

Jan Toerien
avodata@optusnet.com.au

The Phytophthora Challenge

Summary

The Westfalia research and development team in cooperation with many fellow scientists achieved the following Phytophthora related research results during the decade of 1974 to 1984:

1. The first Phytophthora control in the world with Ridomil on young replanted avocado trees under field conditions.
2. The first Phytophthora control in the world with Ridomil with mature avocado trees under field conditions.
3. The first Aliette injections for Phytophthora control on avocados.
4. The first phosphorous acid injections for Phytophthora control.
5. The selection of root rot tolerant rootstocks like Dusa and Latas.

Background

Westfalia Estate is situated in the northeastern part of South Africa on the foothills of the Drakensberg range in a summer rainfall area. In 1973 Westfalia had 1050 acres of avocados in varying stages of decline as a result of Phytophthora root rot. The average avocado production was less than one ton per acre.

In 1979 the legendary Professor George Zentmyer described the Phytophthora problem in South Africa to be of much greater scope

and severity than in California (Zentmyer, 1979).

The Phytophthora root rot in avocados was previously attributed to nutritional deficiencies and a number of other factors. Dr. Harry Broderick returned in 1972 from studying at the University of California, Riverside and correctly identified the cause of the root rot problem in South Africa as *Phytophthora cinnamomi*. It is ironic that *Phytophthora cinnamomi* was first identified in California by another South African pathologist, Dr. Vincent Wager in 1946.

The time and motivation for the fight back was strategically ideal as Westfalia previously lost 80,000 citrus trees in the years 1968 to 1971 as a result of greening disease. The thought of losing an additional 1,000 acres of avocados was a very real threat. Research and technological development became the only hope and a high priority

I was appointed in 1973 as horticulturist and later Agricultural Manager. The directive message was clear: “*Fix the problem and save the avocados*”.

It was a great challenge for a young scientist to lead a research and development program to solve the Phytophthora problem in avocados.

The Research in Progress

Information was a vital element and the California Avocado Society Yearbooks were initially a valuable source of information. The bad news was that there were lots of background and basic information but there was no cure for Phytophthora rot root.

We built a small laboratory and were soon able to do effective surveys and basic experimental work.

I believe very strongly in a three stage development process and we followed this basic system in all our research and development work.

1. Experiential stage where you are only limited by your own imagination.
2. Demonstration stage where you use and refine research results and demonstrate the potential benefit on a moderate and affordable scale.
3. Implement research results after the benefits were confirmed during the demonstration phase.

The situation in the field was varied and many surveys were done which confirmed the basics of severe Phytophthora in most orchards. Wet areas with poor drainage were identified; high calcium levels were associated with better trees, soils with high organic matter showed less Phytophthora symptoms. The variation in individual tree condition indicated variability in rootstock susceptibility to Phytophthora

We spent much time in the orchards and learnt much from observations and analytical comparisons under field conditions. Robbie Madison was a very experienced production manager and his practical knowledge was of great help. Many traditional and non-traditional treatments were tried to find cures for Phytophthora infestations.

Initially we tried to improve the tree condition with improved drainage, increased calcium levels, increased organic materials and better irrigation control. The results were modest and not very convincing.

We began cooperation with research institutes and universities to get more skills and facilities involved in our research effort. We created an avocado industry research group in 1973 to share and stimulate research programs. I studied all available scientific articles to get a better understanding of our problem and potential control mechanisms. Professor Jan Kotzé was then appointed as research coordinator for the avocado industry

I was very fortunate to have a surprise visit from a Californian tour group to Westfalia in 1975. The group included many great avocado personalities, and we met Don Gustafson, Oliver Atkins, Alva Snider, Louis Lohneiss, and Ted Todd. These were the same people that I was reading about in many of the Yearbooks. It was a wonderful experience to meet them.

