

DANIEL McALPINE MEMORIAL LECTURE

Diseases of Citrus Trees in Australia — the First Hundred Years

I must first thank the Australian Plant Pathology Society for the honour it has conferred in inviting me to give the first Daniel McAlpine Memorial Lecture, a task and a responsibility which I have undertaken with diffidence. I would also like to thank those colleagues whom I have consulted and whose work I have used, and Mr. Stan Fish who allowed me a preview of his contribution to the APPS Newsletter — "Daniel McAlpine, A Pioneer Plant Pathologist of Australia."

Since diseases of citrus trees are my own special interest I have interpreted this task by attempting to place in perspective McAlpine's contributions to citrus pathology at the end of the last century and to review the body of information which has accumulated since his time.

McAlpine in Victoria and Cobb in New South Wales faced a tremendous task, as pioneers in an area where scientific research was in its very early stages, of establishing plant disease diagnostic and advisory services in their respective states. They were appointed as the direct result of the wheat rust outbreaks of the late 1880's, which convinced the politicians of the time that plant diseases could be important enough to require the attention of trained scientists. With the formation of Departments of Agriculture in these two States plant pathology became a government service.

Both McAlpine and Cobb found it necessary to make careful microscopic studies of organisms which they found associated with plant diseases, and McAlpine in his seven books and numerous reports and contributions to scientific journals described many species of fungi new to science. He clearly was a most diligent and painstaking man who felt strongly the need for a basis of accurate scientific description to enable the identification of the phenomena he observed.

The material which McAlpine collected in the field or had sent to him for diagnosis was examined, described and clearly illustrated, and it was part of the thoroughness of his approach that all this should be collated in book form for each crop and presented, with clear introduction and explanation to bring to the grower means of identifying his troubles and treating them by the most suitable methods then known.

His books have been equally valuable for plant pathologists who followed him by giving a picture of the disease status of each crop at the time he wrote. All published records were examined, correspondence carried on with workers in other states and overseas and with growers, and to this was added his own observations and evaluations.

I have taken for my main title the title McAlpine used for the book "put together" as he wrote "at odd times and for the benefit of growers" — Diseases of Citrus Trees in Australia. This title provides the opportunity for a tribute to him as the founder of citrus pathology in Australia and also it has a particular aptness. The commercial citrus tree, as I need not emphasise, is a composite of two parts — the scion of which there are over 25 species and varieties in common use in Australia (and many more overseas) and the stock of which there are at least seven, not counting selections and strains, and these comprise representatives of two genera, several species and intergeneric and interspecific hybrids. This given plenty of scope for variety in disease reaction, and variety there

certainly is. Both stock and scion varieties show ranges of reaction to fungal and to viral infections which affect the health of the tree as a whole through the diseases which they cause of the stock or of the scion.

McAlpine listed nine principal diseases, all fungal, of citrus trees, with descriptions of symptoms and of the fungi which he found associated with them, and with suggestions for treatments which he was careful to point out he had not had the opportunity of testing. These diseases were —

- False melanose caused by *Cladosporium brunneo-atrum* n.sp., an important disease of oranges in coastal New South Wales, attacking fruit, leaves and twigs. "Oranges spotted over with the disease were to be found in the Sydney market literally by the ton" remarked Cobb in 1897 (5).

- Black spot, or anthracnose, caused by *Phoma citricarpa* n.sp., a serious disease of orange, mandarin and lemon fruit in coastal New South Wales.

- Sooty mould caused by *Capnodium citricolum* McAlp., which grew on exudate of scale insects — a serious problem in all citrus growing areas. In this section he discussed the possible use of the three fungus parasites of scale insects, which he also described, drew attention to the effect of the destruction of birds on scale build-up, and the large issues raised by man's interference with nature.

- Black scurf of Citrus fruits caused by *Coniothecium scabrum* n.sp. on orange and shaddock at Burnley, Victoria.

- Scabbing of fruit and leaves of orange, lemon and citron in Victoria, New South Wales and Queensland. These clearly caused him trouble because of the numbers of fungi associated, many of them saprophytic on exudates from damaged rind. Several different types were distinguished, and of the many associated fungi, six species were described as new.

- Wither tip caused by *Phoma omnivora* n.sp., widespread in all states, on lemon, orange and citron.

- Bark blotch of lemon caused by *Ascochyta corticola* n.sp., associated with declining health of lemons in Victoria.

