

REPORT ON PHYTOPHTHORA ROOT ROT OF AVOCADO IN SOUTH AFRICA

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Prof Zentmyer was very impressed with the progress made on chemical control of Phytophthora, but was emphatic about the greater importance of plant resistance. In the above picture Prof Zentmyer examines a "resistant" tree at Westfalia Estate. From left to right: Joseph Darvas, Dr John Moll, Prof George Zentmyer and Prof Kotzé.

The following report is based on a visit to South Africa in the period from February 2 to February 14, 1980. This visit was made possible by funds provided by the South African Avocado Growers Association and the Department of Agriculture. The visit was facilitated, and the avocado areas seen with the cooperation of many people, especially Professor JM Kotzé, Head, Department of Microbiology and Plant Pathology, University of Pretoria; Dr JH Grobler, Director of the Citrus and Subtropical Fruit Research Institute, Nelspruit; Dr John Moll, plant pathologist at CSFRI and his associate, R Wood; Dr Lindsey Milne, Manager of Westfalia Estates, Tzaneen; and Mr. JC Toerien, Mr. J Darvas and Mr. Martin Slabbert at Westfalia.

The report will be divided into two primary sections: Impressions and Recommendations including ideas for future cooperation.

IMPRESSIONS

One of the early impressions obtained, both at Nelspruit and at Westfalia, was of the tremendous severity and extensive occurrence of Phytophthora root rot on avocados in

those areas. From observations and from information obtained from personnel there, it was readily evident that root rot is a problem of much greater scope and severity and more rapid development and deterioration of the trees than in California.

The widespread occurrence, (with nearly 100 percent of the plantings affected in many areas is apparently related to the quite different climatic and soil conditions from those in California. The heavy rainfall during the summer months in the Northern Transvaal makes the area extremely favourable for development of *Phytophthora cinnamomi*. The high soil temperatures are favourable for development of the fungus (optimum temperatures 24 to 30°C) at a time when moisture conditions in the soil are also favourable for the fungus to grow. In the avocado areas of California there is no rainfall during summer and autumn and soil moisture can be more carefully controlled by efficient irrigation practices (though this is sometimes difficult to do in soils with very poor internal drainage). In the winter months the soil temperatures are quite low in California so that the disease has less opportunity to develop in spite of the occurrence of winter rains.

Another probable reason for the much more widespread occurrence of *Phytophthora* root rot on avocado in the Transvaal is apparently the more uniform occurrence in South Africa of soils with restricted drainage (at least in the Nelspruit and Tzaneen areas observed). There is a very close correlation in avocado areas between restricted drainage and development of *Phytophthora* root rot.

Apparently much of the development of *Phytophthora* root rot of avocado in the Nelspruit and Tzaneen areas, and probably the other areas of South Africa, has been facilitated by movement of infected nursery stock. This was also true in California, especially in the early years of the industry, before we developed recommendations and procedures for producing clean nursery stock. This situation has obviously been improved greatly in recent years. Two nurseries were visited, viz H L Hall & Sons at Nelspruit under the direction of Mr. Clive Mitchell and the nursery at Westfalia, under the direction of Mr. JC Toerien.

Both nursery operations were found to be of very high caliber and to meet the requirements that we have established in California for production of nursery stock free from *P. cinnamomi*: heat treatment of seed to prevent any possible seed transmission of the fungus into the nursery; fumigation of potting soil with methyl bromide; growing the nursery stock in containers raised above the ground; and careful sanitary procedures to prevent entry of the pathogen into the nursery area.

Another problem in the Transvaal avocado areas has been movement of *Phytophthora* into nurseries and into new plantings in water draining from infected groves into rivers or reservoirs, then subsequent use of that contaminated water of irrigation of nurseries or the new plantings. At the Hall's nursery, this problem was very well taken care of by establishing a filter system with two separate filters to remove the excess silt and organic matter, then to treat that water in a more purified form in another tank with chlorine, to kill any possible *P. cinnamomi* inoculum. At Westfalia contaminated water is not a problem because of the use in the nursery of pure water from the Westfalia drinking supply.

