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THE INTRODUCTION TO NEW ZEALAND OF ELMS RESISTANT TO DUTCH ELM DISEASE

S.A. PARKINSON

Soil Conservation Centre, Aokautere
Ministry of Works and Development
Private Bag
Palmerston North

Elms (*Ulmus* spp.) are hardy deciduous trees common throughout the northern hemisphere. They are used both for timber and amenity plantings and for centuries they have been predominant in the European countryside in hedgerows, fields, and wooded areas. Their use most pertinent to New Zealanders is in the urban environment where they are used in street plantings and parks and are frequently seen in the larger home garden. This, however, could change in New Zealand as it has in Europe, the United States, and Canada with the advent of Dutch elm disease (DED), if this dreaded fungus disease ever reaches this country.

HISTORICAL BACKGROUND

There has been two major outbreaks of DED in the northern hemisphere. The disease was first identified in western Europe in 1918 by Dutch scientists — hence the name Dutch Elm Disease. In 1927 it was found in southern England where it caused the deaths of many elms. The epidemic reached its peak about 1936 and then declined with fewer trees being infected and the symptoms becoming less severe. Europe was not alone with its problems, as in 1930 the disease was also identified in the U.S.A. where it was reducing the American elm population.

In Europe, DED appeared to be controllable until the late 1960s when it became obvious that there was another epidemic in England and that the causal fungus was far more virulent than that which had previously infected the elm tree population. Research showed that the second epidemic had been caused by a more aggressive strain of the original fungus and

that it had probably been carried on unbarked elm logs imported from Canada. Since 1970 over 10 million elms in England and over 40 million in the U.S.A. have died.

LIFECYCLE AND SPREAD OF THE DISEASE

DED is caused by the fungus, *Ceratocystis ulmi*. The disease is carried from dead and dying elms to healthy trees by the elm bark beetles, *Scolytus scolytus*, and *Scolytus multistriatus*.

Elm trees which have recently died or are dying from the diseases are a breeding site for mature bark beetles. The beetles are attracted by pheromones given off by the tree and by the beetles already present on the tree. Both the adult beetles and the larvae tunnel characteristic insect galleries under the bark. Hyphae produced by the fungus grow through the bark and sporulate in the galleries. The spores become attached to the bristly hairs on the body and legs of the young beetles and are carried with them when they emerge in the spring. The beetles will fly or are carried by the wind to healthy elms where they will feed (maturation feeding) in the crotches of the twigs in the crown. The spores of the fungus carried by the beetle can then enter the tree through these feeding wounds. The spores develop in the woody tissue and are transported through the tree in the vascular system (Figure 1).

It is the defense reaction of the tree to the fungus in the vascular system which first make it obvious that the tree is infected with DED. The presence of the fungus stimulates the host tree to produce gummy deposits which clog the vascular tissue, leading to wilting and yellowing of the leaves, the first symptoms of the disease. Water is stopped in its passage up the tree and the crown wilts and dies. The gummy deposits in the vessels help in the identification of the disease. On stripping the bark off the twigs or cutting across their stem, brown streaks or spots can be seen in the outermost annual ring. The disease cycle is completed as the tree is weakened by the disease and becomes a breeding site for the beetles.

The disease is also spread by the tree itself. When the roots of adjacent healthy and diseased trees meet, the roots graft together and the sap intermingles, carrying the fungus from one tree to another, thus spreading the disease. Disease transmission via the roots is the predominant way in which the disease is spread in hedgerows in England.

Man cannot be ignored as an agent in disease transmission as he has been responsible for spreading the disease first between Europe and the U.S.A. and then returning the more virulent strain to Europe. As well as bearing this responsibil-

ity, man has moved infected timber within most countries where the disease occurs. Infested beetles within the timber emerge at their new location and infect the healthy trees in the area. There is also evidence that the beetles can emerge during transport of infected logs and new outbreaks have been found associated with major transport routes.

