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## DIVISION OF FORESTRY

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### Activities of the Division

The staff of the Division of Forestry at Ilanot is involved in various projects in the fields of forest ecology, silviculture, wood utilization and technology. Although the stress is on applied research to foster sound forestry practices, many projects are by necessity of a more basic character due to the lack of data on forestry in the Eastern Mediterranean, and on our major forest trees.

Research on tree introduction is focused on new species suitable for reforestation in the mountains and in the drier parts of the country, and on proper identification of exotics introduced in the past. At the same time, efforts are continuing to deepen our knowledge of the ecology and reproduction of native trees, with tree growth on old walls providing an example of adaptation to extreme conditions.

Owing to their fast growth and adaptation to a wide range of conditions, eucalypts figure prominently in current research. A comprehensive study of the autecology of Eucalyptus occidentalis was completed, the species being shown to be most resistant to drought, flooding, salinity and lime content of the soil and to be highly frost-tolerant but moderately cold-tolerant; salt resistance appears to be related to seed origin. Research into inter-provenance variation in E. camaldulensis and its relation to geographical and environmental factors was continued and new plots were established to evaluate clinal variation from east to west in Australia; of particular significance is the finding that the fastest-growing provenances produce

the best coppice regeneration. Growth and regeneration of eucalypts were found to be most rapid on Lake Hula peat, with significant reduction of soil nitrate levels in the planted area reducing the eutrophication hazard to Lake Tiberias. Primary production and caloric content of eucalypt plantations are being investigated as an alternative energy source for industry. Application of suitable drying techniques leading to the obtention of sawnwood opens new vista to industrial utilization of E. camaldulensis and to a revision of present management practices. Studies of the service life of impregnated posts are being continued.

Several research projects deal with the ecology and management of Aleppo pine and other conifers owing to their prominent place in hillside afforestation. Close relationships were found between tree growth, water potentials and geological substrate, and promising results were obtained with direct sowing and planting of seedlings as a substitute for the current practice of planting one-year-old container-raised nursery stock. Effects of stand density on tree growth were investigated and long-term studies of effects of density of planting and intensity of thinning are in progress. Natural regeneration by a shelterwood system is shown to be a practical alternative to replanting of cut forests. Investigations on the crown decline of Aleppo pine in the Sha'ar haGay forest tend to support the view that the disorder is the result of drought stress during the late 1950s and early 1960s and emphasize the need for selection and breeding, since different genotypes apparently display different resistance to the disorder. Provenance trials of Pinus halepensis and P. brutia have been established. Research on wood properties of cypress is under way.

Current research relevant to the quality of the environment deals with the management of natural oak forests for conservation and recreation and the acoustic properties of trees for noise reduction.

## RESEARCH SUMMARIES

### Contributions to the arboreal flora of Israel

R. Karschon, A. Weinstein, Hanna Koyumdjisky\* and Clara Grunwald

Several studies of the Division deal with various aspects of the distribution, biology and ecology of some of the lesser-known native trees.

A comprehensive study was made of environmental factors at El Arakah, 16 km north of Jericho, the northernmost outlier of Salvadora persica. The survival of this outlier is attributed to favorable climatic conditions, local edaphic conditions eliminating competition by other species, and the sanctity of the site until very recently.

In a related study the past and present occurrence of Acacia raddiana in Jericho, the northernmost point of its general distribution, was investigated. The Lower Jordan Valley may be the only area in the Middle East where the range of A. raddiana overlaps with that of A. albida.

Seed germination of A. raddiana and A. tortilis and its relation to infestation by bruchids was examined. Natural regeneration may be expected to occur mainly from damaged seeds with a still intact embryo axis due to removal of seed coat dormancy by bruchid infestation. Recommended practices for nurseries are pretreatment of seed prior to sowing, fumigation of stored seed, and sowing of unripe seed.

In contrast to A. raddiana and A. tortilis, the dominant mode of propagation of A. albida was shown to be by root suckers which may spread over 0.15 ha within 50-60 years. This suggests that many of the small relics of the species may be clones (or remnants of clones) formed by ramets from a single ortet. Hydrochory is postulated to be an additional means of dispersal.

