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Soil biological constraints and benefits to quandong and other native food production

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Foreword

“Sudden death syndrome” or “dieback” of quandong is of considerable concern to the industry (worth >$1 million p.a.), as its cause has not been positively identified. This publication reports on current practices and potential problems in the nursery production of quandong seedlings, which may relate to subsequent difficulties experienced in the orchard. It also reports on potential measures to control seedling death in nurseries.

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Simon Hearn
Managing Director
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Contents

Executive Summary

"Sudden death syndrome" (also called "dieback") of quandong is of considerable concern to the industry (worth >$1 million p.a.), as its cause has not been positively identified. The syndrome is characterised by dieback and rapid death of trees. It has been thought that sudden death is caused by a soil-borne fungal pathogen such *Phytophthora* or *Pythium* species, as both of these root-rotting fungal pathogens have been previously isolated from quandong orchards. However there are a number of other possible explanations for losses in the orchard that fall into several categories: water relations, pathogens, an interaction between water and pathogens, herbicides, graft incompatibility and host plant-related factors (outlined in section 2.3 of this report).

The main focus of the work reported here has been on potential problems with quandong seedling survival in the nursery, because there may be a causal relationship between these and later losses ("sudden death") in the orchard.

The two phases of the work were (1) to collect information on current practices from nurseries and growers and (2) experimental work to test for possible causes and potential controls for quandong seedling losses when grown in containers in potting media.

It was clear from interviews that losses in quandong propagation are generally higher than for other plant species even when grown by experienced nursery staff. In addition, quandong propagation nurseries tended to suffer losses and / or heavily cull quandong seedling stocks to remove unsuitable seedlings. Plants that are culled may have disease but not exhibit severe symptoms. Conversely, and more importantly, plants that are not culled may carry low levels of disease but not show symptoms, especially where fungicides are not used. In some cases, fungicides are used either curatively (when plants are performing poorly) or preventatively (upon transplant). In other cases biological products for disease control have been used or are being trialled.

The experimental work focused on the effect of different watering regimes, potential pathogens and possible control measures on the survival and growth of quandong seedlings in pots.

Seedlings obtained from a commercial nursery and grown in a commercial potting mix were used in the first experiment, which was conducted in two stages. In the first stage the effect of different watering regimes was tested. The results showed that excessively wet and dry conditions did not by themselves lead to any substantial death of quandong seedlings. Nevertheless, seedlings that were kept in waterlogged conditions lost many leaves and grew more slowly than those growing in drier conditions.

In the second stage, half of the pots were infested with the root pathogen *Phytophthora parasitica*, and the different watering treatments were continued for all pots (both with and without the pathogen). It was clear the plants were affected by the pathogen in both the excessively wet and dry soil conditions and a high proportion of the seedlings were lost in these water treatments in this second phase of the experiment. On the other hand, no seedlings at all were lost in the "adequate" or "medium" watering treatment, even when the pathogen was present.

The results indicate that both excessive and inadequate water can lead to problems with decreased seedling survival when pathogens are present in the potting medium or soil. These effects, i.e. greatest damage due to soilborne disease occurring in both wet and very dry conditions, could also apply to the situation in the field in quandong orchards.

In a second experiment, quandong seedlings at an early stage of development were subjected to a range of soil-borne fungal pathogens to test their susceptibility to disease, and various disease control treatments were applied. Quandong survival and seedling height were improved by the use of the

chemical fungicide Banrot and the biological treatment *Trichoderma koningii* 7a. Quandong appeared to be more sensitive than other plants to the chemical fungicide Ridomil Gold Plus. The results of this work will need to be repeated before any firm recommendations on treatments can be made. This is because of the prior infection of the seedling material with another (as yet unknown) pathogen.

A third experiment was conducted to try to control the unknown seedling disease with chemical and biological treatments. Use of formulations of *Penicillium bilaiae* and *Trichoderma koningii* had a beneficial effect on quandong seedling survival. Identification of the pathogen associated with the disease symptoms is highly desirable.

Based upon experience gained in the experimental work reported here and some earlier studies, we recommend that potting media used for propagating quandong should be well draining and easily re-wet after drying. The potting mix used in the initial experimental work became resistant to re-wetting when it was allowed to dry out, and this effect could easily lead to seedling death, especially if there are pathogens present. The resistance of the growing medium to re-wetting may be due to its high content of organic material, and a more suitable medium would contain less organic matter. The mix that was used in later experiments contained 2 parts coarse sand and 1 part peat moss, which seemed to be more suitable for successful quandong seedling growth.

