changes in the next ten years will be in communications which will enable us to speed up order processing and shorten delivery delays.

Stricter environmental control will inevitably push up our growing costs and we must face up to the fact that in the future we will be expected to treat effluent and reduce the nitrogen that is being poured into our water courses.

Changes in Propagation Techniques. My impression is that our approach to propagation is polarising; on the one hand some of us are increasing the use of simple methods of propagation for mass production of cheaper plants, while at the other end of the spectrum, the use of micropropagation demands more precision and strict environmental control.

In this country, we are at last acknowledging the role of mother plants in not only improving the health status and yields of our crops but also in reducing cost of collection of cuttings. In recent years, we have also begun to realise the folly of poor grading at the liner stage and the trend of using larger, well finished liners will continue to increase the resulting improvement of the finished plant.

Introduction of New Plants. The scope for the introduction of new plants and improved cultivars is still immense. Micropropagation will probably facilitate the re-introduction of a number of difficult to multiply plants.

Repeating one of my earlier comments, the future of the industry is indeed good; it will be up to the industry whether we take advantage of the situation, by attaching significant importance to the effect of supply and demand and avoiding the temptation of over-production.

CUTTINGS FROM CONIFEROUS SPECIES — TYPES AND ROOTING FOR CONTAINERS

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In Bulgaria our current studies with vegetative propagation of conifers are based on an examination of the following factors: (1) rooting potential and plant form as affected by the maturity of the mother plant; (2) seasonal physiological and anatomic features of the cutting as affecting quantity and speed of rooting; (3) selection of suitable types of cuttings to reduce the production time of pot-grown liners; (4) development of equipment to provide suitable regimes for rooting cuttings without the use of heat; and (5) grafting in the open to produce conifers for landscaping and seed orchards.

It is impossible to discuss all these aspects thoroughly. The third will be covered here, with reference to the others where applicable.

The studies carried out confirm that the life and regenerative potential of trees produced from rooted cuttings are closely related to the age of the mother tree as well as the position in the crown (upper portion) of the tree from which they are collected. Cuttings taken from the highest positions in the crown of the mother tree will reach the reproductive growth phase more quickly than those from lower portions. In this case vegetative growth is reduced. The plants form cones, which is a sign of their advanced maturity, and they will not be long lived.

For example, young rooted cuttings of *Thuja occidentalis* L., and some of its forms, when collected from old mother trees, produce cones in the nursery and remain dwarf. Because of this it is necessary to select forms which possess positive decorative qualities from the progeny of coniferous species. It is preferable if the selected plants are used only once for propagation during the juvenile phase (i.e. under 15 years). These will provide rejuvenated stock plants.

Experimentally, it is established that the optimum stage for rooting the cuttings is closely related to their carbohydrate supplies and the presence of young tissue with active cell growth. Physiologically, this stage is characterised by the predominance of reducing sugars over the quantity of starch (as defined by the Hagedorn-Jensens method, modified and improved by Blich, Sandstedt, and Popoff). Anatomically, this coincides with the time just prior to summer wood formation.

The effect of the above factors on the rooting process is illustrated with experimental results obtained in rooting cuttings of *Picea excelsa* Link. The data from this species must be accepted as quite indicative because of the difficulty of rooting cuttings of this genus compared to species and forms in the Cupressaceae family.

Preliminary studies have determined the type of cutting which will root, i.e. its age and length. These studies showed that good practical results can be obtained with two types of cuttings — those made from one-year-old shoots, and those having a basal portion of two-year-old wood (Figure 1). They are collected from trees and seedlings of *Picea abies* (L) Kanst. (Syn.: *Picea excelsa* (Lam.) Link) of varying ages. From 12-year-old seedlings all good shoots are taken, while from older trees cuttings are taken only from the top of the crown. Their ability to root at different times of the year has been examined.

Figure 1. *Picea abies* cuttings. *Above.* Type B, with 2-year old basal section. *Below.* Type A, one-year-old shoots.

Rooting is carried out in cold frames using a medium of washed river sand over layers of compost and drainage material. A suitable regime for rooting can be maintained in such a frame for a maximum of 7½ months a year. The average temperature is from 20° to 25°C, with humidity over 80%. The experimental treatments include hormone-stimulated cuttings with two controls — wet and dry. Hormone treatments consisted of solutions of heteroauxin (IAA), indolebutyric acid (IBA), alphanapthaleneacetic acid (NAA) at suitable concentrations (Table 1). Duration of the treatment was 14 to 16 hours.

Summarised results from prolonged experiments show that *Picea abies* cuttings of both types root best when collected from early July to late August. Morphologically, this period begins when the shoot stops elongating and a terminal bud forms. The shoot's newly-formed bark is yellow-green in colour and is still soft. Cuttings collected in the second half of July give the highest rooting percentage. They have considerable resistance to desiccation since the young needles will absorb water and the cuttings remain turgid. Rooting is complete by the end of autumn but planting of the rooted cuttings in containers or in open ground can be done later.

From the data for *P. abies* in Table 1 it is seen that the percentage rooting of the two types of cuttings from seedlings up to 12 years of age is two to three times higher than that of the cuttings collected from older trees. This correlation is typical for both hormone-treated cuttings and the control. For example, in the wet control there was 74% rooting of Type A cuttings from young seedlings compared to 30% for those from old trees. With hormone treatment using IAA, rooting reached 78% for cuttings from young trees and 36% for those from old trees. The range is similar for cuttings with a 2 year base (Type B). In addition, cuttings from young seedlings develop stronger root systems and produce bigger plants.

