PT300
Attendance at Potato Conference,
Madison, USA, 1993
New Developments in the control of
potato diseases

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Know-how for Horticulture™

PT300

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GENERAL COMMENTS

A four week study tour was undertaken to investigate the latest developments in the control of potato diseases and to develop personal contacts with overseas researchers. The study included the International Plant Pathology Congress at Montreal and the Potato Association of America Conference at Wisconsin. Both these conferences brought together many of the key American and European Researchers working on potato diseases.

The 6th International Congress of Plant Pathology held in Montreal, Canada, was attended by over 2,000 delegates from various countries. Symposia and poster-discussion sessions covered a wide range of topics including various aspects on the latest developments in disease diagnosis, disease management and education and information technology. Several workshops were also conducted on *Rhizoctonia, Botrytis, Phytophthora,* post harvest diseases and biological control. Overall there was a broad range of new and useful information presented and the attendance of the authors at the poster sessions enabled useful contacts to be made as well as obtaining addition information to that formally presented.

The next Congress is to be held in Edinburgh, Scotland, in 5 years time and it is recommended that plant pathologists from PISA and SARDI attend this Congress as the benefits would outway the costs.

The Potato Association meeting held at Madison, Wisconsin, was attended by several hundred delegates consisting of researchers in various areas such as pathology, entomology, physiology, plant breeding etc. Scientists from Universities, United States Department of Agriculture (USDA) and commercial seed and processing companies attended. Other

delegates were extension workers mainly associated with the Universities in the USA and private consultants.

Most delegates were from the USA and Canada with a few from Europe (mainly the UK) and some from the Carribean and South America. The program was well planned and over 4 days consisted of several general symposium and current sessions in the areas of Production and Management, Breeding and Genetics, Physiology, Plant Pathology, Entomology, and Certification.

Abstracts from the conference are available and have been circulated to researchers within SARDI and PISA. Some brief comments on some of the highlights of this conference are listed below under various topics. Overall this was an excellent conference with all delegates willing to exchange information on research being conducted in many areas of potato production in USA and Canada.

It is recommended that potato researchers be encouraged to attend future conferences of the P.A.A. as the development of personal contacts at this conference will ensure that researchers are kept up with the latest developments in their particular field and ultimately that this information flows into the Potato Industry.

DISEASES AND OTHER SUBJECTS

RHIZOCTONIA

Although *Rhizoctonia* is recognised as a serious problem of potatoes wherever they are grown, few pathologists are presently working on the disease in America. Most work is being done in Europe. For example interesting work by Dr. E. Shaldyaeva of the Research Institute of Chemization and Land Tillage, Krasnoobsk, Russia, reported assaying the soil borne inoculum levels to predict *Rhizoctonia* disease development and yield losses of potato in Siberia. Soil levels of *Rhizoctonia* varied from 0 to 50 propagules/100 g of soil. Yield losses of 12 to 15% occurred at levels of 0.3 to 0.7 propagules/100 g of soil whereas 18 to 25% losses developed where 2 - 12 propagules were detected/100 g of soil. Unfortunately details of the method used in this work were not available. A diagnostic Elisa dip stick test has been developed by Dr. C. Thornton, Department of Plant Sciences, University of Oxford, to detect live propagules of *Rhizoctonia solani* in soil. The test reacts with *Rhizoctonia cerealis* and it is uncertain how useful this technique will be in distinguishing different anastomosis grouping of *Rhizoctonia solani*.

The main area of research in *Rhizoctonia* in potatoes is in the area of biological control where a wide range of potential antagonists are being evaluated by a number of research groups. Dr. R. Lumsden, USDA Beltsville, reported on the commercial development of *Gliocladium virens* which has been registered in the USA by the EPA and is one of the first to be registered for biocontrol. This product is effective against *Rhizoctonia* and is marketed as "Gliogard".

The mycoparasite *Verticillium biguttatum* was shown by Dr. J. Whipps Horticultural Research International, Littlehampton UK, to be indigenous to the UK and to be effective on *Rhizoctonia solani* sclerotia of anastomosis group 3. Commercial production of *Verticillium* and bacterial antagonists is being undertaken by several European biotechnology companies. Attempts will be made to import the formulations for evaluation in Australia.

Research conducted in Holland by Dr. G. Dijst, Wageningen, has shown that volatiles released from dying foliage at harvest stimulates the production of *Rhizoctonia* sclerotes on the tubers. In Holland pre harvest treatments to remove the tubers from stolons, windrowing tubers to allow the dissapation of volatiles and spraying tubers with antagonists reduced the incidence of scurf (sclerotes).