Problems of seed soundness, seed germination and seedling morphology were investigated in Pistacia palaestina and

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Arbutus andrachne. The susceptibility of exotic leguminous trees to bruchid attack is being examined.

A mutant of Fraxinus syriaca with yellow (in place of red) anthers was discovered in a 30-year-old row plantation at Ilanot. The significance of this find is being examined.

#### The flora and vegetation on old walls

R. Karschon, A. Weinstein and D. Heth

Studies of plant growth on old masonry walls throw new light on successional processes of interest to the forester and deepen our knowledge on adaptation of plants, particularly trees, to extreme site conditions.

Colonization of walls by higher plants and the beginning of a succession toward a forest climax were shown to progress very rapidly with the decay and ruin of abandoned buildings, with succession proceeding in the direction of the edaphic and vegetational climax. The vascular flora of vertical walls is relatively rich and its composition is determined primarily by that of the surroundings; of particular interest is the major part played by forest, maquis and batha plants and the prominent presence on walls of many native and cultivated trees. In spite of local differences, all vegetation on walls can be assigned to one single plant association, Hyoscyametum aurei.

Investigations on the water balance of trees on walls showed that Pistacia lentiscus is much better adapted to water stress than Aleppo pine.

In the course of taking comprehensive records of wall vegetation, new data were obtained on the distribution of Antirrhinum siculum, a xenophyte of relatively recent introduction.

#### Genetics of Eucalyptus camaldulensis

R. Karschon, Clara Grunwald and Y. Zohar

Measurements were continued in eight experimental plots containing 52 progenies from 33 seed sources to follow up earlier studies of variation in growth along a

north-south cline in Australia. At 'En Teo (Hula Valley), at 10 years of age, there were but minor changes in rank of provenances according to yield; the previously obtained juvenile-mature correlations and outstanding performance of some seed sources from the southern parts of Australia were confirmed.

New experimental plots containing 71 progenies from 21 seed sources from the tropical parts of Australia were established on three sites to investigate variation along an east-west cline. Measurements were taken of morphological characters and early growth to relate patterns of variation to seed origin.

On three sites 18 half-sibs from two lakes in north-west Victoria were planted to investigate within-provenance variation of this outstanding seed source. Early results demonstrate that the Lake Coorong and Lake Albacutya provenances belong to the same population, thereby increasing the scope for seed collection; significant differences in performance point to the possibility of obtaining marked genetic gains by selection of seed trees.

In a related study, the variation of morphological characters and growth of two populations from the environs of Broken Hill, N.S.W., was studied. The occurrence in the same area of two morphologically distinct populations is attributed to historical factors, i.e., different age of populations. The blue-leaved provenance from the surroundings of Broken Hill is known to be particularly adapted to dry-zone reforestation.

Effects of flooding and water salinity were investigated in a nursery experiment. Plant response varied significantly with the seed source and is believed to be the result of in situ selection that led to the formation of populations adapted to specific environments such as salt lakes, stream banks and seasonal watercourses. The results of this study are decisive for selection of seed sources for liman plantations, plantations on saline soils, and plantations to be irrigated with brackish or saline water.

Investigations of leaf dry-matter content in the winter showed that variation according to seed origin in Australia is clinal from north to south and from west to

east. The possibility is shown of selecting provenances on the basis of geographic and climatic parameters of the seed sources, with latitude, longitude and mean minimum temperature of the coldest month taken together providing the best estimate of frost resistance.

Coppice cutting was conducted in three experimental plots to determine the relation between coppice regeneration and seed origin. It was concluded that regeneration after cutting is directly related to tree growth prior to cutting, with the fastest-growing provenances and trees on a given site producing the best coppice, i.e., the largest number, height and biomass of coppice shoots. Coppice formation is affected by genotype-site interactions and by differences in growth between half-sibs from the same seed source. There is no evidence that there are fast-growing provenances which coppice poorly. Measurements to assess yields of first-generation coppice of various seed sources are now being conducted.