- Collar rot caused by *Fusarium limonis* Briosi, a serious and widespread disease, first described in the Azores in 1832.

- Root rot caused by *Phoma omnivora* n.sp., which he considered to be distinct from root rotting associated with collar rot.

Not included in this section, but included in the section of technical descriptions of fungi were brown blotch of the lemon, caused by *Septoria depressa* n.sp., a minor fruit spotting disease of lemons in Victoria and *Ramularia scabiosa* McAlp. & Tryon causing a scab disease of lemon and orange leaves in Queensland. This was the first description of the Australian lemon scab fungus.

The second section of the book comprises technical descriptions and figures of the eighty two species of fungi which he had found on citrus adding 78 to the list of species previously recorded on this host. Of these 58 were new to science. The bulk of them were saprophytes and were included so a distinction could be drawn by anyone who "took the trouble to examine" affected tissue. He says "It is very necessary for inspectors and others who wish to keep abreast of present day knowledge with regard to fungi in relation to plants, to know the various forms which may be met with, so as to discriminate between the really serious pests and those which are comparatively harmless or positively innocuous".

I have chosen the subtitle — The first hundred years — because it takes us back before McAlpine's time to the first well-documented case of a serious disease outbreak affecting citrus trees in Australia. This was root and collar rot, or gummosis, a disease which up to the nineteen thirties had been the greatest single cause of loss to growers wherever citrus trees have been grown.

Citrus trees were brought from Rio de Janeiro to Sydney with the First Fleet and subsequently from other countries along the shipping lane (4), and from China, Japan and other Eastern ports. During the early eighteen hundreds citrus was planted particularly around Ryde, Parramatta and Baulkham Hills near Sydney on a commercial scale. John Dunmore Lang in 1852, (8), describing the scene from one of the two steam-boats which daily traversed the Parramatta River between Sydney and Parramatta says "there are various orchards and organgeries close to the water's edge, the proprietors of which make a comfortable livelihood for their families by selling their fruit on the Sydney market. The orange trees are planted in long double rows, with an avenue between, and the view along the avenue, on each side of which the thick dark green foliage of the trees contrasts most beautifully with the bright yellow fruit with which the branches are loaded can scarcely fail to remind the scholar of the gardens of the Hesperides".

However by 1865 the thick dark green foliage had become yellow and sickly and trees were dying with gummosis. In 1860 the rainfall recorded at Parramatta was 1850 mm and in 1964 it was nearly as heavy, compared with an annual average of less than 1000 mm. These conditions would certainly have encouraged root and crown rots and contemporary descriptions leave no doubt that the disease now known to be caused by *Phytophthora citrophthora* had struck on a very wide front. Thousands of trees died and many more were rendered unprofitable.

So serious was the position that a Select Committee of nine members was set up by the New South Wales Legislative Assembly, on 31st October, 1865 "to report... upon the Disease in Fruit Trees". This committee began hearing evidence on 15th November, 1865. From the evidence it was clear that the disease was associated with poor drainage and the unusual rains which had left trees in very wet soils for longer periods than previously. It was implicit in many of the statements that gummosis was recognized to be an infectious disease.

The report, issued on 13th September, 1866, (1), concluded that the destruction of orange trees had been enormous during the last few years, occasioning great loss to individuals and to the community at large, recognized the connection with defective drainage and too much rain, drew attention to the need for good drainage, and stress the need for better meteorological observations. Charles Moore, Director of the Sydney Botanic Gardens, who was about to take charge of Colonial Products at the Paris Exhibition offered to visit Portugal and Spain en route and examine the disease which was reported to be affecting the citrus industry there. This he did and his report of 1868 (12), provides a vivid description of the affected trees and clearly he understood the nature of the trouble, that it was caused by a fungal disease, and recommended the trial in Australia of sour orange stock which had proved resistant in Spain.

The disease was also reported in Victoria and Queensland (9), though not on such a disastrous scale as in New South Wales. The use of sour orange, or Seville orange as it has always been called in Australia, had been recommended much earlier, by Suttor in 1843, who recorded that he had obtained some good trees of China

orange on Seville, and by Shepherd, a Sydney nurseryman who in 1851 had published an informative Catalogue of Plants, recording amongst other things a high regard for shaddock, Lisbon lemon and Seville orange as stocks for citrus trees (4). Other stocks he said were a "waste of time". Mackay in 1874, reasoning from the Spanish experience also thought that this stock should be useful, quoted "the veteran grower Mr. Pye", as sanctioning its use, and remarked that it had been tried successfully in Queensland. Mackay also stated however "in the matter of the best stocks to work the orange, our best growers are not unanimous" (4).

