DANIEL McALPINE MEMORIAL LECTURE 1995

The ever-changing challenges of plant pathology

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This lecture commemorates the life and work of Daniel McAlpine and his contribution to the science of plant pathology. He was born in Scotland, and arrived in Australia in 1884 at the age of 35. He had already received considerable training in biology, and became a lecturer at the University of Melbourne. Six years later he became vegetable pathologist in the Department of Agriculture. At the time, plant pathology and plant breeding were facing the challenge of coping with the stem rust epidemics, so McAlpine, together with Farrer became involved. Over the next 26 years McAlpine published 226 papers, a monograph on rusts (1906), and books on the smuts (1910) and on the diseases of citrus (1889), stone fruit (1902), and potatoes (1911). His work is well documented in articles by Fish (1970) and White (1981).

In New Zealand, the pioneer of plant pathology was Gordon Herriot Cunningham. Like McAlpine he was of Scottish descent, but was born in Central Otago and grew up on a large sheep station. At the age of 16, he became interested in fruit-growing and worked for a year on an orchard at Roxburgh, also in Central Otago. During the next two years he moved to Australia, and worked in orchards in Tasmania, Mildura and in a vineyard near Adelaide. But he also worked as a farm hand in New South Wales, cut sugar cane in Queensland and drove a camel train in Central Australia. At the age of 20, he bought land in Nelson, New Zealand and established a fruit orchard. He was active in racing motor cycles and later helped a survey party in the bush of North Westland. When the first World War broke out he volunteered, and landed at Anzac Cove, Gallipoli. He was wounded and invalided back to New Zealand. At the age of 25 he joined the Department of Agriculture as a temporary third grade orchard instructor based at Palmerston North. Following favourable reports, the Director suggested he specialise in plant pathology. And so his career began. He set up a laboratory in his own home, and read widely on the subject. A move to a laboratory at Levin enabled him to work full-time on plant pathology, and this was continued when the laboratory was moved to Wellington. While in Wellington he was encouraged to gain formal qualifications, a BSc at the age of 32, then a MSc, and finally when 35 a PhD. During this time he published his first book – Fungus Diseases of Fruit Trees in New Zealand.

Early in 1928 he moved back to Palmerston North to lead a team of four mycologists at the new Plant Research Station. By 1935 the team had increased to eight scientists. In 1930, he completed The Rust Fungi of New Zealand, gaining a DSc for his efforts. He then took an interest in chemical control of diseases, and in 1935 published the book Plant Protection by the Aid of Therapeutants. Frustrated with delays in providing adequate facilities, Cunningham resigned. The fruit growers were outraged and the issue became political. Following a change of Government, the Plant Diseases Division was formed in 1935 and was responsible for plant pathology, entomology and pomology, with Cunningham as Director. It was eventually established in Auckland at Mt Albert, and for the next 56 years, PDD, as it came to be known, made a tremendous contribution to plant pathology.

In spite of an administrative load, Cunningham worked hard at mycology and plant pathology. But he also developed an excellent team with expertise in fungi, bacteria, viruses and mineral deficiencies. The team was greatly respected by growers for their practical common sense and service. Cunningham's own efforts were excellent. Over his career he published 222 papers and six books, with the later ones being on the Gasteromycetes (1942), the Thelephoraceae (1963) and the Polyporaceae (1965). He became a Fellow of the Royal Society of New Zealand in 1929, and a Fellow of the Royal Society in 1950, and was awarded the CBE in 1949. His was a truly remarkable career, which did much to strengthen the science of plant pathology in New Zealand. His career is fully described in articles by Chamberlain (1965) and Ramsbottom (1964).

But what is plant pathology?

In simple terms, it is the study of plant diseases and their control, with disease being defined as a harmful deviation from normal growth. Plant pathology also involves the study of the host plant and its environment (Figure 1).

Why get involved in plant pathology?

As pathologists we have an obligation to the farming community to prevent or reduce the losses in quality and quantity of produce, and also to the taxpayers and users who fund many of our activities. This can be referred to as our efforts for the Public Good.

We must not forget the social impacts of plant diseases, for it was the Irish potato famine in the 1840s that really was the stimulus that initiated our profession. Dr Berkeley and others working with very basic equipment were able to discover much of value leading to a greater understanding of the problem. The late blight epidemic caused thousands of Irish to emigrate with many coming to Australia and New Zealand.

If you have not done so already, then I would recommend that everyone, especially younger scientists, read the book Famine on the Wind by Carefoot and Sprott (1969). This not only describes the late blight epidemic, but also other situations where plant diseases caused significant social change. For example, did you realise that the United Kingdom switched from coffee to tea drinking because rust destroyed the coffee plantations in Ceylon and they switched to tea production. In Scotland, there was a switch from brandy to whisky, because three new grape diseases reduced the supply of brandy from France.