In 1976 I visited Israel and also attended an international course on subtropical fruit in Florida. It was a chance of a lifetime to visit California as guest of Don Gustafson. I had unforgettable discussions with the most respected scientists of that era like Dr. Roy Young, Dr. Tingwa, Prof. Art Schroeder, Dr. Tom Embelton, Bob Platt, Dr. Bob Bergh, George Goodall, and the great Professor George Zentmyer. These visits were very exciting and I was very fortunate that they patiently answered my many questions. We visited the impressive Brokaw nursery and also Oliver Atkin's nursery. Oliver gracefully entertained us at his home.

Phytophthora Research

On my second visit to Professor Zentmyer's laboratory, I saw a petri-dish with a Phytophthora culture and an unbelievable inhibition zone. The inhibition zone was created by an experimental Ciba Geigy chemical. I recognized the code and was very excited. On arrival back in South Africa, I contacted Ciba Geigy and acquired a sample of experimental Metalaxyl (Ridomil).

We employed the brilliant Joe Darvas as research pathologist in November 1976.

Westfalia now had a team of two researchers and we had the possibilities of two exciting experimental chemicals to control Phytophthora – namely Fosetyl-Al and Metalaxyl.

The golden era for Phytophthora control for Westfalia had begun.

By the end of 1976 we planned a comprehensive research program which included a soil study, water treatment for the nursery, clonal rootstock production and chemical treatment of replanted seedlings and mature trees.

The soil studies confirmed the importance of drainage, aeration, high calcium levels and organic matter (Darvas, 1997). These basic results confirmed findings by Dr. Ken Pegg from Australia. A clean water source for the nursery was achieved by filtering down to 2-4 microns. Dr. Anton Hough made valuable contributions and we also installed an inline UV light system.

Joe Darvas started laboratory tests with Ridomil and Aliette to determine efficacy, mode of action and concentrations of the chemicals (Darvas *et. al.*, 1978) Field trials started soon afterwards for treatment of seedlings in Phytophthora infected soils. We also treated mature trees with soil applied Ridomil Wettable Powder, and foliar and stem-painting application of Aliette (Darvas, 1978b).

The avocado seedlings treated with Ridomil were the first to respond and we soon saw excellent results and we were very excited (Darvas, 1979a). Joe Darvas developed a technique for quantitative and qualitative evaluations of avocado roots and Phytophthora spore populations (Darvas, 1979a). New Zealand Blue Lupine seedlings were used as bait plants. We increased the number of trials with Ridomil and Aliette and Joe did a comprehensive survey of the effects by using the lupine and other soil and root tests (Darvas *et. al.*, 1979b).

By spring of 1977 we had enough data on the effect of Ridomil to move to the demonstration phase. I asked Ciba Geigy to formulate Ridomil granules rather than wettable powder for the treatment of 30 acres. We selected different soil types, tree conditions, different rootstocks and a number of other variables for these large demonstration trials. We mapped and rated all trees and created the 0 to 10 Phytophthora rating scale instead of the Californian 1 to 5 scale. We took photos of trees infected by Phytophthora at different levels of severity to be able to measure the commercial cost efficacy of the Ridomil treatments. Ciba Geigy later took over these photos and produced a rating chart according to the 10 point scale.

Joe Darvas cultured thousands of Phytophthora isolates to determine infection levels in the soil and roots from the different treatments (Darvas, 1978a and Darvas, 1979b). We were very impressed with the results. The demonstration trials confirmed and refined the research results.

The development of a clonal propagation system progressed well. Dr. Oded Reuveni from Israel taught me the basic elements of avocado rooting and the impressive Brokaw nursery was an inspiration. We built a nursery of high standards and with Phytophthora free water to produce Phytophthora free clonal avocado rootstocks. By 1977 we successfully produced commercial volumes of quality clonal Duke 7 rootstocks for new orchards.

By spring of 1978 we were ready for the first commercial treatment of Phytophthora with Ridomil. What a great feeling of excitement! We treated a few hundred acres with Ridomil granules and Joe monitored the effect with the lupine seedlings. We had to build much bigger growth chambers and laboratory facilities but it was exciting times. All the tests confirmed the experimental and demonstration phase results. The avocado orchards looked great and we were very pleased with the progress. We continued with experimental work that included mainly Aliette as a foliar spray, stem painting and soil applications.