This phenomena has also been demonstrated by Dr. J. Davis of Idaho University. The technique should be evaluated in Australia as a means of reducing black scurf in table potatoes. Davis also consideres that green manure crops of rape should be evaluated for the control of *Rhizoctonia.* Other factors that according to Davis are important with reducing this problem are shallow planting in winter crops and the use of press wheels behind the planter to speed up emergence.

POTATO EARLY DYING

Potato early dying, caused by an interaction between the fungal wilt *Verticillium* and the nematode *Pratylenchus*, is a serious disease in many potato growing areas in the USA. This reflected by the many research groups working on the problem. Potato early dying is considered by growers and researchers as the most important disease currently limiting commercial potato production in the USA. The disease causes plants to senesce 1-4 weeks earlier than normal maturity and can often go undetected as the symptoms resemble natural senescence. The disease causes yield reductions of 30-50%. Control is difficult as 2 to 3 year crop rotations are not effective and the use of soil fumigants such as metham are expensive and only effective in light textured soils. Many researchers believe that growers often do not realise that the yields are low and consider early maturity as a normal situation in their plantings. In these situations early dying has prevented the realisation of increased yield by investment in control of other pests and diseases.

Interesting work by Dr. Jim Davis of the University of Idaho showed that the disease was depressed following a broadcast treatment of rape meal (*Brassica napus* var napus Dwarf Essex) at rates of around 6.7 metric tons/ha. Over two years this treatment consistently suppressed populations of *Verticillium* and *Pratylenchus*. In these experiments 57% of plants in untreated areas were wilted, resulting in a yield of 25 tons/ha, whereas the rape meal treatment reduced the incidence of wilt to 6% and increased yield to 31 tons/ha. In contrast however no inhibitory effects were shown with green manure treatments of the rape varieties Bridges, Dwarf Essex and Jupiter.

The active ingredient in the rape meal has been identified as gluco sinolate which shows potential as a pesticide.

The role of *Verticillium tricorpus* (Vt) in the biosuppression of *Verticullium* wilt of potato was investigate over several years by Dr. J. Davis and others, University of Idaho, Aberdeen. They showed in pot experiments that both wilt incidence and *V.dahliae* colonization were supressed in the present of Vt, and yield was increased by 15%. In field experiments however, where Vt was applied to soil as alginate pellets at 63kg/Ha, there was no significant increase in yield but rather an increase in malformed potatoes, indicating that Vt is a mild pathogen of potatoes. Dr. Davis was more optimistic on the use of green manures to change soil microflora to suppress disease of potatoes rather than the use of specific antagonists. For example Dr. Davis investigated the effect between weed free fallow and green manure treatments on the severity of *Verticillium* wilt *(V.dahliae)*. Green manure crops of either rye, oats, corn or sudan grass were grown for 2 years and compared to rape and peas grown for 3 year. *Verticillium* wilt and root colonization was greater in fallow compared to the green manure treatments. In other similar experiments potatoes grown in non fallow plots out yielded fallow by 17 to 22%.

Dr. Davis has also conducted interesting work on the influence of cropping practices on the dynamics of *Verticillium* species in soil. His work showed that the removal of infected potato stems at the end of the season prevented build up of soil borne inoculum levels of *Verticillium.*

The potential of wilt resistant varieties to control early dying is being investigated by Dr. D. Corsini, University of Aberdeen, Idaho. This work has shown a poor correlation between yield and *Verticillium* resistance which suggests that the first selection criteria for breeding for resistance to *Verticillium* wilt should be yield. The height yielding cultivars had moderate wilt resistance. If wilt resistance is the sole selection criteria, a high proportion of late maturing

LATE BLIGHT

Late blight caused by *Phytophthora infestans* is the most wide spread and destructive disease of potato foliage in the world. This is reflected in the number of researchers working on the disease in most potato producing countries.

Of recent concern is the appearance and spread of the A_2 mating type of *Phytophthora infestans*. Most strains of the fungus belong to the A_1 mating type, and the spread of the A_2 mating type throughout the world could give rise to more fungicide resistant strains of the fungus. Work by Dr. S. Kato, Sankyo Ltd, Shiga-Ken, Japan, for example indicated that the A_2 strain now predominates in many districts of Japan as it tolerates higher concentrations of mancozeb than the A_1 strain. A high incidence of A_2 isolates were also reported from Korea by Dr. N. Kondo, Hokkardo, University, Sapporo, Japan, who also showed the isolates to be insensitive to 10 ppm metalaxyl (Ridomil). Further work from Korea by Dr. Wang-Hyu Lee, Chonbuk, National University, Chonju, Korea, showed some A_2 isolates grew at 100 ppm metataxyl. This work also showed that oxadixyl, fosetyl-Al and phosphrous acid (H_3PO_3) were less suppressive than metalaxyl. The new fungicide dimethomorph was effective at 1 ppm suggesting that it may be a useful alternative to metalaxyl.