In 1890, at a Fruit Growers' Conference in Sydney (4), Mr. Thomas Pye, son of the veteran grower already quoted, and himself a grower of 25 years experience, said "never use Seville orange stocks as they have proved a complete failure" and this was to be the experience in many subsequent trials in New South Wales. Much later it was shown in South America and California that the cause of death of orange trees on sour orange stock was the aphid-transmitted virus disease — tristeza, a disease which had long been present in South Africa, where sour orange stocks had also been a complete failure.

We can therefore infer that tristeza was present, though symptomlessly, in trees in the New South Wales central coast well before 1890. The record that shaddock, Lisbon lemon and Seville orange were well regarded as stocks in 1851 would put the introduction of tristeza (or its vector) later than that, as all these varieties are susceptible to tristeza as stocks. The reservations expressed by Mackay in 1874 may indicate that some growers had experienced failures with Seville stock before that time. The penetration of the South Australian and Victorian industries by tristeza came later. Seville orange had been widely used as a stock in the early plantings at Mildura, for orange varieties, the budwood of which had been imported direct from California, and it was the main stock used in South Australian irrigation settlements on the Murray River. These trees, comprising groves of 40 years old or older were starting to succumb only by the late 1930's, probably because of the later entry of aphids (10).

The disease would have been distributed in trees from the several large nurseries round Ryde, in the Sydney district which from the turn of the century, for the next 50 years, sent nursery trees on the tristeza-tolerant rough lemon and sweet orange stocks to all parts of Australia, to New Zealand and even to South America. In 1933 several large shipments were sent by Thomas Eyles from his nursery at Dundas to large estates then being developed in Argentina (personal communication). It seems likely, therefore, that Australia shares responsibility with South Africa for the tristeza epiphytotic which, starting about 1937, eliminated millions of trees on sour orange stock in South America over the next 20 years. The origin of tristeza introduction into New South Wales cannot be pinpointed. While there seem to be no specific records of introductions from South Africa (4), these may well have occurred, since vessels on the route from London called there. We know little of the early history of tristeza in South West Asia, another possible source, or the source of, or the time of entry of the aphid *Toxoptera citricidus*, its most efficient vector.

Another disease which was evidently present before 1899, but not a problem, is exocortis, which affects the deciduous Chinese rootstock, *Poncirus trifoliata*, but is symptomless in other generally used stock and scion varieties. Crichton in 1893 (quoted by Bowman) referred to *Citrus trifoliata* as giving satisfaction as a stock in Victoria because it was hardy and little affected by disease

("possibly the first intimation of its *Phytophthora* resistance"), but he comments that it had a dwarfing tendency and that it might therefore prove particularly suitable for mandarins. It is a fair assumption that this indicated the presence of the exocortis-gummy pitting complex in mature trees on trifoliate stock at that time. The virus disease psorosis may also have been present. It was identified first in New South Wales in 1928 in old trees, and was a legacy from bud-lines introduced much earlier from California and Europe. The delay in the appearance of symptoms, sometimes as long as 40 years, would explain the lack of earlier records.

Of the diseases listed by McAlpine, melanose, sooty mould, scab and black spot, were well established and had probably been present for years previously. Lemon scab was evidently troublesome in Queensland by 1876. The forms discussed by McAlpine as greyish brown and dirty brown scabs of the fruit and described by Cobb (5), as grey scab of lemon fruit are clearly also this disease, as well as the scab on lemon leaves from Queensland, which is the type collection. Black spot was first referred to by Benson in 1895 (2), causing heavy losses in the Sydney Hills district and at Kurrajong and Emu Plains. The causal fungus was figured and described by Cobb in 1897 and given its scientific name by McAlpine in 1899. Melanose was already serious in 1897 in New South Wales (5).

Several of the diseases listed by McAlpine — black scurf and some of the types of scabbing — are not recognizable as diseases now, and were probably various types of injuries and abrasions, to which the immature fruit and leaves are very subject, and on which a surface flora of saprophytes establish, as McAlpine suspected. The disease described as lemon bark blotch and attributed to *Ascochyta corticola* has not been identified since, nor has any species of *Ascochyta* with parasitic potential been found in such a habitat. From the symptoms described and figured it could well have been the disease known now as shell-bark, a presumed viral disease, universal in old-line lemons, almost certainly present in any lemon variety originating from Europe or America. The disease described by McAlpine as withertip, and by Cobb (5), as die-back, and in Queensland as die-back (9) cannot with confidence be equated with any known disease. A number of unrelated pathogens or deficiencies could have been involved.

