DEVELOPMENT OF SALT TOLERANT CLONAL TREES IN AUSTRALIA

PAUL G. VAN DER MOEZEL AND DAVID T. BELL

Department of Botany, The University of Western Australia
Nedlands 6009
Western Australia

IAN J. BENNETT, MELANIE STRAWBRIDGE
AND JEN A. McCOMB

School of Biological and Environmental Sciences
Murdoch University
Murdoch 6150, Western Australia

INTRODUCTION

More than one billion hectares, or 7.6% of the world's land, consists of salt affected soils (1). Much of this area is naturally occurring saltland, such as mangrove forests, internally draining basins, and floodplains. However, an increasing proportion of land is becoming saline as the result of agricultural practices. In Western Australia about 12 million hectares of land has been classified as salt-affected, of which about 650,000 ha (5 4%) is induced salinity as a result of artificially high watertables, or as scalds caused by wind and water erosion (4).

Saltland forestry is one of the many strategies proposed for making productive use of salt affected soils. Planting trees is an attractive option because of the primary benefits of salinity control and land reclamation and the secondary benefits of wood products, livestock shelter, windbreaks, and ecological habitat construction. In many developing countries, planting trees on saltland or using saline groundwater to irrigate trees, will help alleviate chronic fuelwood shortages anticipated in the near future (2).

Salt affected soils have properties which can severely limit plant growth. High salt content and, in many cases, high sodium absorption ratios, waterlogging, and boron toxicity render saline soils very difficult to revegetate. Trees must be tolerant of high soil salinity and, where waterlogging is a problem, such as in Western Australia, plants must be tolerant of both salinity and waterlogging. Many Australian trees and shrubs have evolved in response to naturally occurring saline soils and have developed a high salt tolerance to cope with the stressful conditions In recognition of the ability of certain species to tolerate saline soils, a range of field trials have been conducted using seedlings of such species. In Western Australia the most consistently tolerant species used in field trials are *Eucalyptus camaldulensis, E. occidentalis,* *E. sargentii, E. spathulata, E. platypus* and *Casuarina obesa*. Many other species of *Eucalyptus, Casuarina, Melaleuca, Acacia,* and *Tamarix* also show potential as highly salt tolerant species. Nearly all existing field trials of salt tolerant trees have used seedlings grown from seed collected from natural stands. Limited information is available on the variation for characters such as salt tolerance among and within species provenances. As a result, the supply of highly salt tolerant seed from natural stands, or as a result of controlled breeding programmes is virtually non-existent. Micropropagation of trees selected for their salt tolerance has been recently used as a means of supplying genetically superior salt tolerant plants for revegetation of salt affected land (3).

TREE TECHNOLOGY PROJECT

In 1986 a consortium of public and private interests was brought together to develop salt tolerant clones of Australian tree and shrub species. The group consisted of Alcoa of Australia Ltd., The University of Western Australia, Murdoch University, CSIRO Division of Forests and Forestry Products, and Plantex (Australia). From 1986 through 1988 the emphasis of the project was to collect seed, screen the seedlings for salt and waterlogging tolerance, and tissue culture the selected tolerant individuals. Seed was collected by the CSIRO Tree Seed Centre from *Eucalyptus, Casuarina, Acacia,* and *Melaleuca* species growing naturally on or near saline areas. Seedlings were then grown by Alcoa's nursery for screening experiments at The University of Western Australia. Salt and salt/waterlogging screening experiments were conducted on seedlings in such a way that only the most tolerant individuals survived the stressed conditions. Altogether eight screening experiments were conducted using nearly 17,000 seedlings from 101 species. A total of 410 seedlings, representing an overall selection pressure of 7%, were selected for tissue culture at Murdoch University and at CSIRO, Canberra. The tolerant species and provenances identified during this initial screening phase were later subjected to more intense mass screening of a much larger number of seedlings than the initial research experiments and hence a greater selection pressure was applied. From the research and mass screening experiments a total of 601 mother plants from 60 species have been selected for tissue culture research (Table 1). Each species undergoes research at the tissue culture phase to maximise shoot multiplication rates, rooting percentage, and hardening-off rates. In many instances individual lines within a species vary as to the level of hormones, etc. required for optimum clone production. Lines vary considerably in their growth rate *in vitro*, and those that perform best are selected for commercial use. Mass multiplication of clones for field trials and further research experiments has been carried out by a commercial tissue culture laboratory, Plantex (Australia).