The other means, in addition to contaminated nursery stock by which *P. cinnamomi* can

be spread into new plantings is by water moving over infested soil, and by movement of equipment from infected to non-infected plantings. As noted above, water draining from infected areas has undoubtedly in the past resulted in infective propagules entering water sources subsequently used for irrigation, from which the fungus could spread to new plantings. This type of situation, under conditions in the Nelspruit and Tzaneen areas, is very difficult to control, and it is difficult to visualize how it could be remedied, barring a complete revision of the irrigation system.

Fungicides

Progress in research on controlling *Phytophthora* root rot by use of the new organic soil fungicides that are effective against *Phytophthora* — particularly Ciba-Geigy's Ridomil (an acryl alanine) and Rhone-Poulenc's Aliette (aluminums ethyl phosphite) at Nelspruit and at Westfalia was found to be excellent. Also in some instances, Terrazole (Olin's thiadiazole) gave some response, as for example in some plots in combination with Aliette, though Terrazole was not as effective generally as Ridomil.

In a number of experiments involving substantial numbers of trees in the Nelspruit area and at Westfalia, outstanding results are apparent with Ridomil, and in some plots also with Aliette. This was true both with young replants and with older trees. In several plots, such as one at Friedenheim in Nelspruit and Westfalia, cutting back of trees moderately to severely affected with root rot, followed by application of granular Ridomil, resulted in excellent growth of the trees. Aliette spray gave some benefit, but was not so effective as Ridomil in the

Friedenheim plot for example. There are several other examples of cutback trees responding well to Ridomil, including a plot at Cairn Trust, one in the Evenrond Section of Westfalia, and in Block 9A of the Westfalia Section. In some of these areas also, Aliette spray on cutback trees gave an excellent response. In the Evenrond Section of Westfalia also, Terrazole at the dosage of 10 grams active ingredient per square meter monthly gave very good results, while the lower dosage of 5 g a.i./m² was not effective.

Several examples were also seen of older trees responding well to Ridomil and to Aliette applications even though not cut back. The fungicidal treatments showed great promise for alleviating the root rot situation. The research in the Nelspruit and Tzaneen areas is certainly the most extensive that I know of in the world for control of *Phytophthora* root rot of avocado, with large plots involving large numbers of trees, and with accumulation of much good data.

Resistance

The clonal rootstocks from California with moderate resistance or tolerance to root rot, Duke 6 and Duke 7, are being propagated in large numbers in South Africa for trial in the field. Vigorous grafted specimens of both clones were observed at Nelspruit and at Westfalia; the growth was typical of those clones as we have them in California. At Westfalia Mr. Toerien has a large number of very vigorous Duke 6 and Duke 7 trees growing in the Evenrond Section. These trees are providing and in the future will provide abundant graft material for producing cuttings by the etiolation method in the

nursery.

Duke seedlings have been used as rootstocks in several plots at Westfalia, and to date appear to be making very good growth. Duke seedlings, in our experience in California, are somewhat variable in resistance to *P. cinnamomi* but usually have considerably more resistance than very susceptible rootstocks such as Topa Topa. Also in the Evenrond Section at Westfalia a planting of Edranol on Duke seedling rootstocks was observed to be in very good condition, much better than surrounding plantings on other rootstocks.

Amendments, Biological Control

Some plots were observed in which various amendments were used, including lime, gypsum, manure, intercropping or cover cropping with velvet beans, and various combinations of those treatments. In the plots observed there was no obvious improvement by use of these various materials. Where some of these materials were used in combination with Ridomil there was no obvious improvement. It appears that this type of amendment would have to be evaluated over a considerable period of time.