Post McAlpine Development

The 77 years since the publication of McAlpine's book have seen many changes in our knowledge of diseases of citrus trees. Studies both overseas and in Australia have elucidated the life histories and clarified the taxonomic status of the pathogens causing melanose, scab and black spot, and this has helped to give a rational basis for their control. Containment of some virus diseases has been achieved by regulatory measures. Some diseases have all but disappeared, others have become a problem because of changes in usage, and new ones have appeared.

Black spot is a remarkable disease in several ways. The young fruit is susceptible to infection for four to five months after blossoming, but infections remain latent as resting cells below the cuticle. Latent infections also occur in leaves in company with similar resting bodies of *Colletotrichum gloeosporioides* and other fungi. These remain quiescent until the rind matures, but not only maturity but also a period of conditioning of the rind by exposure to high temperature is required before visible lesions develop. Consequently the disease is a problem only for late Valencia oranges and is of particular significance for export fruit, since it can show up after harvest. Cobb's description of the disease in 1897 is

accompanied by recommendations to begin regular spray applications immediately after fruit set, and this observation gives the first clue to the latent nature of the infection. In the early part of this century losses due to black spot were tremendous in coastal New South Wales and early files of the New South Wales Department of Agriculture contain newspaper clippings describing meetings of angry growers demanding more government action. Early spray programmes have been greatly improved, to give disease control without detrimental effect on fruit or crop production. A fairly recent development has been the demonstration that preharvest sprays with systemic fungicides, and post harvest dips with senescence-retarding growth regulators improve control in stored fruit. The origin of the disease is obscure. It was recorded first in New South Wales, where no species of citrus is native. The disease was subsequently found in south east Asia, South America and more recently in South Africa. A very similar fungus exists as latent infections in the living leaves of east coast native shrubs and trees, and has been found similarly in the leaves of many perennial ornamental species, forming its perfect stage in dead fallen leaves, as does the citrus pathogen, and observations on disease outbreaks (7), suggest that this may be a source of infection for citrus. The problem, however, is not solved. The pathogenic strain has not as yet been found in native plants, though it may occur. Very similar forms have been recorded on a wide range of tropical and subtropical hosts, including avocado.

Septoria spot, in 1899 a minor fruit blotch of lemons in Victoria, became in the 1930's and 1940's somewhat of a problem in the Murrumbidgee Irrigation Areas in New South Wales and in orchards of the mid-Murray area. It is now readily controlled by a single spray applied before the autumn rains. Like black spot it was found to have a long period of latency in fruit, and like black spot it can remain latent throughout the life of the fruit or leaf in which it establishes. In contrast to the conditions required to activate the black spot fungus low temperatures, approaching freezing, are necessary to produce the rind changes required for the latent infections of *Septoria* to develop; so it is the winter-ripening Washington navel orange, as well as lemons and mandarins, which develop the disease.

Collar and crown rots continued to be important in spite of the lessons of the early Sydney outbreak. The most spectacular outbreak was in the Murrumbidgee Irrigation Areas of New South Wales between 1930 and 1942. This area was developed as a soldier's settlement following the 1914-1918 war. In the desire to get men started quickly on productive farms, large areas were laid out for fruit growing and were planted up before proper soil surveys had been made. Many of the settlers had little horticultural training, the irrigation layout was often inefficient, water was cheap and the tendency was for the growing trees to be given more water than they could utilize or which could be removed by existing drainage systems. Deterioration of tree health was noted in the early 1930's and following periods of above average rainfall in 1931, 1933 and 1942, by spring 1942, 50 per cent of orchards had been destroyed by root rot and large numbers of trees in the remaining blocks were affected.

Other irrigation citrus in all parts of the state and in Victoria and South Australia have suffered at different times though not to the same extent. The heavy loss of trees and the impossibility of replanting infested soil with trees on the stock in general use, the susceptible rough lemon, made the location of a suitable resistant stock imperative. Nurseries in the Sydney area were also having trouble, not surprisingly since they were located in the

area which had experienced so much disease in the 1860's, and this of course meant that the disease was being distributed with the planting stock.