A three year study to test the occurrence of metalaxyl resistance in North American populations of *Phytophthora infestans* has been undertaken by a group leaded by Dr. D. Kenneth of the USDA, Vegetable Laboratory, Beltsville, Maryland. This study showed that isolates from the USA varied greatly in response to metalaxyl. For example of 100 isolates from Washington, 83 were highly resistant and 17 moderately resistant compared to 22 samples from North Dakota that were all sensitive to metalaxyl. Canadian isolates ranged from

high levels of resistance in populations in British Columbia to mostly sensitive isolates from Atlantic Canada. Mexican isolates were mainly resistant to metalaxyl.

The rapid spread of *Phytophthora infestans* was demonstrated in field plots set up by Dr. W. Fry of the Cornell University, Ithaca. In these plots plants were susceptible within seven weeks from planting but this was not correlated with tuber bulking. At the time of the visit to New York State, frequent rain and high humidity provided conditions conductive to the development of late blight which was spreading in potatoes and tomatoes throughout the State. Fry commented that many outbreaks could be associated with infected tomato seedlings introduced from Southern States.

Late blight was also developing in potato crops in Wisconsin for the first time since 1986. New outbreaks were showing up at the rate of 2 new fields per day. Initial outbreaks were considered to occur on properties that had been planted with infected seed. Resistance to metalaxyl had not developed in Wisconsin, as isolates were all sensitive to 1 ppm compared to other parts of the USA where some isolates were resistant to 100 to 200 ppm.

The importance of seed infection was emphasised by several scientists particularly where tubers are infected with little evidence of foliage attack. Many growers in the USA ensure that the health status of there seed crops is known.

TARGET SPOT

Target spot or early blight caused by *Alternaria solani* is one of the most important foliage pathogens of potatoes world wide. An excellent overview of early blight and fungicide inputs in the USA was presented by Dr. W. Stevenson of the University of Wisconsin, Madison. Stevenson reported that between 2 to 12 fungicide applications are used to control the disease. In some states yield losses ranged from 25 to 50% where fungicides were not applied. In the USA, bravo, mancozeb, and maneb are the main fungicides used with a range of fixed copper materials, Rovral and triphenyl tin hydroxide. Fungicide use on potatoes contributed to a significant proportion of fungicide sales in the USA. For example application of Bravo to the Wisconsin potato crop costs near US$3 million in chemical costs alone. Other non chemical costs associated with spraying account for $14/acre. Most research centres in the USA involved in potato production also conduct contract research on the evaluation of new fungicides, fungicide formulations and mixtures for target spot control. Considerable effort is directed towards fungicide evaluation as E.P.A. guidelines limit E.B.D.C. fungicide use (mancozeb, maneb etc.) to 11.2 lb ai/acre/season. This has led to the use of copper fungicides early in the season and E.B.D.C. near harvest, or E.B.D.C. applied early and finishing with Bravo. Score, which is about to be released commercially in Australia, is not currently being evaluated on potatoes in the U.S.A. presumably due to a commercial decision by Ciba.

Stevenson also reported that early blight was often associated with low Zn levels. Improved target spot control was achieved with the Zn formulation of Bravo.

Biological control of target sport is being investigated and although it has worked in the glasshouse it is yet to be evaluated in the field.

Other points of interest with target spot are that the development of the disease depends on the site selection (ie sheltered areas), length of crop rotation, crop nutrition and irrigation management as well as the management of other pests and diseases.

In general potato crops that are stressed are more susceptible to target spot, and those of low N status are particularly susceptible. Young tissue is resistant to target spot and late maturing cultivars are less susceptible to the disease. Some new cultivars being developed, eg Russet Nugget, are more resistant or field tolerant to target spot than Russet Burbank. Cultivars such as Castile can be grown without fungicides as the disease is slow developing on those plants.

It is generally assumed that due to factors such as safety to the worker, consumer and the environment, many fungicides presently registered for use on potatoes may no longer be available. Considerable effort needs to be put into breeding and selection programmes to develop potato cultivars with a high level of field resistance to target spot. However plant breeders in America expressed concern that limited funds were available for this type of research.