It is important to understand that the rooting process for cuttings with a 2-year-old base is identical to that for cuttings from annual shoots. In addition to high rooting percentage for some variants, they develop a better root system which, even with the control 12-year-old seedlings, reached 150 cm in length. Root growth of Type B cuttings is equal to that of cuttings from 3 to 4 year old seedlings (Table 1). It can be seen that a practical advantage in using Type B cuttings is to shorten the production period for conifer liners by 2 to 3 years. This is particularly important for container production, as cuttings can be planted directly into a larger container, saving the costs of potting on.

The observations and data cited show that hormone treatments promote earlier rooting and a slight improvement in rooting percentage. This is seen more clearly with cuttings from older trees. Also treated cuttings develop a better root system. Irrespective of these advantages, hormones cannot overcome the age factor of the initial cutting material. On the other hand, good rooting of the control cuttings shows that rooting of conifer cuttings can be improved with hormones.

The second period of the year of practical importance for rooting cuttings in cold frames is from the end of February to the first half of April. In this period the annual shoots are typically mature morphologically and have good rooting potential. Taking the cuttings depends on the weather, but it must be done before growth starts. At this period there is a tendency for the cuttings to callus rather than to form roots. The top and lateral buds of the cuttings sprout quickly which retards root formation and growth. Rooting percentage at this period is 3 to 5% lower than in summer and the root system is weaker.

Table 1. Rooting of *Picea abies* cuttings collected in July or August. Results over a 5-year period (Nursery VLTI-Sofia).

Treatment	Percent rooted	No. of roots/ cutting	Mean root length (cm)	Mean shoot height (cm)
Type A cuttings from 3-year-old seedlings				
Dry control	80.0	10	90	11.4
Wet control	70.0	10	91	10.9
IAA 100 mg/1-16 h.	84.0	13	95	11.6
Type A cuttings from 6-year-old seedlings				
Dry control	78.0	7	56	12.3
Wet control	74.0	6	51	11.6
IAA 100 mg/1-16 h.	68.0	6	57	12.8
Type B cuttings from 6-year-old seedlings				
Dry control	86.0	8	65	18.6
Wet control	70.0	7	100	19.3
IAA 100 mg/1-16 h.	78.0	8	99	19.5
Type A cuttings from 12-year-old seedlings				
Dry control	70.6	8	145	17.2
Wet control-14 h.	63.2	8	133	16.5
IAA 150 mg/1-14 h.	65.3	11	130	15.0
IBA 30 mg/1-14 h.	68.3	10	145	16.5
NAA 30 mg/1-14 h.	67.3	10	154	16.0
Type B cuttings from 12-year-old seedlings				
Dry control	66.3	8	150	22.2
Wet control-14 h.	74.0	9	150	21.8
IAA 150 mg/1-14 h.	70.3	16	173	21.0
IBA 30 mg/1-14 h.	78.5	11	160	19.8
NAA 30 mg/1-14 h.	76.3	12	182	23.6
Type A cuttings from 70-80-year-old mother trees				
Dry control	32.4	3	92	11.9
Wet control-14 h.	29.8	3	96	—
IAA 150 mg/1-14 h.	36.3	8	115	12.0
IBA 30 mg/1-14 h.	34.6	5	103	10.8
NAA 30 mg/1-14 h.	35.2	5	124	12.3
Type B cuttings from 70-80-year-old mother trees				
Dry control	28.4	3	83	16.4
Wet control-14 h.	27.5	3	79	15.7
IAA 150 mg/1-14 h.	38.5	9	124	16.5
IBA 30 mg/1-14 h.	37.0	6	128	16.0
NAA 30 mg/1-14 h.	41.2	7	141	16.7
Type A cuttings from 120-130-year-old mother trees				
Dry control	29.6	3	84	10.6
Wet control-14 h.	28.3	3	78	11.2
IAA 150 mg/1-14 h.	32.4	7	116	12.0
Type B cuttings from 120-130-year-old mother trees				
Dry control	31.5	3	80	14.8
Wet control-14 h.	28.6	4	86	15.2
IAA 150 mg/1-14 h.	34.7	8	132	15.6

The least suitable period for taking cuttings is from early May to early July, when new growth is soft and cuttings quickly lose turgidity.

Successful rooting of autumn struck cuttings required greenhouse conditions with heat. Shoots at this time are becoming dormant and rooting at this period needs more detailed study. Preliminary studies show, however, that acceptable rooting percentages can be obtained but require a longer rooting period. Considerable callus is formed at this period and an economic assessment is needed to determine whether it is feasible to propagate at this time.

Experimental and practical results show that our work with *Picea abies* has widespread interest. Forms representative of the genera *Thuja, Libocedrus. Cupressus, Juniperus*, and others have achieved a high percentage rooting (over 82%) from Type B cuttings when struck in early July. This shows that under Bulgarian conditions the anatomical and physiological factors are optimum for rooting Type B conifer cuttings at this period. Consequently they are being used for container production at the nursery at the Higher Institute of Forestry Engineering and will gradually be introduced in other ornamental nurseries in Bulgaria.