The control of seed-borne pathogens in quandong propagation is extremely important. The use of broad-spectrum biocides for pre-treatment of quandong seed before germination is highly desirable. The results, subject to confirmation by further testing, support the use of either Banrot or *Trichoderma* Tk7a for their ability to improve seedling survival and growth. A wider range of potential disease control treatments could be tested in future.

The research reported here was done without a host plant for the quandong. Indeed, many commercial nurseries supply quandong seedlings without host plants, which are supplied separately. Whether the presence of a host plant in the pot with the quandong plant would have changed the results obtained in the experimental work is a question that may be addressed in future research.

1. Introduction

"Sudden death syndrome" or "dieback" of Quandong is of considerable concern to the industry (worth >$1 million p.a.), as its cause has not been positively identified. It is thought that a possible cause of sudden death may a soil-borne fungal pathogen such *Phytophthora* or *Pythium* species, as both these root-rotting oomycete fungal pathogens have been previously isolated from quandong orchards. The syndrome is characterised by dieback and rapid death of trees, and occurs mainly in waterlogged and poorly drained soils. These conditions also favour the spread of oomycete fungal pathogens. The use of the fungicide phosphorous acid appears to have some beneficial effect further supporting the contention that the cause is a soil-borne fungal pathogen.

The native food industry is at an early stage in its development. Research is needed to assist with problem solving so that the economic benefits, and potentially also the environmental and social benefits of establishing new industries around native food production can be fully realised. If the causal agent of quandong sudden death is a disease caused by *Phytophthora* or *Pythium* species, this may pose a serious threat to the long-term economic viability and environmental sustainability of not only quandong but also other native food crops because these pathogens tend to have wide host ranges, are usually highly virulent and can spread easily.

There may be a causal relationship between quandong seedling losses in nurseries and later losses (sudden death) in the orchard. Therefore, the first stages in the research have been to (a) review current practices in nurseries that propagate quandongs, and (b) to investigate the potential causes and controls of seedling losses in the nursery.

2. Objective 1: Review nursery practices

2.1 Method

A questionnaire (see Appendix 2.) was prepared and propagators from 7 quandong nurseries were interviewed to assess potential sources of problems (potting mixes, water, seed, and nursery practices) and current methods of solving those problems.

2.2 Results

It is clear from these interviews that (a) losses in quandong propagation are higher than for other plant species even when grown by experienced nursery staff, and (b) that quandong propagation nurseries tend to suffer losses and / or heavily cull quandong seedling stocks (up to 50% loss) to remove unsuitable seedlings (poor form or poor growth). The plants that are culled may have disease but not exhibit severe symptoms. Conversely and more importantly, plants that are not culled may have low levels of disease but not show symptoms, especially where fungicides are not used. In some cases, fungicides are used either curatively (when plants are performing poorly) or preventatively (upon transplant). In other cases biological products for disease control, for example Companion (*Bacillus subtilis*), have been used or are being trialled (Table 1).

Table 1. Fungicides and biological products that are used on seeds or seedlings in quandong propagation nurseries

Fungicide	**Rate**	**Application**	**Use**
Banrot	0.4 – 0.8g product per litre	seedling drench	preventative
Sporekill	1.0 ml product per litre	seed	preventative
Rovril	1.0 ml product per litre	seedling drench	preventative
Fongarid	1.0 ml product per litre	seedling drench	preventative
Companion	1.0 ml product per litre	seedling drench	preventative

.

Indications from current nursery practices are that it is very likely that soil-borne pathogens can cause quandong seedling death. **Objective 2** was designed to find out which are the main potential pathogen problems. This should lead to recommendation on the use of appropriate control treatments (general nursery practices and/or specific disease control treatments).

The questionnaire prepared for **Objective 1** was distributed to quandong growers at the 2002 annual conference of the Australian Quandong Industry Association (AQIA). There has been only 1 response to date, but this process will be followed up with AQIA.

2.3 Possible causes for ‘sudden-death’ of quandong

A list of several possible causes for ‘sudden-death’ of quandong has been prepared based on observations made in nurseries and orchards, and information and suggestions received from growers. Evidence for and against these possible causes is being collected.