BLACK DOT

Black dot caused by the fungus *Colletotrichum coccodes* is a serious disease of potatoes mainly in Washington and Idaho where yield losses of 10-12% have been reported from the field. The effect of foliage infections on the yield and quality of Russet Burbank are being investigated by Dr. D. Johnson of the Washington State University, Prosser. Johnson and others consider that yield reductions of greater than 10% may be occurring naturally as it is difficult to eliminate the disease from control (check) plots. Also total yield reduction of 32% were measured in glasshouse experiments. Most workers consider that the importance of this disease is underestimated as reduced yields are a result of interaction with other pathogen such as *Verticillium* and potato virus Y (PVY).

Johnson's work has shown that foliage infection occurs when leaves are inoculated after wounding with a sand blast of 15 km/hr for 0.5 seconds. Leaf symptoms are similar to those cause by Target Spot except they do not form concentric rings in the dead tissue. Spores of *C.coccodes* have been recovered from plant sap 15 days after emergence. Levels of 1.6 and 9.9 colonies/cm of stem have been found in naturally infected and inoculated plants respectively. By mid season 80% of plants may be infected.

Fungicides such as Fungidex (triforine) and Rally (myclobutanil) have reduced leaf infection, but there is no information on the most appropriate time of application.

Overall the general opinion was that black dot is a significant and generally underrated disease that is most likely seed borne. Soil fumigation is not considered the answer to this disease as this only delays the onset of the epidemic. Further work on resistant cultivars, crop rotations,

nitrogen and irrigation management were seen as the main areas in need of further investigation.

Dr. Anne Barkdoll of the University of Idaho - Research and Extension Centre reported on her work with black dot. She found the black dot fungus in soil from 70% of the seed producing fields from 100% of the fields in production areas of Idaho. This work indicated that seed is an important source of introducing the fungus into non infested soil.

SILVER SCURF

Silver scurf caused by soil borne fungus *Helminthosporium solani* is a disease of potatoes that is becoming an increasingly important problem world wide. It is a major cause for down grading and rejection of table and processing potatoes. Until recently there have been few studies conducted on this disease. Dr. R. Dorian of the North Dakota State University, Fargo, has been investigating the problem and has shown that the disease cannot be effectively controlled in storage by chemical treatments, due to the development of resistance to the fungicide thiabendazode (T.B.Z.). His studies also showed that silver scurf developed most in potatoes where the time between planting and harvest was longest. Studies on *Helminthosporium solani* during storage also showed that the fungus sporulates on tubers during storage and that spores produced infect seed potatoes during seed handling.

The variability of thiabendazole sensitive and resistant isolates of *Helminthosporium solani* have been studied by Dr. R. Loria, Cornell University, Ithaca. Temperature differences in optimum growth rate and spore production as well as genetic analysis suggested independent development of fungicide resistance at different locations in the United Sates. Studies are continuing to identify disease resistant cultivars.

Another interesting study by the Ithaca group was the use of green manure crops to control *Helminthosporium solani*. Sulphur containing compounds such as gluco sinolates are present in all *Brassica* species and these break down in soil under conditions of neutral pH to produce isothiocyanates (I.T.C.), which are chemicals similar to the anti fungal fumigants vortex and trapex. Preliminary results indicated black mustard (*B-nigra*) and Indian mustard (*B.juncea*) were more effective than rape (*B. napus*).

POWDERY SCAB

Powdery scab caused by *Spongospora subterranae* is now recognised as an important disease of potatoes in the USA despite being a problem in Australia and Europe for many years. However the research on the problem in the USA is limited and at this stage appears focused at the laboratory of Dr. B. Christ, Pennsylvania State University, Pennsylvannia. In 1991 and 1991, potato cultivars were evaluated for susceptibility to powdery scab. Further work in this area is continuing as differences in cultivar ranking differed between years.

A soil bioassay for powdery scab has been developed by Dr. S. Wale of the Scottish Agricultural College, Aberdeen, Scotland. This involves potato micro plants (cv Estima) grown in test soil on a 3 day wet, 10 day dry watering regime at 14°C. After 21 days plants are removed from soil, and the roots stained with Toluidine blue to indicate infected root hairs. Use of the bioassay over 4 seasons indicated wide spread contamination of potato soil in north east of Scotland. The bioassary is used as one component of a predictive scheme in which soil type, drainage, soil Zn, cv resistance and irrigation are used to develop a risk assessment scheme for seed growers. Scores for each factor are totalled and a multiplication factor applied according to disease resistance rating. Score 0 - 40, = low risk, 40 - 80, = moderate risk and > 80 high risk.

