temperatures often relatively high. Under these conditions fertilizer rates are reduced by up to half, particularly for salt-sensitive species.

2. *Comparison of Rooting Media.*

Following reports of successful use of pine bark for propagation, its use under mist and polythene systems was investigated using a commercial granulated pine bark available in the U.K. (Cambark). The fine grade proved more suitable than the coarser "100" grade, cuttings being easier to insert, better supported, and drying out less rapidly. Mixes of 75:25 peat:grit, 50:50 peat:bark, and 100% bark have been compared, with and without the addition of controlled-release fertilizers.

The 100% bark proved more difficult to manage, holding less water and drying out quickly, particularly after weaning, and while used wtih success on nurseries, at Efford better results were obtained using the 50:50 peat-bark mix. The inclusion of the granulated pine bark produced a marked improvement in rooting and root development and, provided fertilizer was incorporated, produced excellent quality cuttings. Without fertilizer, rooting was still good but top growth suffered and starved more rapidly than in unfertilized peat:grit mixes. Cambark is not composted with nitrogen during its maturing process and consequently has the property of absorbing nutrients after use, particularly nitrogen, a potential advantage in providing cuttings with some safety against excess nutrient release under high temperatures.

3. *Granulated Pine Bark + Controlled Release Fertilizer*

The use of granulated pine bark appears to offer several advantages for use in propagating media: improving structure, increasing aeration (drainage), and allowing safer use of fertilizer incorporation. Other factors may well be involved and need further investigation. Type and rate of fertilizer addition with a 50:50 peat: pine bark mix varies with time of propagation.

Under mist (mainly spring/summer): 1.0 kg/m^3 of 8-9 or 12-14 months formulations of Osmocote or Ficote (Nutricote) have given excellent results.

Under polythene covers (mainly autumn/winter) where

leaching is minimal and temperatures can increase rapidly 0.75 kg/m^3 of the 12-14 month formulations appear reasonable.

The extended release 12-14 month Osmocote 17:10:10, and Ficote 16:10:10 (140), as well as being safer to use than 8 to 9 month formulations, have the advantage of nutrient reserves which help maintain cutting quality until potting. This in turn improves establishment and uniformity of growth in the batch of plants and, with some species, can improve growth, e.g. in *Camellia*, where early branching increased with plants from fertilized rooting media. Even longer term formulations (16-18 month) of coated fertilizers are now being monitored, and higher rates of incorporation than those outlined above look promising, particularly for propagation under mist.

DIRECT STICKING

With the ability of fertilized rooting media to maintain cutting quality over a relatively extended period, one of the main problems of direct sticking was overcome — namely the need to start a feed programme immediately after rooting. Work still in progress at Efford is concentrating on looking at responses of a range of species to direct sticking both under mist and polythene covers with a major objective being that of monitoring, whether a "liner strength" propagation mix could be used without adverse effects on rooting.

1. *Propagation Under Mist*

Hydrangea, used as a preliminary indicator species, was direct stuck into 70 mm pots in various media. As previously, rooting improved in 50:50 peat:pine-bark compared with peat:grit mixes and the inclusion of 1 kg/m^3 of 12-14 month Osmocote or Ficote produced a marked improvement in cutting quality. The work was repeated with a range of vigorous to salt-sensitive species during the summer of 1984, but increasing rates of fertilizer up to 2 kg/m^3 (plus 1.2 kg/m^3 magnesium limestone and 0.3 kg/m^3 Fritted Trace Elements (WM 255) were included.

All species rooted equally well whether direct stuck in 70 mm pots or seed trays, but cutting quality and early growth improved with direct sticking where competition for available nutrients was less. Overall, results were better in peat:bark than peat:grit mixes and cutting quality improved with increasing fertilizer. This was to be expected with the vigorous species (*Hypericum* × 'Hidcote', *Forsythia* × 'Lynwood') but it was encouraging to see species normally considered salt-sensitive responding in a similar manner (Japanese azalea and *Viburnum burkwoodii*). This improvement was not just foliage

colour, but increased stem thickness and active leader and axillary buds which produced well-rooted, small liner plants direct from propagation. No problems were encountered by using the 2 kg/m^3 rate of fertilizer in the peat:bark mixes, but rooting of camellia was reduced where it was used in the peat:grit mixes.

2. *Propagation under Polythene Covers.*

Following the success with direct sticking under mist, work was repeated over the autumn/winter period under polythene covers. Under these conditions it quickly became evident that salt-sensitive species were not doing well in fertilized peat:grit mixes, particularly at the higher rate (2 kg/m^3) — when deaths occurred. Inclusion of bark in the media improved rooting, but rate and type of fertilizer were important since there was evidence that too high a rate of 12-14 month fertilizer (2 kg/m^3 Ficote 16:10:10 (140) could be damaging to sensitive species (Japanese azalea). The same rate of the 16-18 month formulation of Osmocote, however, proved safe.

As with the summer propagation, direct stuck cuttings were a better quality than those from seed trays — but time of potting is important to obtain the greatest benefit from this improved propagation. The earlier the potting of slow-growing species, or those with distinct growth flushes, the better the growth by the end of the season. A delay in potting of the more vigorous species was not so detrimental, their growth rate enabling them to "catch up" on the earlier potting.

Advantages of direct sticking include:
— reduced root disturbance
— faster growth potential
— reduced handling

Its success will depend upon:
— species which guarantee a high rooting percentage.
— correct rooting media/fertilizer combination.
— availability of space.

The potential for direct sticking of cuttings appears considerable, its use having been extended by the development of fertilized peat: pine-bark rooting media, which have the ability to maintain cutting quality without adversely affecting rooting, which leads to improved growth.

Trials are continuing looking at rate and type of controlled-release fertilizer as well as inclusion of phosphate, lime, and fritted trace elements, and the proportion of bark needed in the mix. The potential for direct sticking in "liner mixes" looks promising from preliminary results, but more work is needed before recommendations can be formulated.

Use of a 16-18 month formulation, (Osmocote 16:9:9 + 3 MgO) needs further investigation. This has a slower rate of release than 12-14 month materials and can therefore be used more safely at higher rates and lasts over a considerable period.

The disadvantage of the extra space required for direct sticking may require a change in the propagation system, so the use of fog and gantry systems are already under consideration.

Increased Number of Cuttings per Pot.

Poor utilization of space resulting from propagation failures can be reduced by increasing the number of cuttings per pot. This will reduce propagation losses, produce faster growth rates and quality plants for earlier marketing. An adequate stock area will be essential to provide the increased number of graded cuttings required, and correct pruning schedules in the stock area will be important. A wide range of species has been successfully propagated with increased cuttings per pot, including those in the following categories:

Ground cover species: (*Hedera*, *Hebe*, *Hypericum*, etc.)

Easily-rooted "amenity" species: (*Senecio*, *Forsythia*, *Weigela*, etc.)

Slower growing species: (e.g. *Elaeagnus pungens* 'Maculata')

Higher value species: (azalea, *Pittosporum*)

Poor branching species: *(Camellia)*

Hedging species: *(Ligustrum, Griselinea)*

Trials with this technique are on-going, comparing 1, 2 and 3 cuttings per pot. While 3 cuttings/pot produces excellent quality plants, 2 cuttings per pot have given good results and reduces the strain on available stock. The initial work was with 70 mm pots, but current trials, as well as looking at size and type of fertilizer incorporation, are also examining direct sticking into 1 litre containers under fog and under mist systems.