Since sour orange could not be used in New South Wales, another stock which possessed resistance to the disease had to be found and many species and varieties were screened. The hardiness of the trifoliate orange, which had been grown on a very minor scale in New South Wales for many years proved to relate not only to its cold hardiness, but also to its immunity to *Phytophthora citrophthora*. No other available species showed sufficient resistance to make it worth considering.

The great demand for trees on resistant stock brought into prominence the major fault which had prevented general use of trifoliate stock in the past. It had the reputation in all citrus growing countries of being a dwarfing unreliable stock. Not all the trees on this stock however, were dwarfed. Some, including most Valencia oranges grew well. Dwarfing was ultimately found to be caused by the presence symptomlessly in the scion of a bud-transmissible but not insect-borne factor (3). Great variation in the degree of dwarfing occurred in the plantings scattered through the central coast. Two apparently distinct sets of symptoms were distinguished in association with dwarfing, one was a persistent heavy bark scaling of the stock, the exocortis disease, the other was an enlargement of the stock without external symptoms. Intermediate stock reactions commonly occurred. Gum-impregnated pits commonly developed in the surface of the wood in the stock of non-scaling and intermediate types, but were rare in the stocks with typical exocortis scaling. So far there is no good evidence to show whether two separate entities are concerned in the reactions in the dwarfing complex or whether all the symptoms seen are caused by various combinations of strains of the one organism. In some trials there are indications of interference between strains and there is lack of uniformity in the distribution of strains from parent trees to their progeny, which suggests uneven distribution of components within the tree.

Trials have been under way in New South Wales for the last 14 years to examine the feasibility of using a commercial scale trees which had been deliberately dwarfed by inoculation. Close-planted dwarfed trees have given yields per hectare comparable with those of normal trees planted at normal spacings and this permits savings in management costs.

An advantage in the fight against root rot has been the relative uniformity of the resistance shown by clones of the trifoliate stock in Australia, and the lack of a significant degree of variation in the pathogenic potential between isolates of *Phytophthora citrophthora* such as has been shown to exist in California. Trifoliate stock and the hybrid Troyer citrange are also adequately resistant to *Phytophthora parasitica*, which takes the place of *P. citrophthora* in the warmer areas of Queensland and the New South Wales north coast. A third species, *P. hibernalis*, described in Western Australia in 1925 and in New South Wales in 1928 is of limited range because of its low temperature optimum for growth, and is rarely seen in eastern Australia. It causes defoliation and fruit rot, but its root-attaching potential is not known.

Trifoliate stock and the trifoliate hybrid citrange stocks are fortunately not affected in Australia by the tristeza virus, and can be used with safety as stocks for varieties which carry it. However, as well as causing the death of oranges on sour orange stock tristeza induces symptoms directly in grapefruit, which take the form of more or less severe pitting and furrowing of the trunk, and the production of small deformed fruit and impaired tree vigour. Symptoms in naturally-infected field trees exhibit

a wide range of intensity, from nil to the most serious deterioration, the intermediate types varying in intensity of pitting and fruit effect, and various combinations of these. In the late 1930's and early 1940's it seemed that the disease might spell the end of grapefruit growing in Australia. However, it was common to find occasional mature trees which were vigorous and productive, in orchards where most of the trees were in various stages of deterioration. These trees induced very mild reactions when indexed on standard indicators. Trials were laid out at Somersby in 1954 and at Dareton in 1959 to explore the possibility of protecting grapefruit trees, originally virus-free, from aphid-borne infection, by inoculating them with mild strains from healthy appearing trees. An acceptable degree of protection has been obtained at both sites but this is less complete at Somersby, where the mild coastal climate favours maximum symptom expression and vector activity is higher than in the hot arid climate of Dareton (6). Satisfactory protection has also been achieved against aphid-borne infection in a trial in the Mildura area in 1961, using pre-immunised grapefruit on sour orange stock (13). These trees were inoculated with an avirulent strain from Lisbon lemon selected for its protective value after preliminary trials with strains from grapefruit and Meyer lemon. On the other hand tissue inoculation with severe strains has caused early and marked deterioration of mild strain-carrying trees in a trial at Gosford.

The changes in the disease situation from McAlpine's day to the present are due not only to more precise taxonomic knowledge of the pathogens and of their life history and behaviour, to the controls devised by plant pathologists, or to the availability of new chemicals and to improved means of spray application. Extension of citrus planting is now generally taking place in arid or semi-arid areas. Here diseases such as black spot, melanose and scab are under effective climatic control. Mandarin brown spot, caused by *Alternaria citri* is now unimportant due to declining popularity of the susceptible Emperor variety. This disease was recorded for the first time in 1904 by Cobb and proved difficult to control in coastal areas, but it does not occur in arid climates.