The rapid spread of powdery scab was reported by Dr. I. Ahamad of the Crop Disease Research Institute, Isalamabad, Pakistan. Powdery scab was first detected in isolated pockets in Pakistan in 1986, but by 1990 was wide spread and established in the main potato growing areas. The work suggested that powdery scab was introduced at inconspicuous levels of incidence and severity.

Australian work reported by Dr. R. Taylor of ICI-Australia showed the powdery scab could be controlled with fluazamin applied to the soil at planting. The fungicide is effective if applied in the furrow and targeted to the zone of soil where tubers form. This was achieved by applying fluazamin at 1000g ai/ha at planting using 4 spray nozzles around the planting boot. Fungicide was applied with a "T" nozzle in front of the furrow areas, a cone nozzle in the furrow and 2 "T" nozzles parallel to the row. Fluerescent dye in the spray showed that this configuration provided good distribution of fungicide in and around the seed piece.

SEED PIECE DECAY AND TUBER HANDLING

In collaboration with French researchers Dr. W. Stevenson is developing a computer expert system for use in diagnosing post harvest disorders of potatoes. With this system the computer performs the reasoning and problem solving tasks while directing questions and issuing diagnostic reports. Although the development of this type of work is in its early stages it indicates that in future potato growers should be able to identify common pests and diseases by responding to a series of yes/no questions with a computer rather than an adviser.

Seed piece breakdown can be caused by bacterial soft rot *(Erwinia carotovara* subsp. *atroseptica)* and dry rot caused by *Fusarium* sp. The effect of seed piece handling and growth environment on seed piece decay has been extensively studied by Dr. W. Stevenson, University of Wisconsin, Madison. The three year study showed that any procedures that enhance the natural healing process of cut tubers reduces seed piece decay and the need for chemical treatments. The work showed bacterial decay was least with moderate soil moisture and healed seed pieces. *Fusarium* decay was a major problem particularly when *Fusarium* infected tubers were cut and healed before planting.

In the USA captain and Tops (TBZ) is applied at cutting to control *Fusarium* but fungicide resistant strains of *Fusarium* are now wide spread in the USA and this has limited the use of TBZ. Screening for alternative fungicides for seed treatments has been carried out by Dr. P. Nolte, University of Idaho, Idaho Falls. This work showed that the combination of benzimidazole fungicides (TBZ) with other fungicides such as mancozeb provided excellent control.

Other workers such as Dr. K. Burkhead of the USDA and some commercial companies are evaluating microorganisms for potential biological control of *Fusarium*.

Bruising of seed tubers is considered by many researchers in the USA to be one of the most important factors affecting tuber quality, as bruising provides entry sites for pathogens and increases the physiological age of the seed. Studies to determine the extent of bruising in the seed industry have been conducted by Dr. S. Johns-Thompson & co-workers of the University of Idaho, Aberdeen. These studies showed that in many seed lots 20% of tubers were bruised and infected with dry rot. Some lots had 7 bruises per tuber and all lots had more than 2 bruises per tuber. They also found that 56% of bruising occurred at the truck and a further 15% of bruising developed on moving tubers into the cellar. In general total yield and tubers per plant declined with an increase in bruising on seed potatoes. In the USA it is recommended that tubers should not drop more than 6" (150 cm).

COMPUTER SOFTWARE

One of the highlights of this conference was the development by Dr. Walt Stevenson, University of Wisconsin, Madison, of computer software for use in potato production. Weather and crop data is entered into a computer and used to predict emergence, outline the most appropriate times for pesticide application and schedule irrigation. The system Potato Crop Management (PCM) is used in over 30,000 acres of potatoes in the Mid West of USA and has resulted in significant savings to growers.

For example since its release in 1989 the system has been widely adopted by growers and IPM consultants in Wisconsin and neighbouring states and has resulted in savings of over US$1 million per year with significant reductions in pesticide use. In the disease management modules of the PCM program, daily data on the temperature, relative humidity, irrigation and rainfall are collected and used to predict the appearance of potato early and late blights. This is then used to indicate the initiation and subsequent timing of fungicide application. The incidence and severity of the two diseases is also recorded at weekly intervals and the rates of fungicide application and adjusted according to the disease progression as indicated in the PCM programme. The programme is being updated from DOS to a window platform and the new version is expected to be completed for 1994. In the meantime the original version has been purchased and its potential will be evaluated in SA. In New York this system was being used by extension officers and progressive growers. Weather stations situated in potato fields were set up to collect data and were accessed by means of modems. This enabled extension workers and growers in particular to compare meteorological data from different fields and districts.