Table 1. Development stage of salt tolerant clones for species in the Tree Technology Project Stages of development described below

1 Salt screening (initial)	6 Hardening off research being done
2 Superior selected plants kept as mother plants	7. Tissue culture research complete
3 Initiated in culture	8 Field trails established
4 Shoot multiplication research being done	9. Seed orchard established
5 Rooting research being done	10 Second generation screening of seedlings from seed orchard

Species	Number of Mother plants	Development stage (see above) 1	2	3	4	5	6	7	8	9	10
Acacia ampliceps	3	x	x	x	x						
aulacocarpa	2	x	x								
auriculiformis	2	x	x	x	x						
brumalis +	1	x	x								
cyclops	5	x	x	x	x						
hemsleyi	2	x	x								
ixiophylla	1	x	x								
maconochieana +	6	x	x	x	x	x	x	x	x		
mutabilis ssp *mutabilis* +	2	x	x								
mutabilis ssp *stipulifera* +	2	x	x								
patagiata +	3	x	x								
pendula	2	x	x								
redolens	4	x	x								
saligna	23	x	x	x	x						
sclerosperma	1	x	x								
stenophylla	13	x	x	x	x						
Casuarina glauca	20	x	x	x	x	x	x	x	x	x	
cobesa	38	x	x	x	x	x	x	x	x	x	
Eucalyptus calycogona	6	x	x	x	x	x	x	x	x		
camaldulensis	60	x	x	x	x	x	x	x	x	x	x
comitae-vallis	1	x	x	x	x	x	x	x			
coolabah	16	x	x								
exserta	2	x	x								
famelica +	0	x									
halophila	31	x	x	x	x	x	x	x	x		
intertexta	14	x	x	x	x						
kondininensis	7	x	x	x	x	x	x	x	x		
kumarlensis +	3	x	x								
leucoxylon ssp *megalocarpa*	1	x	x								
microtheca	31	x	x	x	x	x					
occidentalis	41	x	x	x	x	x	x	x	x		
pileata	2	x	x								
polybractea	3	x	x	x	x	x	x	x	x		
raveretiana	18	x	x	x	x	x					

Table 1 Continued

Species	Number of Mother plants	Development stage 1	2	3	4	5	6	7	8	9	10
robusta	2										
rudis	3										
salicola +	4										
sargentii	39										
sideroxylon ssp. *sideroxylon*	1										
sideroxylon ssp *tricarpa*	3										
socialis	7										
spathulata ssp. *grandiflora*	3										
spathulata ssp *spathulata*	34										
stricklandii	1										
striaticalyx	15										
tereticornis	*12*										
wandoo	17										
yilgarnensis +	6										
Melaleuca acacioides ssp *alsophila*	4										
acuminata	3										
bracteata	14										
cajuputi	3										
cuticularis	0										
decora	2										
eleuterostachya	5										
glomerata	6										
halmaturorum	12										
lanceolata	8										
lateriflora	5										
quinquenervia	2										
thyoides	5										
uncinata	13										