Other aspects

Some excellent work has been done by Mr Darvas at Westfalia on preharvest and postharvest problems on avocado fruit, under the direction of Professor Kotzé. The possible role of other potential root pathogens in the avocado plantings is also investigated. Also at the University of Pretoria, Professor Kotzé and some of his other students have done excellent research on various avocado disease problems primarily affecting the aerial portions of the tree, including anthracnose on fruit, sooty blotch of avocado (caused by the *Stomiopeltis citri*), and several other fruit problems.

Professor Kotzé also has some interesting research in progress on the role of calcium in growth and structural aspects of avocado roots, involving a study with the scanning electron microscope and analysis of calcium content of the middle lamella. The ultimate aim is to determine whether there is any connection between calcium content of the root and development of root rot.

Mr. Darvas, under the leadership of Professor Kotzé, has identified many of the fungi causing fruit rots (preharvest and postharvest) in the Tzaneen area, and has an excellent series of slides showing the morphology of these fungi, the damage caused and their penetration into and development in avocado fruit. These include a large number of organisms such as *Pseudocercospora*, *Colletotrichum*, *Phomopsis*, *Dothiorella*, *Fusarium*, *Rhizopus* and *Pestalotiopsis*. Control studies are also underway on these fruit problems. This is the most comprehensive research that I know of on avocado fruit problems anywhere in the world.

Mr Darvas also has isolated and identified many soil fungi in addition to *Phytophthora cinnamomi* from avocado roots and by direct isolation from soil in avocado plantings, with the lupin seedling trap. Many of these soil organisms have some pathogenic capabilities, and further research is being done to assay their potential significance.

These include fungi such as: several species of *Pythium*, *Fusarium*, *Verticillium*, *Macrophomina*, *Cylindrocladium* and *Cylindrocarpon*.

Mr. Darvas has also developed a lupin assay that looks very effective in providing a quantitative assay of *P. cinnamomi* in avocado soils. This technique is very useful and has been used extensively in surveying various soils, and in assessing the effect of various soil treatments (fungicides etc.) on the amount of *P. cinnamomi* in the soil.

RECOMMENDATIONS

1. The excellent program for producing clean nursery stock by combinations of clean seed, soil fumigation, water treatment if necessary, and use of sanitary measures to prevent movement of *P. cinnamomi* into the nursery area is certainly to be commended, and should be continued and expanded into other nurseries in addition to those at Westfalia and at H L Hall & Sons. This is one of the primary factors in preventing fungus introduction into new areas.

2. Tests with the extremely effective new soil fungicides should certainly be continued and expanded where feasible, to provide more information on minimum effective dosages. The very promising leads on the great stimulation occurring with the combination of cutting back trees and subsequent application of fungicides such as Ridomil should particularly be expanded.

3. Further consideration should be given to the use of combination treatments, or of alternately using several fungicides — as for example, combinations of a Ridomil drench and an Aliette spray, or an Aliette spray and a Terrazole drench; or treatments with Ridomil for several months, then treatment with Aliette, for example. This type of treatment should aid in combating any possibility of the development of strains of *P. cinnamomi* with resistance to Ridomil, for example, where this chemical is applied exclusively year after year.

4. As trees on the resistant clonal rootstocks (Duke 6, Duke 7, G6) become available, they should be included in a program of supplemental treatment with fungicides such as with Ridomil, Aliette, etc. Experience in California has shown that growth of these rootstocks can be increased tremendously by treatment with Ridomil or with Terrazole; Aliette should give similar results. With the severe disease situation in South Africa, any program to supplement resistance or any combination treatment should be pursued vigorously.

5. Further studies should be made of the possible role of amendments, including organic and inorganic amendments, and mulching in retarding root rot development. If even partially successful, this would provide another means of combatting the disease, and as many approaches as possible are needed in order to attack the pathogen from all possible angles. This would include such aspects as studies of ammonium vs. nitrate nitrogen, calcium applications, various types of organic mulches and manures, and intercropping with various crops such as the velvet bean that is already being used.