PINK EYE

Pink Eye is a disorder of potatoes that is wide spread in the USA and thoght to be due to a bacterial infection, although no one has isolated an organism and reproduced the symptoms experimentally. The disease has shallow pink to brown patches around the eyes of tubers at harvest time. The affected areas usually dry up in dry storage conditions.

Dr. R. Rause, University of Wisconsin, Madison, surveyed 110 potato growers in Wisconsin over 4 years and found a high correlation between the incidence of pink eye and soft rot. His observation suggested that pink eye was less prevalent in fumigated soil. Pink eye was also associated with early dying, and was prevalent in low lying areas and frequently associated with excessoive soil moisture.

POTATO VIRUS Y

A severe strain of PVY, causing a ring necrosis disease of tubers and making them unmarketable, has recently been found in North America. This disease appears as brown rings or cracks on the surface of tubers with dead tissue beneath the cracks. Symptoms first appear at harvest or within a few weeks from harvest. The disease has been found in France, Germany and Hungary with many European and American cultivars susceptible, some with 95% of tubers showing symptoms. Atlantic is very susceptible.

As a result considerable effort has been undertaken in many areas to determine the distribution of the strain. Dr. J. McDonald of the Central Plant Health laboratory, Agriculture, Canada, Ontario, reported that table stock potatoes imported into Canada from California induced the ring necrosis disease while potatoes supplied from other areas did not.

An extensive survey for PVY and other viruses in the Florida potato industry was alo undertaken by Dr. D. Weingartner in 1992 and 1993. A total of 98,410 samples were collected from 936 fields in the first year and 111,000 from 103 fields in the second year. One positive severe strain of PVY was detected whereas ther other viruses were detected with percentages of PVA 2.5%, PLRV, 1.5%, PVN 25%, PVS, 88% PVX 2.5% and PVY (mild) 5.6%. The severe strain was not found in volunteer potato plants nor in weeds adjacent to potato fields. The severe strains of the virus had been imported into Florida on Atlantic seed from Canda. The survey indicated that the virus was not evident in Florida.

The effect of the common strain of PVY on yield and the severity of potato dying has been investigated by A. Mondjana of the University of Wisconsin. This work has shown that PVY infected seed reduced yield by 50% but in the presence of *Verticullium* yield was reduced by 70%, indicating that the effects of the combined disease on yield were addative.

The incidence of PVY in seed production areas of the USA has increased in the past few years, but the cause is unknown. One suggestion is that aphid vectors that have not been recognised may be transmitting the disease. It is thought that these aphids may not be colonizing potatoes but pick up and transmit the virus in seconds.

TRANSGENIC PLANTS

An overview of incorporating genes into plants was presented at the PAA conference by Dr. Bob Marten of Agriculture Canada, Vancover. Agrobacterium has been mainly used to incorporate foreign genes into potato plants to control viruses, bacteria, fungi, and insects. There is considerable concern on how these plants should be managed, particularly if the resistance genes need to be "turned on" or operating continously. It was considered that the transformed plants may be more effective if a specific promoter was used to turn on the gene only when it was required. Transgenic plants needed to be identified from other plants by techniques such as coloured flowers. The need for public education on the use of these plants was also considered.

A number of companies, eg Monsanto and seed companies such as HibridTech Seed International, have produced transgenic plants and many of these are now under evaluation in the field. A number of potato lines have been transformed to control Colorado Potato Beetle by incorporating the *Bacillus thurigiensis* gene. Several transformed lines have been compared in diverse sites across North America and have not differed in growth habit, tuber type, yield and procession characteristics compared to the controls.

Season long control of Colorado beetle was achieved in the transformed plants. There is concern that insect pests may be rapidly selected for resistance where transformed plants are grown therefore management strategies will need to be developed before these plants are released commercially. Another concern is that non aphid transmitted virus may become aphid transmitted in transgenic plants.

Another novel technique reported by Dr. R. Brand, Plant Biotechnology Section, Infrvitec, Stellebosh, South Africa was the use of genes from the giant silk moth that has natural resistance to bacterial pathogens. The South African strategy is to transfer genes from the insect to the plant to confer resistance in the plant to bacterial pathogens.