These were dramatic effects of plant diseases on crop production. Nowadays, our science has been able to reduce the impact of many plant diseases, so much so that students and growers may not appreciate how serious plant diseases can be. Thus lecturers and consultants have to use historical data or illustrations to convince them. No longer is it possible to see the effects of stinking smut with clouds of black spores coming from headers working in infected wheat crops. Similarly, it is now rare to see black patches in wheat crops or blackened crops arising from the growth of secondary fungi on the heads of plants infected with barley yellow dwarf virus. Complete lodging of wheat crops as a result of infection by the stem base eyespot fungus is now much less common.

The impact of potato leaf roll virus has been reduced by using soil-incorporated systemic insecticides for aphid control. This was so effective that Bawden (1970) once said that we can control leaf roll even though we know little about the virus, whereas tobacco mosaic virus control is not satisfactory even though a great deal is known about it. Fan-like patches of bacterial blight resulting from seedborne inoculum and splash-wind dispersal are not now present in pea crops. Stem eelworm can survive in infested lucerne hay so that feeding such hay onto lucerne stands resulted in patches of dead or stunted plants. Better cultural practices have provided control. But not all patches in crops are due to pathogens, for herbicides applied to a previous crop can damage or kill plants in the next crop.

Many photographs showing the impact of plant diseases on crops were taken from fixed wing aircraft by scientists, this being one of the challenges of the 1960s and 70s to use aerial photography to evaluate and document trials. This was achieved and we now have access to information and photographs. Since then the challenge has been to use other types of aircraft to obtain such data. These have ranged from model aeroplanes to balloons, to micro-lights, and more recently to the use of satellite pictures, as well as radiometer devices that can record spectral wavelengths of interest e.g. reflectance of infra-red light from cereal crops affected by leaf rust.

Plant disease diagnoses

Identification of the causes of plant diseases was one of the early challenges. This has continued to be of importance and has led, in New Zealand, to the publication of plant disease records (Dingley 1969; Pennycook 1989). Some of the records have been of plant diseases that clearly have been present in New Zealand for some time but have only recently been recorded e.g. potato cyst nematode and bacterial wilt of lucerne, to name just two. The efforts on plant disease diagnosis will still be needed, as growers demand and pay for the service to identify and provide advice on plant diseases. In New Zealand this work is carried out by Plant Protection Centres of the Ministry of Agriculture, not now readily available for use in the training of young scientists who are about to enter the field of plant pathology.

Plant quarantine

For plant quarantine, accurate and up-to-date records are essential. No longer can you say that a disease does not occur here or there, but only that it has not been recorded. For example, fireblight of pip fruit has not been recorded in Australia. But plant quarantine also involves actions on outbreaks of new problems. For example citrus canker appears to have been eradicated from New Zealand as there have been no recent records. Plant quarantine is expensive, involving the MAF working in association with Customs to prevent the illegal entry of plants and plant material. There have been changes in the relevant acts and regulations. The Biosecurities Act 1993 is going to have a major impact on the way in which plant quarantine is administered. But it is vital that rules are clear and easy to be understood and administered.

Plant pathologists must work closely with the quarantine administrators to ensure their decisions are based on sound scientific principles. Accurate plant pest surveillance information is essential to agricultural security and market access. Thus the Plant Pest Information Network (PPIN) is being developed for the MAF Regulatory Authority.

Free trade concepts may create quarantine problems. A recent example was to allow fresh asparagus for consumption into New Zealand from several overseas countries. This created a risk of introducing asparagus rust and other fungal diseases as well as asparagus virus 1. As asparagus is worth $30m annually, the growers objected to this. The situation became so serious that the growers had to take the issue to Court in an attempt to block imports. Although it was found that MAF had not fully complied with the Biosecurity Act, the judge did issue an interim injunction. Subsequent discussions on risk analysis have resulted in stricter conditions for asparagus imports. Better initial consultation between all concerned would have prevented this situation from occurring. It is a challenge for plant pathologists to be ever vigilant, especially as Australia and New Zealand are free of many serious pathogens. One example would be pine rust in California; from tests we know that the clones of radiata pine in New Zealand are susceptible. Citrus canker still could be re-introduced, as well as many other overseas problems.

Empirical research

In the control of eyespot, much initial research was on the use of Cycocel, a compound that shortened the straw, and thickened the stem base of cereals.

A field trial (Witchalls and Close 1971) in an area prone to eyespot involved a susceptible cultivar treated with a range of compounds. This was when benomyl (Benlate) was first introduced, and it was included. The use of benomyl at Feekes GS 7–8 prevented a yield loss of 31%, compared with Cycocel of 16%.

This was a piece of empirical research which yielded results that were immediately applied. The key was the use of low rates of Benlate at a specific growth stage. There was no information at the time on why it was so effective. This is only now coming to light several years later – in articles in Plant Pathology, by, for example, Bateman (1993).