Research of a more fundamental nature dealt with variation of morphological, physiological and ecological characters. Cuticular leaf waxes (examined with a scanning electron microscope) were found in all seed sources. Plate waxes were found to be most common, but in two provenances tube waxes were recorded; no distinct relation between morphology of waxes and seed origin was detected. Quantitative determinations of cuticular waxes were made in fully exposed and partly shaded plants. Preliminary tests of catalase activity as an early indicator of growth potential showed marked variations according to seed origin; the activity was highest in provenances from the southern parts of Australia. Calibration was completed of a Wescor thermocouple hygrometer for the planned study of water potentials of various provenances.

No depression of growth after inbreeding was recorded in the first generation after one year. Additional tests are under way.

In a related study differences in growth between seed sources of E. viminalis are being investigated on two sites.

## Autecology of Eucalyptus occidentalis

Y. Zohar

The water relations of E. occidentalis were examined to gain further insight into the remarkable adaptation to drought of this species. At various dates, leaf water potentials and water saturation deficits were determined in the field under different environmental conditions, with and without irrigation application. Direct relationships were found between the daily courses of xylem water potential, water saturation deficit and transpiration. The lowest (most negative) water potentials were recorded in the summer during the morning. With irrigation application and in the winter, the lowest values were obtained at noon.

At Ilanot, water potentials in the summer reached -44 to -53 bars and after irrigation increased to -8 to -25 bars. In the winter, the water potential varied from -9 to -14 bars. Values obtained in the summer in E. occidentalis were 2-3 times lower (i.e., more negative) than those recorded under the same conditions in other eucalypt species.

It is assumed that the very low water potentials of E. occidentalis during drought stress are primarily related to the matrix potential of the leaf water stored in the cell walls.

## Effect of salinity on growth of eucalypts

Y. Zohar

The salt tolerance of seven species of eucalypt and of five seed sources of Eucalyptus occidentalis from saline habitats in the natural area of distribution of the species in Western Australia were examined in trial plantations at 'En Yahav, Yotvata and Dizahav in Wadi Arava and on the Sinai coast. The saplings used for planting were selected in the nursery after irrigation with water containing increasing amounts of sodium chloride (up to 12,000 ppm). Early results indicate significant differences between seed sources of E. occidentalis, with the Esperance, W.A., provenance displaying the highest salt tolerance.



## Water status in conifers as an indicator of site adaptation

D. Heth

Water potentials and water saturation deficits of Aleppo pine were measured in the summer and autumn of 1975 at Lahav and Yatir in the southern Judean Mountains, at the southern limit of the Mediterranean phytogeographical territory. At each site, two trees of 10-11 years of age but contrasting height (7-8 m vs. only 2 m), growing under similar conditions except for the underlying rock (and, hence, rooting patterns), were selected. The water regime of the trees varied according to season and growth rate, with differences of 10 bars xylem water potential and 10% water saturation deficit occurring at the beginning of the dry season.

Diurnal and seasonal variations of xylem water potentials and water saturation deficits of Aleppo pine, Cupressus sempervirens and C. atlantica, were measured at Ilanot in 1974. The differences between values obtained at sunrise and at noon or in the afternoon were found to be a significant indicator of soil moisture stress. On red sandy loam of the Coastal Plain, Aleppo pine was found to be under severe water stress at the height of the dry season. Xylem water potentials of pine were not affected by age of branchlets.

This research has been completed and the results are being summarized for publication.

## Growth of Aleppo pine in the Judean Hills as affected by geological substrate

G. Schiller

Growth of Aleppo pine was investigated in the Sha'ar haGay forest, which displays considerable variation in the geological substrate. Statistical analysis of the data collected showed that site quality and development of pine depend primarily upon the nature of the underlying rocks. Growth of Aleppo pine and associated natural vegetation (oak scrub) is highest on dolomite with intercalated bands of marl and chalk, and lowest on hard limestone. Marl layers

arrest downward percolation of rainwater, while fissured limestone promotes deep seepage. There is, therefore, reason to believe that site quality is the direct result of differing soil moisture regimes in the root zone due to different seepage characteristics of the subsoil.