BIOCONTROL

A unique means of controlling diseases of potato tubers was reported by Dr. G. Diuxon & Colleagues of the Horticultural Department, University of Strathclyde, Scotland. Glycoalkaloids, are toxic compounds produced by potatoes in response to light or wounding. These compounds have been shown by the Scottish workers to be antifungal to *Fusarium* and *Colletotrichum* both *invitro and invivo.* The concentration of glycoalkaloids can be increased 30 fold by illuminating tubers. Since it is not degraded over a six month period or translocated, light enhanced seed tubers can produce crops suitable for human consumption. This technique offers a simple evironmentally acceptable strategy for controlling storage diseases. Various workers reported fungal antagonists for the control of a number of different potato diseases. Many of these are listed under specific diseases and include strains of *Gliocladium virens*, *Bacillus subtilis* and *Verticillium bigutatum* for the control of *Rhizoctonia, Bacillus* spp and *Streptomyces* sp for the control of commom scab, and rhizosphere bacteria to control potato cyst nematode. A number of these organisms are being produced commercially in the USA and Europe and some of the companies involved have been approached with the possibility of introducing the products for evaluation in Australia.

OVERSEAS VISITORS

Several American researchers have expressed interest in visiting Australia to work on potato problems during sabattic leave. Dr. Walt Stevenson of the Plant Pathology Department, University of Wisconsin, in particular is interested in spending his sabattical leave in 1995 to work on potato disease problems in South Australia. Dr. Stevenson is considered by his colleagues to be an outstanding plant pathologist, attuned to the problems of the American Potato Industry and acknowledged as the best potato extension pathologist in America. The Australian potato industry would benefit considerably by having Dr. Stevenson working in Australia and the industry should therefore consider contributing travel and operating funds to ensure his visit. This has worked successfully in the past as indicated by the excellent work conducted in South Australia by Dr. Helene Dilland of the Cornell University, New York.

Other key overseas scientists and extension workers should be encouraged to visit Australia and work in the Australian potato industry for extended periods and on specific projects. If appropriate overseas workers are carefully selected on experience as well as their enthusiasm to work in Australia, the local industry should benefit greatly with little outlay of funds.

MISCELLANEOUS

1. Potatoes in space

Potatoes are being evaluated for use in life support systems to supply food, oxygen and water and to remove carbon dioxide for long term space habits according to a report by Dr. T. Tibbits of the University of Wisconsin, Madison. Research is concentrating on controlling plant morphology to limit shoot production and maximise tuber yield. A space shuttle experiment utilising the potato has been scheduled.

2. Colarado Beetle

The Colorado beetle is the most important defoliating pest of potatoes and was observed on both research and commercial potato farms. In may plantings 2 to 5 beetles per plant were seen on partially defoliated plants. Beetles in Wisconsin were immune to all insecticides registered for use on potatoes which limited control to the use of heat. This was applied in a bank of propane burners that applied flame to newly emerged plants. With this technique tractor speed and flame intensity needed to be carefully adjusted to avoid excessive damage to the potato plants. Control of Colorado beetle was costing $300 to $400 per acre.

Studies at the University of Wisconsin are aimed at using trap crops to concentrate beetles along the edges of a field where the crop could be either mulched, removed or cultivated to reduce the overwintering survival of the beetle population. Considerable effort is being put into the development of transgenic plants with resistance to the beetle based on *Bacillus thuringiensus*.

3. Survey of insect pests in USA & Canada

Dr. E. Radcliffe of the University of Minnesota, St. Paul, surveyed entomologists working on potatoes throughout the USA and Canada to determine the importance of major insect pests. Colorado beetle was rated the top pest in the North East and Central Regions, while green peach aphid was rated second and first elsewhere. Other pests of importance were wire worms, leaf hopper, potato flea beetle and aphids.

4. Screening the potato genebank for pest and disease resistance

A number of wild species of potato and close relatives have been collected in the wild from South American and the accesssions (over 2,600) held at the US potato collection at Sturgeon Bay Wisconsin. The collection referred by NRSP-6 has been evaluated for resistance to a number of pests and diseases as well as physological disorders and the results of many of these studies were presented at the PAA meeting.

Dr. D. Spooner of the USDA, University of Wisconsin, presented an overview of the sources of resistance in the collection and reported 223 of 1240 tested to be resistant to *Verticillium*, 4 in 2477 resistant to PLRV and 6 in 676 resistant to early blight. Plant breeders commented that the collection is of little value unless funds were made available for breeding to incorporate the resistance into commercial cultivars.

5. Hancock Agricultural Research Centre

The Hancock Agricultural Research Centre is the main research centre of the University of Winconsin focussing on irrigated vegetables. The centre serves the Central Sands area of the centre of Wisconsin and has 135 acres of research plots on the 412 acre centre. Potatoes account for a third of the plantings and include projects such as calcium uptake to improve storage, weed control, fertility and management, irrigation scheduling, transgenic potato evaluation, Colorado Potato Beetle, Potato Virus Y, early blight, early

dying, pink eye and seed piece decay. The overall emphasis is on refining practices that reduce or eliminate ground water contamination by nitrate pesticides. In 1993 over 40 scientists were working on a total of 120 research projects based on the station.