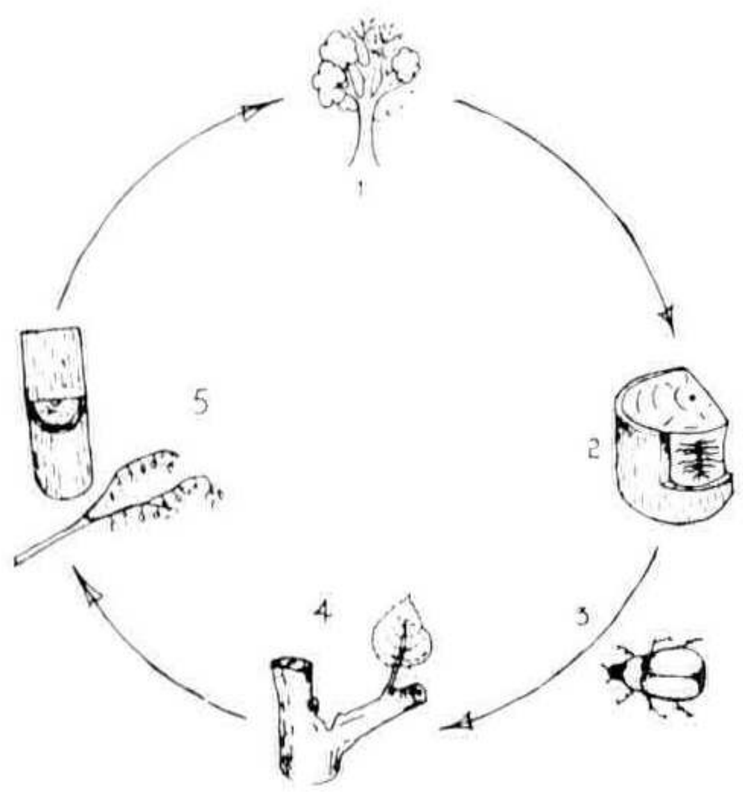

Figure 1. Life cycle and spread of the disease.
1. Trees weakened by the disease become breeding sites for beetles.
2. The adult beetle and larvae tunnel characteristic insect galleries under the bark.
3. Adults emerge in the spring and early summer from the bark of dead and dying elms, carrying spores of the fungus.
4. The beetles feed in the twig crotches of healthy trees and introduce fungal spores into the tree.
5. Infected parts wilt and diseased twigs show characteristic dark spots or streaks.

CONTROL

When the disease first broke out in England some control was achieved using a sanitation programme of felling the dead and diseased trees and destroying the bark. In this way the beetle larvae were killed before they could emerge as adults. When the disease was first discovered in the U.S.A. an effort was made to eradicate it using this sanitation programme. The programme was very successful up until the beginning of the second world war when manpower and funds were directed into the war and the attempt to eradicate the disease failed.

The insecticide DDT was also used as a method of control in the U.S.A. The idea was to spray the healthy trees with DDT to kill the beetles before they could introduce the disease to the tree. This reduced the number of infected trees but it also killed the wild life in the trees and surrounding vegetation and the programme was stopped. A less persistent chemical — methoxychlor (Marlate) — is now recommended. The healthy trees are sprayed in late winter and early summer to

kill the young beetles as they come to the trees to feed. Seasonal protection can also be given by injecting the trunks with the fungicides, carbendazin hydrochloride (Lignason), and benomyl (Benlate) which spread upwards in the tree with the rising sap.

A current method of controlling the spread of the disease via the roots of infected trees is to inject a soil sterilant, metham sodium, into the soil where the roots of elms could meet and exchange the disease. The chemical kills only tree roots that may try to grow through the treated soil and the trees are effectively isolated from each other.

ELMS RESISTANT TO DED

An alternative to control and prevention of the spread of the disease is to breed and select elms resistant to DED. A breeding programme began in Holland soon after the disease was first identified. The first resistant cultivars were released in 1936 but were not successful as they were susceptible to other diseases and lacked vigour. Two further clones were released in Holland in 1960. They are:

Ulmus × *hollandica* 'Commelin' — described as a fast-growing elm of moderate resistance to diseases and wind and suited for rural plantings, and

Ulmus × *hollandica* 'Groeneveld' — a slower-growing elm, with a rather dense crown, suited to the urban situation.

Both 'Commelin' and 'Groeneveld' were widely planted in Holland and small numbers were also introduced into other European countries including Britain. Late in the 1960s it became obvious that, in particular, the clone 'Commelin' was susceptible to the aggressive new strain of the fungus.