Field work in other forest plantations of the Judean Hills is under way to gain further insights into the relationship between tree growth and geological substrate as an aid for selection of the most suitable sites for reforestation.

#### Growth of Aleppo pine as related to site factors in the Sha'ar haGay forest

G. Schiller

Decline of Aleppo pine - drying of lower branches followed by loss of trees - in the Sha'ar haGay forest on the road to Jerusalem (planted 1926-1936), led to a comprehensive investigation into site factors and their effects on tree growth and mortality. Detailed records were taken in 62 sample plots of 0.1 ha each, of topographical and edaphic factors and characteristics of tree growth. Increment cores of affected and unaffected trees were also examined in each plot.

Significant correlations were found between stump diameter on the one hand, and diameter at B.H., height and volume on the other hand. This made possible the use of stump diameters to obtain full data on growth of trees removed during sanitation cuttings.

Stand density was found to be as low as  $200 \pm 100$  trees per ha (vs. an average density of 289 trees per ha in 1953).

No relation was found between decline of Aleppo pine and site factors: aspect and slope, soil type, geological substrate, etc.

Affected trees were found to produce very narrow annual rings but they had produced wide rings prior to 1960, i.e., they were apparently dominant and growing strongly at that time. In contrast, unaffected trees producing wide rings

at the time of the study, had produced in the 1950s narrow rings, i.e., they were apparently co-dominant or dominated.

Significant relations were found between tree diameter, social position (dominant, co-dominant, etc.), pattern of branching and amount of cones as related to crown volume. Type of branching, amount of cones and bark type on the one hand, and straightness and vigour on the other hand, were also significantly related. This leads to the assumption that Aleppo pine at Sha'ar haGay comprises at least two genotypes: (i) a genotype with relatively smooth bark, thin branches and few cones which is generally not affected by the decline; and (ii) a genotype with deeply fissured bark, coarse branches and numerous cones which is most prone to drying of branches followed by loss of the tree.

It is concluded that the decline of Aleppo pine at Sha'ar haGay is apparently the result of stress caused by the rapid succession of two drought years - 1959/60 and 1962/63, the stress being greatest in trees that were dominant and least in trees that were co-dominant or dominated. The importance of selection and breeding in Aleppo pine is emphasized.

### Tree introduction trials

A. Weinstein and R. Karschon

Seventeen new experimental plots were planted, with the emphasis on previously untried eucalypt species from the drier parts of the south and west of Australia. Provenance trials involving seed sources from most of the natural range of Aleppo pine and Brutia pine, sponsored by FAO as part of an international trial, were also established. American pines from dry rocky mountains in California and Mexico as well as Pinus eldarica are also included in the trial. Observations and measurements in existing plots were continued.

Experimental plots planted since 1960 were surveyed and the results are now being summarized. Species showing promise in the Lower Jordan Valley are: Acacia ciliata, A. salicina, A. victoriae, Casuarina luehmannii, Eucalyptus angulosa, E. astringens, E. dundasii, E. lesouefii, E.

occidentalis, and Prosopis alba.

The critical revision of all species planted in the Ilanot arboretum is being continued and identifications of exotics are being made in many of the older forest plantations.

Casuarina plantations were found to be composed of two species - Casuarina cunninghamiana and C. glauca, with growth of the latter being superior to that of the former. The use in reforestation of pure stands of C. glauca is recommended; this may be achieved either by importing pure seeds or by creating seed orchards by removal of all trees of C. cunninghamiana.

Plantations of so-called Arizona cypress were found to consist of two closely related species which are now recognized to be varieties: Cupressus arizonica var. arizonica (Arizona cypress) and C. arizonica var. glabra (Arizona smooth cypress). True Arizona cypress occurs at only low rates in plantations and is clearly superior in growth to Arizona smooth cypress; its exclusive use is, therefore, recommended.

The phenology as related to crown decline of Aleppo pine is under study in the Sha'ar haGay forest; additional observations are being made at Ilanot.

### Natural regeneration of Aleppo pine

G. Schiller

Research on this project was completed and the results are being summarized for publication.

Death of seedlings from natural seeding is due to lack of light inhibiting rapid root growth. Depletion of soil moisture is decisively affected by competition by grasses and other weeds. The regenerated area must be cleared of weeds.