A development which has had an important bearing on the disease position in citrus was the formation in 1928 of the New South Wales Bud Selection Society by grower and nurserymen's associations. The need for some regulation of the quality of propagating materials used by nurseries had become very apparent as the result of the great demand for citrus trees in soldier settlement developments following the First World War. Propagating material was in short supply and quite a lot was collected without consideration of the performance of parent trees. As a consequence when the young trees came into bearing many were found to be of poor type, and the Bud Selection Society was formed to ensure that this would not happen again. To be approved as a source of budwood by the Society, candidate trees had to be inspected over a three year period for cropping, fruit quality, tree vigour and genetic stability by Officers of the Department of Agriculture. This ensured the rejection of trees showing visible signs of disease, including the virus diseases such as psorosis, concave gum and lemon crinkly leaf. The Bud Selection Society incidentally gave us the first example in citrus of application of mild-strain protection, since any grapefruit trees with symptoms of stem pitting disease would be eliminated as bud sources. Grapefruit was a rather late addition to the range of citrus in Australia, being mentioned for the first time in 1870 (4), but by the 1930's it was an established crop in both irrigation and coastal districts. At that time most of the budwood for the

Sydney nurseries came from coastal orchards, where the climate favoured maximum symptom expression of stem pitting and the vector was abundant. Stem pitting had been recognized as a disease in 1939 but was well known to growers and horticultural advisers for some years previously. Any tree which remained vigorous and symptom-free under such conditions must have been carrying effective protectant mild strains, and it is significant that a number of orchards planted in the Murrumbidgee Irrigation Areas in the nineteen thirties remained largely free of symptoms of severe stem pitting, and some were used subsequently as sources of approved budwood. Older orchards in the Murray River Settlements, virus-free until the 1930's, later showed disease symptoms more severely.

The Bud Selection Society expanded its functions to cope with the requirements for virus-free budwood for use on trifoliate stock, under the Parent Tree Registration Scheme in 1953 and xyloporosis was added to the list for which parent trees had to be screened. In 1968 a mother tree block of the most commonly used varieties was planted at the Horticultural Research Station at Dareton to ensure that the Bud Selection Society would always be able to meet its commitment. It can be said, therefore, that some of the more serious diseases of citrus trees are controlled by regulation.

In this brief section it would be impossible to discuss all the diseases recorded on citrus trees since the publication of McAlpine's book. The total now recognized in New South Wales is 49, Most are not commercially significant.

The Current Disease Position — Areas of Ignorance

Diseases of citrus trees exhibit a range and diversity which may well exceed those of any other perennial crop. Some of this is the result of transport to many lands to which citrus is not native and its accumulation of diseases, particularly insect-borne, during this progress. This can be seen to be happening now — in Florida with Young Tree Decline, in Uruguay with Die-back of trees on trifoliate stock, in California with Stubborn, in South Africa with Greening, and here in Australia with Australian citrus die-back.

Fungal diseases being for the most part under reasonable control, chemical, climatic or by resistance, the emphasis is now on virus or virus-like diseases, particularly those not controlled by regulation. But even in the case of diseases which are satisfactorily controlled there are questions, the answers to which could be of great scientific and perhaps practical value. Take for example black spot — the fruit disease the expression of which is dependent on high temperature induced physiologic changes in the rind, a state which is reversible by the natural rejuvenation phenomenon of regreening in the Valencia orange late in maturity. An examination of the processes involved in this could make contributions in the area of host-parasite relations. A study of the family of closely similar fungi, with a similar life style in native plants and tropical and sub-tropical crops could perhaps throw some light on the evolutionary processes involved in speciation. Septoria spot shows a temperature-induced susceptibility of rind quite different from black spot. The vulnerable varieties are winter ripening, visible freezing injury is not necessary and like black spot the lesions develop very fast once they start. Rind maturity is involved, since the later maturing Valencia orange rarely shows lesions, though latent infections are present in the rind. Heat does not activate these in summer, nor, conversely does exposure to very low temperature

activate the latent infections of black spot present in Washington navel fruit incoastal orchards. Two different processes would seem to be involved.