6. Farming Systems Reseach

A large 6 year project started in 1991 to investigate the short and long term benefits and risks of 6 rotational sequences involving marketed and non marketed crops grown in rotation with potatoes has been initiated by the Univesity of Madison. This project has been set up on a 25 acre field with centre irrigation donated by a local company for the duration of the experiment. Crops involved are potato, sorghum, snap beans, red clover and sweet corn in various rotations and grown to the best management practices used by local growers. The project is run by a team of scientists from the University of Wisconsin who monitor and collect data from each crop and crop rotation. This includes data on crop growth, development and yield, plant disease, weeds, insects, soil fertility and irrigation as well as the economics of the operations.

The interaction of scientists of different expertise and the interaction of producers with practical experience is seen as one of the most valuable assets to the programme. The overall benefits of such a large and obviously expensive project are seen as being able to identify the main factors that contribute or interfere with the preventative management of pests and diseases in the potato crop. The information gained from this research will be incorporated into software for management modules for various crops.

RECOMMENDATIONS

1. **Potato Early Dying**

Due to the importance of this disease in Russett Burbank plantings in the USA, investigation should be undertaken to determine the relative importance of this disease in Australia. Yield reductions of 12 to 50% have been reported overseas with this disease and similar effects may be limiting the yield potential of crops in many potato growing areas of Australia.

Studies should be undertaken to develop (a) reliable detection methods for the pathogens (b) threshold levels of the pathogens associated with this problem and (c) the yield losses due to this disease.

2. **Late Blight and Early Blight**

The rapid spread of the A_2 mating type of *P.infestans* and the associated resistance to metalaxyl and related fungicides has caused serious economic losses in Europe and America. Australian isolates of *P.infestans* should be regularly tested for the presence of the A_2 mating type and monitored for fungicide resistance to ensure that these problems do not spread within Australia.

The PCM software system developed in Wisconsin for early blight should be evaluated in Australia and incorporated with a system to ensure efficient use of the fungicide Score. The work started in this area in South Australia and Tasmania should be extended to other States.

3. **Crop Rotations**

Crop rotations, particularly the use of green manure crops have been shown by many researchers to reduce the soil populations of important potato pathogens such as Rhizoctonia, Black Dot and nematodes. Similar work needs to be conducted in Australia to determine the efficacy, feasibility and the economics of different rotations in Australian cropping systems.

4. **Seed Piece Bruising and Tuber Breakdown**

Bruising of seed tubers during harvesting and subsequent handling was shown to be a major factor contributing to seed piece breakdown in the USA. The extent of brusing should be surveyed to determine if this is also a problem in the Australian potato seed industry. Extension campaigns identifying causes and means of control should be undertaken if warranted.

5. **Biological Control**

Biological control of many soil borne and post harvest disease of potato is being undertaken in Europe and USA. Work in this area should continue in Australia as it offers potential for reducing chemical input in potato production. Biological pesticides produced and formulated overseas should be introduced and evaluated under Australian conditions. Studies should also continue to determine if natural control agents exist in Australian soils and if so are they different to those occurring overseas.

6. **Overseas Visitors**

Key overseas scientists and extension workers should be encouraged to undertake sabbatical leave to work on projects in Australia for 3 to 12 months. Industry funds should be made available for air fares operating and travel (no more than $10,000) to allow the

overseas workers to link in and collaborate on projects that have been set up by Australian counterparts.

7. Study Tours

Australian researchers and extension personnel associated with the Australian Potato Industry should be encouraged to attend the annual meetings of the Potato Association of America to ensure they are kept abreast of the latest developments in potato production and to develop overseas contacts in the industry. Growers should also be encouraged to travel overseas to inspect potato production in other countries and to visit research centers in the main production areas. This may be best achieved by travelling in a group with an experience tour leader.

ITINERARY

July 25th	Depart Adelaide	
July 26th - 27th	Boston -	Eco Science -Dr. S. Jeffers, and other discussion on biocontrol and post harvest control of potato diseases.
July 28th - August 6th	Montreal -	International Plant Pathology Conference.
August 7th - 12th	Madison -	Potato Association of America Conference.
August 12th - 18th	Geneva & Ithaca -	New York - Dr.'s H. Dillard, W. Fry and others potato diseases and IPM.
August 19th - 20th	Pasco -	Dr.'s D. Johnson, W. Dean and others - potato diseases.
August 22nd	Portland -	Depart for Adelaide.