Previous to the new outbreak, the Dutch had been using European elms in their breeding programme. With the outbreak of the new aggressive strain of DED, the Himalayan elm, *U. wallichiana* was included in the parentage of new hybrids. The new breeding programme resulted in the selection of three clones which showed considerable resistance. The three clones were released in 1975 as: 'Dodoens', which has the appearance of a vigorous Exeter elm (*U. glabra* 'Exoniensis'); 'Lobel', which is a fastigiate narrow-crowned tree with small leaves; and 'Plantyn', which is broader in the crown than 'Lobel' and has greyish-green leaves and twigs. All three clones have the same female parent, *U. glabra* 'Exoniensis' (Table 1).

Elm breeding programmes were also established at various research stations in the United States and Canada. Resistant

parents of Asiatic origin (*U. pumila*, *U. davidiana* var. *japonica*), resistant cultivars from Holland, and *U. glabra* clones have been used in the American programmes to yield a number of resistant elms.

Two of the most commonly planted clones are *Ulmus* 'Sapporo Autumn Gold', of good vigour, disease resistance and ornamental value; and *U.* 'Urban'. Other resistant clones recently released on an experimental scale are *U.* 'Recerta' and *U.* 'Regal' in the USA; 'Jacan' and *U.* 'Thomson' in Canada; and *U.* 'Clusius' in Holland.

Table 1. *Ulmus* cultivars resistant to Dutch elm disease.

Cultivar	*Parentage*	*Selected by*
Dutch cultivars released in 1960 (suspectible to aggressive strain DED).		
'Commelin'	*U. hollandica* 'Vegeta' × *U. carpinifolia*	Phytopathological Laboratory, Baarn, Holland (Dr. Went).
'Groeneveld'	*U. glabra* × *U. carpinifolia*	Ditto
Dutch cultivars released in 1975 (resistant to aggressive strain DED).		
'Dodoens'	Self pollinated from the hybrid *U. glabra* 'Exoniensis' × *U. wallichiana*	Forest Research Station Dorschkamp, Wageningen, Holland. (Dr. Heybroek).
'Lobel'	(*U. glabra* 'Exoniensis' × *U. wallichiana*) × *U. carpinifolia*	Ditto
'Plantyn'	(*U. glabra* 'Exoniensis' × *U. wallichiana*) × *U. carpinifolia*	Ditto
Resistant American cultivars (resistant to aggressive strain DED).		
'Urban'	(*U.* × *hollandica* 'Vegeta' × *U. carpinifolia*) × *U. pumila*	USDA Nursery Crops Research Laboratory, Delaware, Ohio. (Dr. Schreiber).
'Sapporo Autumn Gold'	*U. pumila* × *U. davidiana* var. *japonica* (Open pollinated seed from Botanical Garden, Sapporo, Japan).	Phytopathological Institute, University of Wisconsin (Prof. Smalley).

INTRODUCTION TO NEW ZEALAND OF ELMS RESISTANT TO DED

DED has not yet been found in New Zealand and there is no record of the elm bark beetle. The beetle, however, has been identified in Australia, and has been intercepted on several occasions in New Zealand.

The most common elms in New Zealand are *U. procera*, *U.* × *hollandica*, *U. glabra* 'Pendula' (weeping elm), *U. glabra* 'Van Houtte' (golden elm), *U. procera* 'Variegata', and the Chinese elm, *U. parvifolia*. Except for the latter these are all

susceptible to DED if the disease was ever to become established in New Zealand.

The Plant Materials Group at the Soil Conservation Centre, Aokautere, Ministry of Works and Development, imported 6 cultivars resistant to DED in 1978 and 1980. The trees' first growing season in New Zealand was in quarantine at the Plant Diseases Division, DSIR, Mt. Albert. Plants and cuttings of 'Dodoens', 'Groeneveld', 'Plantyn', 'Lobel', 'Sapporo Autumn Gold' and 'Urban' were released from quarantine to the Centre in June, 1979, and September, 1981. After lining out in the nursery for 12 months, investigations were made into the best methods of propagation.

PROPAGATION METHODS

Hardwood Cuttings: Hardwood cuttings, 25 cm long, were taken in September (spring) from the basal portion of one-year-old shoots. These base of the cuttings was dipped for 15 seconds in 1000 ppm indolebutryic acid (IBA) before setting into a peat: pumice (50:50 by volume) propagation medium in wooden containers. The containers were put in a cold frame with bottom heat and covered with glass and Sarlon shade cloth for six weeks. The frames were ventilated and hand watered daily. When the six weeks heat treatment was completed, the heating cables were turned off and the glass removed. The cuttings were left under shade in the cold frame until early December when the rooted cuttings were transplanted into a medium with fertilizer (Table 2) in planter bags.