There is conclusive evidence to show that with proper planning, Aleppo pine plantations can be regenerated by a shelterwood system, thereby providing an economical alternative to the replanting of cut forests.

## Reforestation by direct seeding and planting of seedlings

D. Heth

Early results of field trials started in 1974/75 showed that good growth and survival of pine were obtained by direct seeding following prescribed burning. Survival of Aleppo pine, Brutia pine and Canary Island pine was best when seeds were covered with 2-3 cm of soil. Scattering of mature cones as a source of seeds failed to produce seedlings.

Birds were more attracted to seeds of Aleppo pine and cypress than to those of Brutia pine, but good protection of seeds and seedlings was obtained by applying a repellent ('Reta', produced by Assia, Ma'abarot) to the mulch.

Application of fresh chicken manure in direct seeding improved growth of Brutia pine but depressed survival and growth of Aleppo pine and Canary Island pine. No response to fresh cattle manure was observed.

Survival and growth of planted seedlings were improved by spray application of water at the rate of about 0.3 liter per pit. Spraying was done once in February at the time of planting and three times (at monthly intervals) in the spring. Planting early in the winter to dispense with the need for spraying is under investigation.

Herbicide application ('Dukatlon', produced by Makh-teshim, Be'er Sheva) was found to reduce competition by weeds without injuring the seedlings.

## Effect of stand density and thinning on growth of pine

D. Heth and E. Spetter\*

Experimental plantations to study the effect of planting density on the growth of Aleppo and Brutia pine were established in March 1975 at Gezer and Eshtaol, respectively. Density of planting was 10,000, 3,500, 3,000, 2,500, 1,500 and 500 plants per ha. Measurements of growth are being taken periodically.

\*Forest Department, Land Development Authority, Qiryat Hayyim.

In a preliminary study of the effect of stand density on growth of Aleppo pine plantations, it was found that to achieve maximum yield more trees are needed per hectare on site class III than on site class I. Recommended densities according to age and site class are tabulated.

Long-term investigations on the effect of thinning intensities on growth of Aleppo pine and Brutia pine were started in 1975 and 1976. Five thinning treatments were applied to 11-12-year-old plantations with a stand density of about 3,000 trees per ha; up to 50% of the standing volume and up to 80% of the number of trees were removed. Measurements of tree height and diameter were taken before and after thinning and will be continued periodically to obtain data on the effect of thinning on yields. Photographs were taken with a 'fish eye' (wide-angle) lens to follow up changes in crown closure after thinning.

#### Growth of eucalypt on Lake Hula peat and its effect on nitrate levels

Y. Zohar

Nitrate contents in the 0-90-cm soil layer averaged 9.68 t/ha under eucalypt as against 33.64 t/ha outside the plantation. This difference cannot be due to absorption and accumulation of nitrate by the trees since their amounts are as low as 40-60 ppm in the stem wood and 70-100 ppm in the leaves. It is apparently due to chemical effects of root exudates and decomposition products of leaf litter. In addition, the nitrate-containing peat layers in the planted area are protected by the tree crowns against wind and water erosion and microclimatic conditions are less extreme than in the open; for instance, the soil temperature at the 5-cm depth in the plantation is 20°C less than that outside the forest.

Regeneration after cutting of 6-year-old E. x teretis trees was most rapid, with the first coppice appearing after 12 days and reaching a mean height of 6 m one year after cutting.

Growth of E. camaldulensis planted at different spacings (1x3 m, 2x3 m, 3x3 m) was very fast, reaching a height of 7.4 m and a B.H.D. of 8 cm after two years. No

significant differences were recorded so far between plots of different densities and between plots on neutral and acid peat. Growth occurred mainly from May to November, while little, if any, growth was measured from December to February when the terrain was flooded.

In a related nursery experiment flooding of the root zone of E. camaldulensis severely depressed growth without affecting the rate of survival, while maximum growth was recorded when half of the root zone was flooded. After one year the mineral composition of the leaves was examined; levels of phosphorus in leaves from flooded plants were only half of those in partly flooded or regularly irrigated plants.