The list is:

1. Soil borne pathogens; eg *Phytophthora* or *Pythium*
2. Water relations:
   (a) waterlogging (related to soil type)
   (b) soil too dry
   (c) quandong killed by other quandongs via competition for water, especially if no large host plant present.
3. Interaction between soil borne pathogens (1) and water relations (2)
4. Lack of large enough host plant.
5. Graft incompatibility.
6. Herbicides taken up via quandong itself or the host plant.
7. Girdling of quandong by host plant (*Myoporum*).

Discussions on possible causes of sudden death have been held with Dr Brian Loveys (plant physiologist, CSIRO), Ms Barbara Hall (plant pathologist, SARDI) and Dr David Guest (plant pathologist, University of Melbourne). This initial work has formed the foundation for the design of the laboratory and glasshouse trials.

3. Objective 2: Identify causal agent of seedling death of quandong in nurseries

3.1 Method

Plant and soil samples were taken from nurseries and orchards to be screened for pathogens on selective laboratory media. Small pieces of tissue from actively progressing lesions on roots and stems of quandong plants from an orchard were plated onto Phytophthora Selective Medium (PAR; Kannwischer and Mitchell, 1978) and Pythium Selective Medium (VP_3), Ali-Shtayeh et al. (1986).

3.2 Results

Fungi have been isolated from plant samples with seedling dying / death symptoms. Identification to genus level has been made. The root pathogens *Phytophthora* and *Pythium* have been found in recently dead quandong plant material from orchards. These isolates have not yet been tested for pathogenicity towards quandong. The work in the following experiments has been done using pathogen isolates from culture collections at SARDI (B. Hall) and CSIRO Land and Water (Dr P. Harvey), Adelaide.

3.3 Experiment 1

An experiment was designed to assess (1) the effect of different growing medium water potentials on quandong seedling growth as well as (2) a possible interaction between a known root pathogen and the growing medium moisture content.

Materials and Methods

(1) The effect of different growing medium water potentials on quandong seedling growth
Quandong seedlings were obtained from a commercial nursery. Plants were growing in 7 cm plastic pots in a medium consisting of 3 parts soil, 2 parts washed sand, 1 part peat and 1 part perlite. Seedlings were selected on the basis of uniform height. The experimental design to assess growing medium moisture content on growth of quandong seedling growth was a randomised complete block, with 24 replicates of each of the three water content treatments.

Three growing medium water potentials were achieved by watering the plants to free draining either daily, twice weekly or once a week. The volumetric soil moisture content was measured and recorded before and after watering using a Theta Probe Soil Moisture Sensor (Measurement Engineering Australia). The volumetric soil moisture ranges of the potting medium were: 33% to 45%,for the pots watered daily; 15% to 41% for those watered twice weekly; 1% to 35% for the pots watered once a week. The poor ability of the potting mix to be re-wet to a high water content after more extreme drying (i.e. the dry treatment) was noted (see Appendix 1). Plant height, numbers of leaves, plant survival and shoot symptoms were recorded weekly.

(2) The interaction between a pathogen and the growing medium moisture content.
After 12 weeks the 'healthiest' plants (replicates) from each treatment were chosen, divided into two lots and half were inoculated with *Phytophthora parasitica.* This pathogen (from almond, SARDI collection) was chosen because *P. parasitica* has been reportedly isolated from quandong. There were nine plants in each of the growing medium water potential treatment and pathogen treatment. The experimental design to assess the interaction between the pathogen and the growing medium moisture content was as follows:

1 Waterlogged minus *P. parasitica*
2 Waterlogged plus *P. parasitica*
3 Adequate water minus *P. parasitica*
4 Adequate water plus *P. parasitica*
5 Dry minus *P. parasitica*
6 Dry plus *P. parasitica*

Plant survival was recorded after 7 weeks in a controlled environment chamber (12 h light / 12 h dark, 25C).

Results

(1) Effect of different growing medium water potentials on quandong seedling growth after 12 weeks

There was a significant (P<0.001) effect of growing medium moisture content on plant height (Fig.3.1). The average increase in plant height was 4.2 cms for the adequate water treatment compared with 3.5 in the dry treatment and 1.5 in the waterlogged treatment.