It is clear that empirical research is justified, especially in field situations, where there is not the time or expertise to conduct careful laboratory experiments and field trials to investigate all aspects. The challenge here is to be responsive to grower problems.

Teleomorph – anamorph links

In the 1960s and 70s there was the challenge to find the perfect or teleomorph stage of several fungi. The search was on for the perfect state of Phoma lingam, the cause of dry rot of brassicas, challenging the idea that it only had an asexual stage. The teleomorph was found on old crop debris and identified as Leptosphaeria maculans producing a pseudothecial ascospore stage (Smith 1964).

Similarly, Septoria tritici, the cause of speckled leaf blotch, was investigated by Sanderson (1972). As a result, the ascomycete Mycosphaerella graminicola was located on the stem bases of crop debris. Ascospores released from perithecia between March and August infected the emerging autumn-sown wheat crops, leading to the presence of blotches and pycnidia of S. tritici.

The message is to challenge accepted ideas. The perfect state of Mycosphaerella graminicola had been described in 1894, but had never been linked with the pathogenic conidial or anamorph state – Septoria tritici. In the same way, Leptosphaeria maculans was described in 1863, but not linked with Phoma lingam until 1964. In Australia, there has been much research to link the perfect and imperfect stages of Eutypa lata.

Another excellent example is the simultaneous discovery of the teleomorph, Tapesia yallundae of Pseudocercosporella herpotrichoides in Australia (Wallwork and Spooner 1988) and New Zealand (Sanderson and King 1988).

Information technology and computers

There are challenges nowadays in information technology. The science literature keeps on expanding. Thank goodness for the CD Rom, and the ability to rapidly search literature abstracts on the silver platter. But it is important to remember that there is literature prior to 1984, the date that the first set of CAB Abstracts, including Review of Plant Pathology, was placed on disk. Are we in danger of re-inventing the wheel, or repeating work perhaps in a different manner, while the information is already available?

Computers have been invaluable in allowing science to record, sort and analyse data, and organise its presentation. The challenge is to ensure you get the most out of the computer. They are very versatile, and with the software now available can do all manner of things. This requires a time investment. The computer is a tool that you drive, but which should not control you. They are indispensable, and it is not surprising that we see the increased sale of powerful PCs and the use of laptops. Many devotees cannot do without their laptops these days.

Administration of science

The greatest challenge facing plant pathology in New Zealand has been the seemingly endless re-organisation of science administration and changes in the method of providing the money for research. As recent as 1991 a new Plant Protection Division was formed by the bringing together again of plant pathology and entomology within the DSIR. Then when the Crown Research Institutes (CRI) were formed in 1992, all discipline-based divisions like DSIR Plant Protection were split and their staff became incorporated in the range of new Institutes. It was traumatic for the persons involved. Some were made redundant. Others had to choose the direction of their research e.g. a person could not be involved in both agriculture and horticulture under the new regime. Still others were able to establish their own consultancy research businesses and successfully compete for funds. Since 1992 all money for research has become contestable.

Initially the grant applications were required on an annual basis and the timing of preparation of these applications, in October-November, had a detrimental effect on the research programs of those in land-based research. The money comes from what is known as the Public Good Science Fund. In spite of its name the general public appears to have little input into decisions on allocation. As part of the re-organisation the Government established MORST, the Ministry of Research Science and Technology responsible for determining policy in science, and FORST, the Foundation for Research Science and Technology, which administers the allocation of funds. Who gets what is based on peer review, which has its own defects. Everyone acknowledges this, but as in the United

Kingdom, it has not been possible to determine a better system, other than to grant non-specific output funding (NSOF) to the Institutes to enable them to make their own decisions. At present 10% is allocated in this way, but 20% would give more independence.

Recently three new developments have occurred:–

1. The Universities can now apply to attract funds from the PGSF.

2. The grant applications are now once every two years and remember salary is part of the grant. Allocations can be for longer periods, up to 4 –5 years.

3. A Basic Science Fund has been established, called the Marsden Fund. In its first year 1995, the Marsden Fund attracted 1000 applications; this has been reduced to 114 full applications applying for a very limited pool of money. This is regarded as cash for scientific risk taking.

As salaries form part of the grant application to FORST, a great deal of insecurity has been created among staff. In addition, MORST the policy arm, can change the percentage allocations to each of the 17 output areas. A recent decision means basically less money for agriculture, horticulture and forestry (Figure 2), and more for the politically correct areas of the environment and social science. The increase was a mean of 57% for their four output areas or $33.7 million more, whereas the overall increase for the 17 output areas was 28% for the next 5 years.