#### Shelter effects on growth and yield of corn

Y. Zohar and J. Brandle\*

Soil moisture and plant moisture contents in plots protected by windbreaks were higher than those in unprotected plots; xylem water potentials of roots were lower in the open field than behind the shelter of windbreaks. Vegetative growth of corn was strongest in the protected plot, and flowering started one week earlier than in the open. Average yields per plant and per unit area were significantly higher behind windbreaks, with the excess yield amounting to 46% of that of the controls.

As a result of the particularly dry weather in Nebraska at the time of this research (summer 1976), improvement of soil-plant moisture relationships and of yields by wind shelter was most marked.

\*Dept. of Forestry, University of Nebraska, Lincoln.

#### Management of Mediterranean oak scrub

A. Weinstein

Experimental plots extending over 2 ha were laid out in a typical oak scrub of Quercus calliprinos at Keren haCarmel. Three treatments were applied on each of two opposing slopes: (i) thinning + pruning to 1/3 of tree

height + brush removal; (ii) thinning + pruning as above; and (iii) control. Detailed observations and measurements of tree height and diameter are conducted on 100 oaks marked for this purpose in the treated plots and on a similar number in the controls. Microclimatic measurements are carried out at one-month intervals at five sites reflecting different ecological conditions. Floristic and phytosociological studies are conducted in 30 quadrats. Fruiting of oak is also being studied.

#### Noise abatement by trees

G. Schiller and J. Keller\*

Abatement of noise intensity along traffic lanes and around industrial zones is of primary importance in improving the quality of life in these areas. Many investigations have indicated that vegetation can be used for this purpose. The present project deals with the acoustic properties of trees to determine suitable species and their lay-out.

A system was set up consisting of a generator producing a "white" noise broadcast by a series of loudspeakers and recorded on a tape recorder connected to a series of microphones arranged on a two-dimensional grid in front of and behind a given tree. The reduction of the white noise as affected by trees of typical growth and shape of a given species was thus evaluated. The species studied were Eucalyptus camaldulensis, Acacia cyanophylla, Pinus halepensis, P. pinea, Cupressus sempervirens var. horizontalis and var. pyramidalis, Thuja orientalis, Quercus calliprinos, Q. ithaburensis, Ceratonia siliqua and Ficus retusa. The rate of noise abatement of car engines was examined in eucalypt and pine plantations of different ages and in deciduous and evergreen oak scrub.

The field work was concluded and the results are being analyzed in the laboratory and summarized.

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\*Dept. of Applied Acoustics, Technion - Israel Institute of Technology, Haifa.



### Root biomass of Pinus radiata

D. Heth and D.G.M. Donald\*

As part of an overall study of primary production of Monterey pine, the root biomass of 20 trees in the Jonkershoek forest, Cape Province, S.A., was determined. The trees were 27 and 36-39 years old and their oven-dry root weight was 66.9-231.0 kg and 149.3-491.4 kg, respectively. Significant regressions and correlations were obtained among root weight, stump diameter and diameter at B.H. Weight of individual roots was related to the diameter at the point of origin of the root; this enabled us to estimate the weight of torn roots and of fine roots (< 5 mm diameter). Absolute amounts and percentage of fine roots decreased with tree age. Roots were most abundant in the 0-33 cm soil layer.

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### Eucalypt plantations as an energy source

K. Tischler and Y. Zohar

In view of the present energy crisis and the high cost of imported oil, research was started on the potential of eucalypt plantations as a renewable resource to be managed for energy production.

Trees in forest plantations on different sites were cut and divided up into stemwood, branchwood, bark and foliage to determine their above-ground biomass and caloric value. The energy content per unit area at different ages and in different coppice rotations is being assessed. Additional determinations and statistical analyses are being carried out.