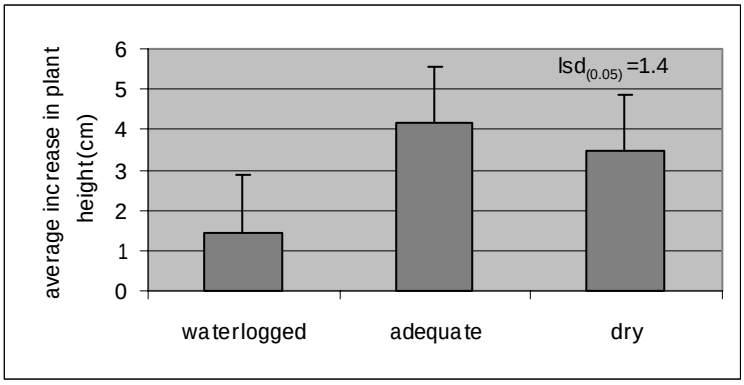

Fig.3.1 Effect of growing medium moisture content on plant height

There was a net loss in the numbers of leaves across all the growing medium moisture content treatments. However significantly more leaves (P <0.001) were lost in the water logged treatment (-78.4%) compared to the adequate water (-4.8%) or dry (-8.4%) treatment (Fig. 3.2).

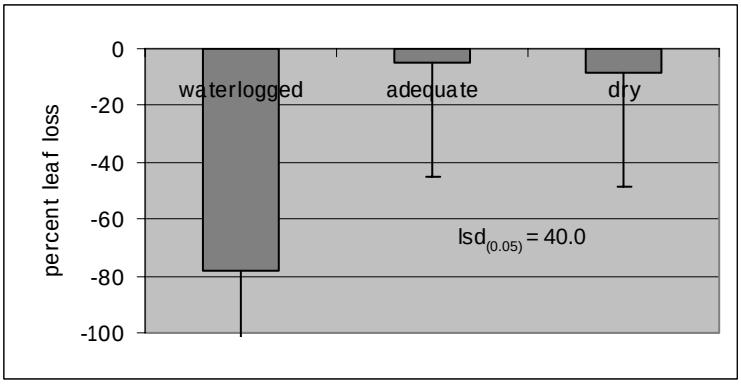

Fig.3.2 Effect of growing medium moisture content on numbers of leaves.

There was a moderate effect of growing medium moisture content on shoot symptoms (Fig.3.3). In the waterlogged treatment, 42% (10 of 24) of the plants remained healthy compared to 63% (15 of 24) in the adequate water and 42% (10 of 24) in the dry treatment. 54% (13 of 24) of the plants developed symptoms associated with water stress in the waterlogged treatment compared to 38% (9 of 24) in the adequate water and 54% (13 of 24) in the dry treatment.

There was little effect of the different watering regimes on plant survival. One out of twenty four plants died in the waterlogged and dry treatments. No plants were lost in the adequate water treatment.

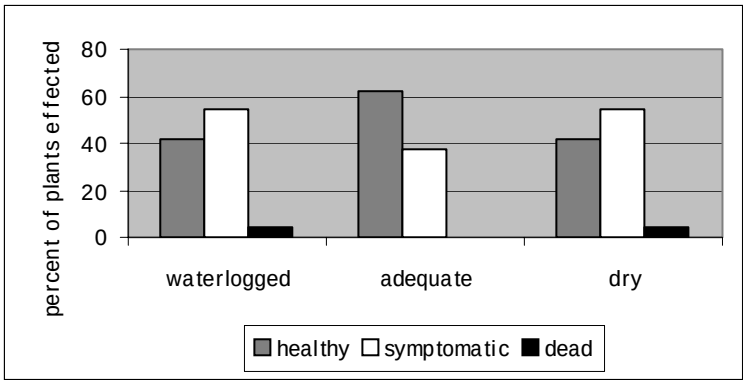

Fig.3.3 Effect of growing medium moisture content on plant survival and shoot symptoms

(2) Effect of the interaction between a pathogen and the growing medium moisture content on quandong seedling survival after 7 weeks

Growing medium moisture content and pathogen incidence both affected (P = 0.083) quandong seedling plant survival (Fig. 3.4). In the absence of the pathogen 11% (1 of 9) of the plants died in the waterlogged minus pathogen treatment compared to 56% (5 in 9) where the pathogen was added. Similarly in the dry treatment 11% (1 of 9) of the plants died in the absence of the pathogen compared to 44% (4 in 9) where the pathogen was added.

No plants were lost where *P. parasitica* (P.p) was present or absent in the adequate water treatment.