After three years of Ridomil applications in the experimental plots, we were disturbed by the first indications that Ridomil becomes less effective with longer exposure times (McKenzie, 1984). We became aware that we had limited time to find an alternative treatment. After three years, the experimental Aliette foliar and stem-painting

applications started to show some promising results. We increased the Aliette experimental program which included six foliar sprays and possible alternatives. A comprehensive experiment was initiated with aerial application of Aliette. After a year we had problems with this approach as the Aliette changed the insect balance. The trees had big populations of sucking insects and sooty mould growing on the sugary excretions.

We were desperate to find a sustainable Phytophthora management option to improve and maintain our orchard condition.

By 1979, Dr. George Zentmyer visited South Africa and we showed him the first clonal rootstock plantings. He also saw the first indications of reduced Ridomil efficacy. Dr. Zentmyer was of the opinion that resistant rootstocks were a better long term approach than chemical control (Zentmyer, 1979).

Our research team grew and we appointed Martin Slabbert as horticulturist and Gerhard Veldman as soil scientist. Dr. Lindsey Milne joined Westfalia as General Manager and contributed to research and development. We introduced an integrated research system that included the search, selection and propagation of tolerant rootstocks like Dusa and Latas. We formed working relationships with many scientists worldwide and had excellent cooperation and participation from scientists like Dr. John Moll from the SCFRI. University of Pretoria post-graduate students conducted many research projects at Westfalia in increasing numbers in cooperation with Westfalia staff and were guided and motivated by Prof. Jan Kotzé. We hosted international students for a number of projects (Darvas and Becker, 1984).

We were blessed again when I saw an experimental zinc injection treatment by Karel Buitendag from Outspan on citrus trees (Buitendag and Bronkhorst, 1980). His injection technique gave us the idea to inject Aliette in avocados as it has a systemic action. We were on the road again to solve the root rot problem. We had to change the available Aliette wettable powder formulation to clean it up. After three months, Joe Darvas showed me the exciting new results with Aliette injections (Darvas, 1979a). New vegetative response, regrowth, and healthy roots developed in old infected trees. We lost the potential use of Ridomil but gained a new and exciting treatment with Aliette injections. The development work was urgent as we came towards

the end of the Ridomil era as an option. We tested a high pressure application system used in citrus. The results were disappointing and we had to accept a low pressure system.

We had to find suitable syringes, find ways to drill and disinfect the holes, determine optimal concentrations, find best synergistic combinations with other chemicals, and find ways to use the treatment safely, determine application rates, and check residue levels and many other issues.

Joe Darvas completed the experimental phase of Aliette injections by 1981, and we were ready for the demonstration phase. I can still remember the disbelief and laughter of our workers on the farm when we showed them how to inject avocado trees

We started injecting the orchards on a moderate demonstration scale and rated trees and orchards on the 0 to 10 scale to monitor results. Joe monitored root development and *Phytophthora* zoospore populations with the lupine bait technique. The results were very positive.

In 1981 Don Gustafson visited us and wrote "*The amount and type of research being conducted by personnel at the Citrus and Subtropical Fruit Research Institute, Westfalia Estates and the University of Pretoria was especially impressive. More avocado research is being conducted in South Africa at the present time than in most avocado production countries. This is commendable. The fungicidal work on avocado root rot is the best and most extensive anywhere*" (Gustafson, 1981)

During 1981 we confirmed the potential of Aliette injections for control of *Phytophthora*. We decided to share the information with Rhone Poulenc, the manufacturer of Aliette, before we made the Aliette injection information public. Bruno Trepoz, who was the Aliette product manager in France, came to see us. We showed him the research work that we have done. Our results showed that one year of injections was superior to three years of foliar sprays or stem painting. We further proved that the injections would only use 3% of the volume of Aliette required for foliar applications and with injections there is no pollution. The injection technique had potential commercial implications for Rhone Poulenc.