## Improvement of eucalypt wood

K. Tischler

Macroscopic, microscopic and submicroscopic characters of the wood of Eucalyptus camaldulensis were studied. Differences in macrostructure were found between fast- and slow-growing trees, the percentage of sapwood being lower and the heartwood being darker in the latter. Variation in earlywood and latewood within growth rings was analyzed across the stem. The earlywood has a straight grain with longer and relatively thin-walled fibres. Microscopic investigation did not reveal substantial differences in cell type between collapsed and non-collapsed zones. However, a change in growth conditions affects the spatial disposition, number and size of vessels. There is but little contact between vessels and fibre tracheids. Examination by scanning electron microscope showed the presence of a warty layer, vestured pits and many tyloses, particularly in the inner heartwood zone. Because of their hydrophobic nature, the warty layer and pit vestures impede free water movement. Amounts of water-soluble and -insoluble extractives vary considerably across the stem.

The specific gravity of heartwood increases from the pith to the bark, being highest at the boundary between the heartwood and sapwood. An inverse relationship exists between the specific gravity and void volume. The wood near the pith has the highest porosity and presents the characteristics of juvenile immature xylem. Water uptake of the wood increases in the direction of the bark. The moisture content in the inner heartwood is higher than in the outer heartwood.

Volumetric shrinkage is not the same across the stem. Very high shrinkage with cell collapse takes place during the early phase of drying; this is presumably due to the incrustations of the pits of the heartwood fibres and to the relatively thin cell walls. Within the growth rings the volumetric shrinkage varies depending on the earlywood and latewood and the wall thickness and inclination angle of the cells.

Green wood shrinks tangentially when the moisture content is higher than the fibre saturation point. Below the

fibre saturation point tangential shrinkage decreases abruptly and radial shrinkage increases. Due to cell collapse, tangential shrinkage is three to five times higher than radial shrinkage at the beginning of drying.

Differences in structure and wood properties (cell size variation, tension wood, interlocked grain, extractives) create internal stresses in the stem which lead to distortion and splitting during the drying process. To reduce uneven abnormal shrinkage a series of drying schedules and methods was applied. Shrinkage was not markedly reduced by kiln-drying or high-frequency electric heating. To prevent warping and reduce uneven shrinkage during drying, the wood was impregnated with polyethylene glycol (PEG) as a bulking agent. It was found that penetration of PEG differs for each wood layer and is governed by two-dimensional diffusion processes. The water content decreases with penetration of PEG into the wood. PEG uptake is highest in the sapwood and lowest at the sapwood-heartwood boundary. The low penetrability of the boundary area coincides with its high content of water-insoluble extractives.

Isotherms of water sorption of PEG-impregnated wood in comparison with untreated wood showed that impregnation reduces both the accessibility to adsorbed water and the active surface of cellulose, and affects its water monolayer and multilayer capacity. The free surface energy and the affinity between the wood and water are changed by PEG impregnation. The best antishrink efficiency under room conditions is obtained with 50% aqueous solutions of PEG 1000 or 1500. The duration of impregnation depends on the thickness of the wood. Volumetric shrinkage decreases on the average from 29% for non-impregnated kiln-dried wood to 4-6% for treated sapwood and 8-9% for treated heartwood. No collapse occurs and the linear shrinkage anisotropy is lowered.

#### Effect of seed origin on wood density in Eucalyptus camaldulensis

K. Tischler

The effect of seed origin on basic density (oven-dry weight/green volume) was investigated in 6- and 10-year-old

trees from six Australian provenances, grown in experimental plots at Gan Hadar and 'En Teo (Hula Valley), respectively. Preliminary results indicate that between-provenance variation of wood density is greater than within-provenance variation.

#### Preservation of wooden posts used in agriculture

K. Tischler

Studies of the effectiveness of seven water- or oil-soluble chemicals are being continued in field tests on the service life of impregnated posts under different climatic and edaphic conditions, with and without irrigation application. Additional observations are being carried out on impregnated posts utilized in agriculture for different purposes.

#### Physical and mechanical properties of cypress timber

K. Tischler

Due to the increasing importance of cypress in reforestation, research was started on timber properties of var. pyramidalis and var. horizontalis. Testing, which is done according to ASTM standards, involves the following parameters: specific gravity, moisture content, shrinkage, toughness impact, static bending, tension, compression, shear, cleavage and durability. The statistical analysis of the data is under way.

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