In the field of virus and virus-like diseases there are three major areas where research is required. These are the tristeza-stem-pitting complex, the exocortis-gummy pitting-dwarfing complex and Australian citrus die-back, which was not discussed in the previous section because its upsurge is very recent.

The tristeza virus is a long thread-like particle, amongst the longest known in this class, which includes the pathogens causing apple chlorotic leaf spot, beet yellows and carnation yellow fleck. The diseases which the tristeza virus causes exhibit a range of symptom type and severity in different citrus species and in different countries, pointing to a range of strains of exceptional diversity. Two major virus components can be recognized, one causing vein flecking and xylem pitting and the other a yellows reaction on sensitive varieties as seedlings. Each component exhibits a range of symptom severity and these are variously combined. There is a variation in the capacity of different citrus species to support the multiplication of particular components of the complex, different species of aphids differ in their ability to transmit the whole complex or parts of it, differences in the ability of the same aphid clone to transmit different strains of the virus have been reported and there are differences in the ease with which strains can be established in different species of the host. Clarification of the relationships of the two components and the nature of the protective effect exercised by mild strains is required if mild strain protection is to be completely reliable.

Protection by mild strains against aphid-introduced severe strains appears to have reasonable prospects of success, under favourable climatic conditions for grapefruit stem pitting, and perhaps for tristeza also, but what of mutants? trifoliate and Troyer citrange stocks have in Australia, proved to be substantially immune to infection by any tristeza component, but reports from California, Argentina and Florida put this in question. In the Ventura County of California, orange trees on Troyer and several other citrange stocks are declining with tristeza. Trifoliate stock are also proving to be sensitive. At Riverside also sensitivity to tristeza has been noted in oranges on trifoliate stock and some of the hybrids, but in this hotter drier climate, the effect is mild. In Argentina there is a recent report of serious decline tentatively attributed to an atypical strain of the yellows component of tristeza. In Florida the appearance of a previously unknown type of pitting, causing a shock reaction on West Indian lime indicators, may indicate the presence of a mutant. The dangers of the appearance of a new and more damaging strain demands constant watchfulness.

The exocortis-gummy pitting complex, with its great range of variation, is an area in need of clarification. The organism causing exocortis is a naked, low molecular weight ribonucleic acid, called a viroid. No insect vector is known, but it is saptransmissible to non-citrus indicators, and therefore can be used experimentally under closely controlled conditions.

The deliberate use of virus-affected trees for the production of special effects is not something that has much appeal to plant pathologists, but, if there is a real need in the citrus industry for dwarf trees, and if these cannot be produced satisfactorily by other means than inoculation with a virus disease, it will be essential to sort out single strains, or groups of strains without much variability and with acceptable dwarfing capacity, which show consistency in transmission. The identification of the gummy-pitting component and clarification of its relationship with the exocortis viroid will be essential. And finally there is Australian citrus die-back.

The Die-Back Problem

In South Africa greening disease of Valencia oranges has been known for about 45 years, but it was not until 1965 (11), that an adequate description was published and the South African citrus psyllid identified as its vector. During that time its spread gradually increased in momentum, until now it is a subject for concern. A similar, but not identical disease with a different but related vector, the oriental citrus psyllid, has been identified in South East Asia. Known in China before 1956, in Ceylon well before 1957 and believed to have entered southern India before 1945, it has swept through India, Ceylon, Pakistan, the Philippines and now seems quite general throughout south east Asia. Certainly Australia is also at risk, with the disease progressing through the island archipelagoes to the north. It is without question one of the greatest calamities to have befallen citrus. The causal organism was at first thought to be a mycoplasma-like organism perhaps related to *Spiroplasma citri*, cause of stubborn disease of citrus in California and the Mediterranean, but it is now believed to be quite distinct.

The disease causes a variety of blotchy leaf patterns, die-back and death. We don't have that disease or its vector here — but we do have something quite like it, a disease which we are calling Australian citrus die-back. It was first noticed in 1942, though at least one grower in the lower Murray settlement of Coomealla was aware of it before then. For many years it seemed to be of little importance, but during the past five or six years there has been a substantially increased rate of spread, particularly in some Murray River irrigation settlements in Victoria, New South Wales and South Australia and in a part of the Murrumbidgee Irrigation Area. It occurs also in coastal New South Wales and Queensland. The total number of trees affected is still quite small, but occurrence is patchy and in localized areas upwards of 80 per cent of trees may be affected. The pattern of distribution, the appearance of die-back in isolated orchards, sometimes in remote areas surrounded by native vegetation, and in trees of mature age, previous good performance and known budline suggest that this is an endemic disease with a native vector.