Bruno Trepoz warned us not to distribute or publish any information on Aliette injections. We were also threatened by court action if

we continued with this research. He followed up this meeting with an attorney's letter forbidding us to publish our results or do further experimental work with Alliette. We were shocked! The excitement of a scientific breakthrough made way for the difficult reality of the legal implications of which we were previously unaware. The prospect that our export avocado fruit will be banned in France was a very threatening possibility. To protect our avocado export to France we decided not to publish the results of Aliette injections in the short term but continued with research

Some confusion was experienced as some information leaked out about the injections without being accompanied by the scientific experimental data. It was very difficult to remain silent and read comments of scientists like Dr. Mike Coffee from UCR that "*there are rumors about injections but it is without any scientific basis of proof.*" A few years later Dr. Coffee wrote "*Phosphorous acid injections forever*" in our visitor's book at Westfalia. Publications only followed after a different injection formulation of Fosetyl-Al became available on the market (Darvas, 1983a; Darvas *et. al.*, 1983a; Darvas, 1983b; Darvas *et. al.*, 1983b; Darvas *et. al.*, 1984; Darvas and Becker, 1984; Darvas, 1984; and Darvas *et. al.*, 1985).

The Westfalia research team became very lucky again when we read an article by Prof. Bompaix from the Sorbonne University in France. Prof. Bompaix described the mode of action of Aliette and phosphorous acid. We learnt that Phosphorous acid is the main active molecule to create the osmophylic band response which protects the avocado root from zoospores infection. The problem was that Phosphorous acid was phytotoxic and burnt the leaves of test plants.

We had all the motivation to find an alternative to Aliette and now we had the idea of a new potential product. We imported Phosphorous acid crystals and had to reformulate it into a non-phytotoxic product by changing the pH with potassium hydroxide and stabilize it with chelated products.

We found that we could use the reformulated phosphorous acid with relative safety on avocados by changing the pH to 5.8 and by injecting instead of spraying it on the foliage. Later work by Dr. Clive Keiser showed that 7.2 to 7.4 is the optimal pH for injections.

Experimental work with Phosphorous acid progressed very well

and we found that Phosphorous Acid was much better than Aliette for the control of Phytophthora. We were excited and could not wait to present and publish the information. Joe Darvas presented the results of Phytophthora control with Phosphorous acid injection at the SAAGA Research symposium in Magoebaskloof in 1984.

Two representatives of Rhone Poulenc were in the audience and reported the information direct to Bruno Trepoz and the attorney's letter followed within days. They claimed an umbrella patent and the familiar threats were made to prevent us from publishing the results. This time they went further and forbade us to publish but also threatened Joe Darvas in person with liability. We were obviously devastated by this news.

The inability to publish the research results again caused frustration and created difficult situations for us and we could not respond to many rumors and speculations.

Bruno Trepoz claimed that Phosphorous acid was not permitted in food although it naturally occurs in plants and using it will disadvantage our exports to France.

We worked closely with patent lawyers and it took more years of frustration and research. Dr. Jurg Bezuidenhout conducted many studies of residue analysis and finally proved that Aliette had a slow release of Phosphorous acid (Bezuidenhout *et. al.*, 1985). Fresh Aliette contains a low concentration of phosphorous acid. Older stored Aliette contains more. This meant that the use of phosphorous acid for injection of avocados could not be stopped any longer.

In 1984 Don Gustafson wrote "*injections has shown fantastic response, Joe's work will be of great benefit to avocado producers across the world.*"

Today Phosphorous acid injections form the basis of root rot control in all the avocado producing countries of the world. When I see the wonderful results, I salute the dedication and brilliance of the many scientists and co-workers who made our dreams to control Phytophthora efficiently a reality. The basic Phytophthora research results with Phosphorous acid injections at Westfalia were not published. Toerien and Slabbert did publish results in 1984 on the effect of Phosphorous acid injections on avocados phosphorous levels but not Phytophthora (Toerien and Slabbert, 1984).

The Westfalia production of 130,000 export cartons in 1974 increased to 1,200,000 export cartons by 1984 as a result of research and the development of technology.

Dr. Joe Darvas was honored for his scientific contributions at the World Avocado Congress II in California in 1991.

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Note: Many of these references are available at:
www.avocadosource.com