It is highly unlikely that the Australian rain forest suppressive soil system can be adapted to other areas of very different climate and soils, so that regimes of that type will undoubtedly have to be individually tailored to specific areas.

6. The initiation of an active program of exchange of personnel and information on avocado programs between South Africa and the University of California at Riverside should be explored; this could be mutually beneficial. This could include short-term studies of graduate students from Riverside, for example, who could pursue some aspect of their studies on *P. cinnamomi* in South Africa. Also, exchange of staff and faculty members for short-term visits would be useful.

7. The development of cooperation in several phases of the research programs on Phytophthora root rot in South Africa and at the University of California at Riverside, should also certainly be explored and stimulated. This could include a number of mutually interesting phases. For example, it would be interesting from the standpoint of our general program of mechanisms of resistance at Riverside to test some of the potentially resistant rootstocks being selected in South Africa for their content of borbonol.

Another phase would be to test some South African isolates of *P. cinnamomi*, under carefully controlled greenhouse conditions, for their virulence to Duke 6, Duke 7 and G6 in California, in comparison with California avocado isolates. This is in relation to our program of developing information on variation in *P. cinnamomi*, with the aim of designating races of the fungus; such tests could also provide a useful and rapid early indication of how these rootstocks might grow in infested soils in South Africa.

Mutual exchange of resistant rootstock material would also seem logical and useful, providing a suitable arrangement can be made. Several outstanding-appearing healthy trees have been observed in old root rot areas in South Africa. When these rootstocks are recovered, material could be rapidly tested in the nutrient solution test in California, in comparison with our materials.

8. Every effort should be made to establish new plantings on soil with good drainage. In California, on deep well drained soils, little or no root rot develops, even if *Phytophthora cinnamomi* is present. Under the climatic conditions of Nelspruit and Tzaneen, some problems may still occur on well drained deep soils but this approach is another example of the many aspects that must be pursued in order to combat the disease. A program of classifying different soil types for the potential root rot hazard should be initiated.

9. On the most poorly draining soils, consideration should be given to the replanting with resistant crops, such as Pecans. Such soils will be a continuing problem even though a combination of new fungicides and root stocks may improve the situation. Problem soils will require higher dosages of chemicals and constant attention to all other beneficial practices to make them as productive as soils with better drainage. The increase of cost necessary to protect such soil should be carefully considered in relation to the case of growing a resistant crop.

10. During the irrigation season a particular effort should be made not to over-irrigate problem soils. When root rot is present, the trees pick up less water, thus water requirements should be monitored as carefully as possible. Tensiometers should be used to determine water usage and soil water situation.

11. Diseased avocado roots from the field or greenhouse pot tests should be examined

in the laboratory for the presence of oospores of *P.c.* to determine if this is a more common spore stage in South Africa than in California. Also extracts of currently used root stocks could be used to test their ability to induce oospores, by the method described by Zentmyer *Phytopathology* 69, 1129 - 1131 (1979). It would also be interesting to check the mating type of more avocado isolates as they become available to determine if they are all A_2 , which is the usual case.

12. It would be interesting to determine if the clones with resistance to *P. cinnamomi* in some areas are also resistant in other areas in South Africa. Plantings should be made in other areas in addition to Nelspruit and Tzaneen. Another possible approach would be to test the clones in a greenhouse or screened enclosure at one location using isolates from several areas as noted under 7. Possibly some approach to this could be made in California.

Addendum

Information will be provided to Mr Toerien in relation to methods for establishing rooted cuttings in California that might be useful in increasing the percent of establishment in his nursery. Also, information will be sent to him on efficient methods of budwood storage, and on the source of grafting tape used in California nurseries.

If supplies of crude borbonol are available, some of this chemical will be sent to Professor Kotzé and to Dr van Lelyveld.