The considerable recent increase in die-back is coincident with a sequence of seasons of above average rainfall, which has encouraged growth of native plants and weeds and a build-up of native insects. There has also been a trend towards reliance on biological control, particularly of red scale, with consequent decreasing use of insecticides in irrigation districts, which may have relevance.

The danger for the future seems to lie in the possible adaptation of a native vector to feeding on citrus, or to a climatic shift making for the continuance of the seasonal pattern which has caused explosion of native insect populations in areas where citrus is grown under irrigation and where they can provide an alternative food source when native plant or weed growth becomes mature and unattractive. It is a challenge and a most urgent duty to clarify this problem.

It would seem appropriate in conclusion to quote McAlpine's guiding principal "the more accurate the determination of the cause, the more likely is a rational method of treatment to be adopted".

REFERENCES

- (1) Anon. (1866) — Report from the select committee on diseases of fruit trees, together with the proceedings of the committee, minutes of evidence and appendix. *Legislative Assembly, New South Wales*, 1866.
- (2) Benson, A. H. (1895) — Black spot of the orange. *Agricultural Gazette of New South Wales* 6: 249.

- (3) Benton, R. J., Bowman, F. T., Fraser, L. and Kebby, R. G. (1950) — Stunting and scaly-butt of citrus. *Science Bulletin No. 70, N.S.W. Department of Agriculture*.
- (4) Bowman, F. T. (1955) — A history
- (4) Bowman, F. T. (1955) — A history of citrus in Australia, 1788-1900. *The Citrus News*, July-December.
- (5) Cobb, N. A. (1897) — Letters on plant diseases. *Agricultural Gazette of New South Wales* 8: 225.
- (6) Cox, J. E., Fraser, L. R. and Broadbent, P. (1975) — Grapefruit stem pitting — field protection by mild strains. *The Seventh Conference of the International Organisation of Citrus Virologists — Abstracts of Papers*. 14.
- (7) Kiely, T. B. (1949) — Preliminary duties on *Guignardia citricarpa* n.sp., the ascigerous stage of *Phoma citricarpa* McAlp. and its relation to black spot of citrus. *Proceedings of the Linnean Society of New South Wales* 73: 249-292.
- (8) Land, J. D. (1852) — *An historical and statistical account of New South Wales*. Volume 2, 3rd edition.
- (9) McAlpine, D. (1899) — Fungus diseases of citrus trees in Australia, and their treatment. *Department of Agriculture Victoria*.
- (10) McAlpine, D. M., and Parsai, P. L., Roberts, R. and Hope, R. H. (1948) — Bud-union decline disease in citrus trees. *Journal of the Department of Agriculture, Victoria* 46: 25-31.
- (11) McClean, A. P. D. and Oberholzer, P. C. J. (1965) — Greening disease of the sweet orange. *South African Journal of Science* 8: 253-276.
- (12) Moore, C. (1868) — Report from the director of the botanic gardens, Sydney, on the state and management of the orange plantations in Spain and Portugal. *Legislative Assembly New South Wales*.
- (13) Thornton, I. R. and Stubbs, L. L. (1975) — Control of tristeza disease of grapefruits on sour orange rootstock by preinduced immunity. *The Seventh Conference of the International Organisation of Citrus Virologists — Abstracts of Papers*. 38-39.

Lilian R. Fraser

This is an edited version of the inaugural lecture presented at the Second National Plant Pathology Conference, Brisbane, May, 1976. Dr. Fraser was formerly Chief Biologist of the B.C.R.I., Department of Agriculture, Rydalmere, N.S.W.

REGIONAL NEWS

N.S.W. Branch

Dr. Sara Zimmerman-Gries from the Volcani Center, Israel, is working with Dr. John Bowyer in the Department of Plant Pathology at Sydney University, until April 1977. She has extensive experience in potato pathology, particularly virus diseases, and her main interest while in Sydney will be purple top wilt of potato.

Dr. Zimmerman-Gries hopes to visit Victoria later in the year.

Victorian Branch

A Fungus Foray and barbecue was organised by Victorian members on June 20th at Dom Dom Saddle near Healesville. The foray was led by Dr. Derek Reid of the Herbarium, Kew Gardens, U.K. Dr. Reid spent six months with the Botany Dept., Melbourne University, studying the taxonomy of higher fungi in Eastern Australia.