This state of affairs is because of two myths: firstly the myth that horticulture production has peaked, and secondly with an improving economy, that there is less need to invest more in production, income-earning research. Horticulture in particular is still in an expansion phase especially in exports. New Zealand still has to pay the bills, and needs to invest more, not less, in income earners.

There have been major changes in New Zealand science. So much so that the changes are not acceptable to many, and two scientists have quite independently told me they would not encourage young people into science. Others are reluctant until funding structures and career pathways are better formulated.

Genetic engineering

This is an exciting and challenging area of research, as it can manipulate genes and move them into new hosts, and so establish or increase resistances to viruses, herbicides and insects, to name just a few of the current possibilities. Plant pathologists and plant breeders must work with the teams, to ensure that genes are moved into the best possible hosts. I have heard that in one case a cultivar, no longer recommended, was chosen for genetic engineering.

It is also necessary to ensure that the general public is kept informed of the inherent safety of the procedures. This is not only up to individual scientists; the science administrators must also play their part as they fund the research from public good science fund. The latest release is a white clover with resistance to white clover mosaic. This is being field tested as a GMO, genetically modified organism, the test being approved by the Ministry for the Environment. All plants with the new gene will be destroyed after the test. It seems that genetically engineered plants are considered dangerous or guilty, unless proved innocent. This seems an extreme or hysterical view of what has the potential to be of great benefit to the public. Perhaps the technique has not been sold well to the consumers. In my view there are no more dangers from plant genetic engineering than from plant breeding.

New techniques

Earlier challenges have come in the form of transmission and scanning electron microscopy. The challenge here is to see whether these techniques can be used to solve problems. They are only tools after all, and should not dominate our science. The same comments could equally well apply to all new pieces of equipment or techniques. It is vital not to succumb to 'technique infatuation', such as PCR, RAPD, etc.

Extension (now called Technology Transfer)

It is important that plant pathologists are involved in extension. Good articles to read are by Fletcher (1989) ''Advisory plant pathology – challenges and opportunities'' and Sequeira (1988).

In New Zealand our Ministry of Agriculture advisory officers have been reduced in number over the years. Now many of them are employed as consultants by a large farm-oriented company, Wrightsons, or have banded together as Companies. Advice is therefore available but everyone must pay.

The Crown Research Institutes are becoming more involved in technology transfer, as this is now part of their contract funding. I can see this increasing. This must be beneficial as it keeps scientists closer to the coal-face (the growers), and ensures that recommendations are accurately passed on. New technologies such as faxes and the internet can be used to distribute information, as well as all the traditional methods of public relations and promotion.

Education and training

I have reviewed my 1978 Presidential address on Education and Training (Close 1978) and have not changed my ideas. Knowledge of healthy plants forms the basis of studying the changes induced by pathogens. This together with details of the ecology and epidemiology of the pathogens will lead to control procedures. One of the challenges is to foster excellence in graduates.

Post-graduate education and training is extremely important and is an area in which APPS should be more active. It is good to see at this conference, not only the workshops, but also the course on learning the techniques for molecular identification, there being 22 participants.

Plant pathology in New Zealand is now split between five CRIs as well as in the Universities, and in the Ministry of Agriculture. The only opportunities for gathering together are in meetings of APPS, and in the NZ Plant Protection Society, which also includes weed and insect scientists.

In Australia, movement between states is not easy, and again APPS is important, not only for the biennial conference, but also in promoting regional activities. We could do more. At this stage we need to try and prepare an operational plan so that all of us are kept up-to-date and knowledgeable about our subject area. Because of distance, regional activities become even more important, and should be encouraged by increased grants based on the numbers in each region.

Conclusion

In conclusion, I would recommend that younger scientists read widely and try to develop a personal philosophy to strengthen their own scientific aims and aspirations. Valuable information can be found in the references I have cited and also in the Presidential addresses and earlier McAlpine lectures.

I have detected a marked attitude change by Australasian plant pathologists. This was assisted by holding the 1983 International Congress of Plant Pathology in Melbourne. We now believe that Australasian research in plant pathology is as good as or better than that conducted elsewhere. The quantity and quality are excellent, and we are often very innovative.

We live in changing times, and being flexible and adaptable could well be key attributes. Whether you specialise or become a generalist will depend much on the position in which you are employed. Always remember that whoever pays your salary deserves clear and concise reports of your work. In this way we can be accountable to all those who pay for our services. It is increasingly important that we convince them of the value of our profession.

A final quote from Sir Fred Bawden (1970) is appropriate 'Always keep an open and questioning mind, query seeming facts almost as much as conclusions, and query your own no less than other peoples'.

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Figure 1 The profession of plant pathology (within the circle and boxes) receives inputs from many disciplines.

Figure 2 Comparison of percent increase in exports from 1985 to 1993 for five sectors of the agri-food industries, with the percent increase in research allocation from 1995 to 2000 (from Bezar, Press, 4 August 1995).