* Casuarina clones for field trials now produced by needle cuttings

Field trials of clonal plants have been established on salt-affected land to examine the salt tolerance of selected clonal material with unselected seedlings from the same provenance A minimum of 3 to 5 years is required to quantify the survival and growth rates of clones and seedlings in soils of varying salinity Field trials of earlier selections of salt tolerant *Eucalyptus camaldulensis* have been established since 1983 in Western Australia New selections of salt and waterlogging tolerant clones have been included in field trials since 1988. A total of 99 lines from 17 species will have been established in field trials by the end of 1990 (Table 2). Most trials are located in Western Australia on private farms in the southwest wheatbelt and grazing districts. Trials have also been extended into Victoria, Queensland, South Australia, and New South Wales in Australia and overseas in Thailand, U.S.A., Namibia, Kuwait, Saudi Arabia, Morocco, and Mexico. The early 1983 plantings of *Eucalyptus camaldulensis* are providing useful information on comparisons among clones and between clones and seedlings. In most cases the clones are performing as well or better than seedlings and with a more uniform result as expected from clonal material. In field trials other aspects of the selected salt tolerant clones become apparent after a number of years. Characters such as growth rate, leaf area, and stem straightness are not selected for in young seedlings but vary tremendously in developing trees. While all clones may be salt tolerant they may have other characters desirable for planting such as high leaf area for water use, straight stems for fence posts, or bushy growth for windbreaks. The paper pulp quality of *E. camaldulensis* clones will also be determined when the plantations are old enough for meaningful analysis.

Table 2. Species and number of clone lines used in field trials on salt affected land

Species	Number of clones in field trials	Age of oldest trial
Acacia maconochieana	1	1990
Casuarina obesa	9	1988
glauca	10	1989
Eucalyptus camaldulensis	44	1983
calycogona	3	1989
halophila	4	1989
kondininensis	2	1988
occidentalis	3	1990
sargentii	3	1990
spathulata ssp *grandiflora*	1	1988
spathulata ssp *spathulata*	9	1988
Melaleuca bracteata	5	1989
eleuterostachya	1	1989
glomerata	1	1990
halmaturorum	1	1990
lanceolata	1	1990
lateriflora	1	1990

Forest tree improvement programs are an integral part of commercial forestry industries worldwide. From successive selections and breeding cycles, the genetic quality of the selected population is increased for the particular trait being selected. In the same manner in which commercial foresters select for economic traits such as yield, form, and stem straightness, the salt tolerant clones developed in the Tree Technology Project are being set up so that salt tolerance will be increased in successive breeding cycles. Seed orchards of clones are planted to maximise natural crossing between clones and to allow for controlled genetic manipulation of particular clones. Isozyme analysis of the seed collected from a *Eucalyptus camaldulensis* clone seed orchard has revealed a high degree of outbreeding between clones from widely varying geographic areas (S. James, pers. comm.). The resultant open-pollinated seedlings exhibit a wide range of salt tolerance with some individuals more tolerant than the clonal parents. These second generation selections are presently being prepared for tissue culture to produce plants for field trials. It is anticipated that seed orchards will be set up for all salt tolerant clones. In the future controlled crosses may also breed into the improved salt tolerance other desirable attributes such as improved growth rates, better form, frost and disease resistance.

CONCLUSIONS

There is a vast amount of salt affected land in the world which can be made more productive by the option of saline forestry. Planting trees on saltland has many ecological and economic benefits. Salt tolerant clonal trees are being successfully grown on salt affected land in Western Australia due to a combined approach of seed collection, plant screening, and tissue culture research. The program to develop these clones is advancing from the initial research phase, to the incorporation of clonal selections into tree breeding programs and second generation selection, tissue culture, and field trials of improved salt tolerant genotypes.

Acknowledgements. Financial assistance was provided by Alcoa of Australia Ltd and by the National Biotechnology Program administered by the Commonwealth Department of Industry, Technology and Commerce

LITERATURE CITED

1. Food and Agricultural Organization of the United Nations/United Nations Educational Scientific and Cultural Organization 1971-81 Soil map of the world—1·5,000,000 (10 volumes). UNESCO, Paris.

2 Fraser, A I 1988 Fuelwood a review of its global use *Outlook on Agriculture* 17.7-9

3 McComb, J.A , I J. Bennett, P.G van der Moezel, and D T. Bell. 1989 Biotechnology enhances utilization of Australian woody species for pulp, fuel, and land rehabilitation. *Austral Jour Biotech.* 3·297-301

4 Selected Committee on Salinity 1988 Report on salinity in Western Australia, first report Parliament of Western Australia, 72 pp