Table 2. Medium plus added fertilizers for growing rooted cuttings.

Medium components		Fertilizers
50 l peat	15 g	potassium sulfate
10 l soil	300 g	superphosphate
20 l pumice	50 g	Osmocote (3-4 mth)
20 l perlite	100 g	Osmocote (8-9 mth)
	10.5 g	fritted trace elements
	200 g	hydrated lime
	300 g	dolomite lime

The percentage of cuttings which were rooted and could be transplanted were:

'Dodoens'	32%	'Groeneveld'	No cuttings made
'Lobel'	32%	'Sapporo Autumn Gold'	10%
'Plantyn'	8%	'Urban'	30%

Grafting: Hardwood material of 'Sapporo Autumn Gold' and 'Urban' was grafted. In September, *U. glabra* stock was

brought into the glasshouse and forced with warmth and light to come into leaf. Both whip and tongue and cleft grafts gave 100% success with both cultivars.

Softwood Cuttings: In March 1983 (autumn) the elms planted in the field came into a second flush of new growth. This new material was used for making softwood cuttings, each 15 cm long with the basal portion of the cutting semi-lignified. The cuttings were treated with Seradix 2 before setting in a 50:50 peat/pumice mix (by volume) in Hillson Root-Trainers. They were then placed under intermittent mist ensuring that the leaves did not desiccate. The rooted cuttings were bagged in May. Only a small number of cuttings were made of each cultivar but the results were promising and further trials will be made.

Root Cuttings: When the plants were lifted after their first growing season in the field, the thickest roots were used to make root cuttings.

The roots were washed thoroughly and cuttings 5 to 15 mm thick and 50 to 150 mm long were prepared. After preparation they were dipped into a weak solution of the fungicide, thiram, and the ends of the cuttings were sealed with Shell Grafting Matrix (a petroleum-based product containing captafol). The roots were placed on a layer of pumice in propagation trays, covered with damp sphagnum moss, and the trays placed on a heated bed under intermittent mist.

Two months later the roots of 'Dodoens' and 'Lobel' had produced shoots 50 to 80 mm long. The shoots were removed from the roots by cutting a small piece of root away with the shoot. (The wounds on the root were sealed with the Grafting matrix). The base of the shoot was dipped in Seradix 1, set in pumice and returned to the mist. Within a month the shoot had produced roots and could be removed from the mist and transferred to a potting medium containing fertiliser (Table 2).

Three months after the roots had first been placed under the mist, more shoots were produced from 'Dodoens' and 'Lobel' and the first shoots were taken from 'Plantyn' and 'Groeneveld'.

The percentage of shoots which rooted and could be bagged from those originally removed were: →

Dodoens	96%	Plantyn	72%
Lobel	54%	Groeneveld	46%

Tissue Culture: In 1981 a culture of *U. villosa*, a Himalayan small-leaved elm, relatively resistant to DED, was received from the Forest Research Station, Wageningen, Holland. Plant-

lets were successfully proliferated on a modified Murashige and Skoog medium.

'Dodoens', 'Lobel', 'Plantyn' and 'Groeneveld' were put into culture using the soft juvenile material from the shoots of the root cuttings. The material produced callus but a suitable medium for promoting proliferation was not found.

NEW ZEALAND QUARANTINE REGULATIONS

To prevent DED from entering New Zealand the Ministry of Agriculture and Fisheries has imposed strict quarantine regulations on the importation of elm material. Seed, rooted stock, or grafting material can only be introduced with a special import permit and the material needs to be quarantined for at least one growing season in the glasshouses of the Plant Diseases Division (DSIR) at Auckland.

Imported elm timber either sawn or as logs must have the bark removed and is inspected for insects at the port of entry by the New Zealand Forest Service.

SUMMARY

In view of the probability of DED reaching New Zealand and becoming established, there are two recommendations. Firstly, that the clones resistant to the disease be propagated and sold for amenity plantings and, secondly, that as new clones resistant to DED become available, they be introduced to New Zealand.

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