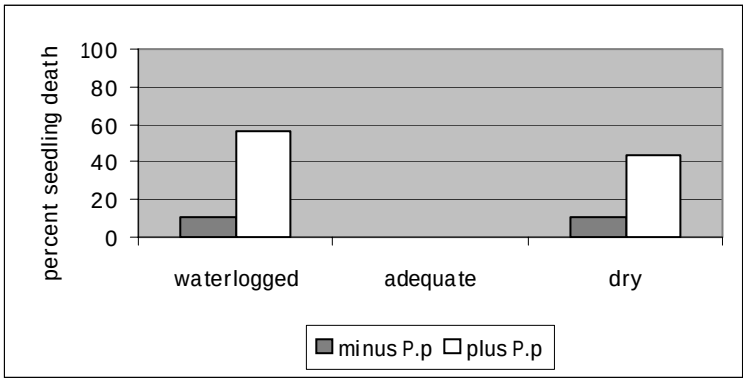

Fig. 3.4 Effect of growing medium moisture content and pathogen incidence on plant death.

Conclusions

(1) The effect of different growing medium water potentials on quandong seedling growth and survival

The optimum growing medium moisture content for plants growing in a 3 parts soil, 2 parts washed sand, 1 part peat and 1 part perlite was between 20 and 25 % v/v. Plants grew significantly better, developed less symptoms associated with water stress and had an excellent survival rate.

Excessive growing medium moisture content does not appear to be the sole cause of seedling losses in quandong propagation: only 1 plant in 24 was lost in the waterlogged treatment.

(2) Effect of the interaction between a root pathogen and the growing medium moisture content on quandong seedling growth after 7 weeks

Quandong seedling losses increased substantially (from 11% to 44% or 56% of seedlings) when the pathogen *Phytophthora parasitica* was added to growing medium with the low or excessive growing medium moisture content respectively. However, no seedlings at all were lost in the adequate water treatment, irrespective of the presence of the fungal pathogen.

Soil conditions such as waterlogging and/or poor drainage promote the infection of roots by oomycete fungal pathogens such as *Phytophthora* and *Pythium* because the fungi produce spores that become 'mobile' under these circumstances. The spores adhere to the root produce a cyst coat and grow into the root tissue. The spores are also attracted by sugars present in the exudates released by plant roots. One of the factors that can increase root exudation is plant stress, which can be associated with flooding or drought. This may explain why there were increased seedling deaths in the dry conditions with the added pathogen. These results indicate that both excessive and inadequate water can lead to problems when pathogens are present in the potting medium or soil.

4. Objective 3: Investigation of methods of control

4.1 Reasons for modification from proposal

In order to do the planned experiments, we required sufficient quandong seedlings of a relatively uniform stage of development (i.e. uniform root length or shoot height). Despite using a recommended method (Loveys and Jusaitis, 1994) we were not able to raise enough seedlings of a uniform size ourselves. Quandong seedlings were therefore purchased from commercial growers. Even so, the size range (radicle length) of germinated seed that we obtained was greater than anticipated. In addition, the quandong seedlings obtained for experiment 2 appeared to have become infected with either fungal or bacterial pathogens.

Experiments were designed to test which of a range of soil-borne plant pathogens are able to cause disease symptoms on newly emerged seedling roots of quandong as well as to test biological and chemical treatments to control disease when applied either preventatively (upon transplant), experiment 2, or curatively (when plants are performing poorly), experiment 3. *Trichoderma* was used a biological control treatment (as suggested in our proposal) as well as additional beneficial soil fungi being investigated by our research group.

4.2 Experiment 2

The aims were to test whether isolates of *Pythium* and *Phytophthora* reduce the emergence and/or survival of quandong seedlings and to investigate possible chemical and biological disease control upon transplant.

Materials and Methods

Newly emerged quandong seedlings were obtained from a commercial nursery. The plants received were growing in perlite in seedling raising trays. Seedlings were transferred from the growing cells, treated and transplanted into a potting mix that was 2 parts coarse sand and 1 part peat moss. The experiment was conducted in 300ml non-draining plastic pots. Plants were grown in a controlled environment chamber at 25C and 12 h light / 12 h dark. Soil moisture level was maintained at 10% (v/v) by watering to starting weight three times a week. There were 4 plants in each treatment and the experimental design was a factorial matrix of pathogen (5) by control method (4).

The seedlings were treated with the following biological and chemical treatments to attempt to control disease:

1. Nil
2. BANROT (Banrot 40WP, active ingredients 25 % thiophanate-methyl + 15 % etradiazole)
3. RIDOMIL (Ridomil Gold Plus, active ingredients 5 % Metalaxyl-M + 39 % Copper)
4. TRICHO (*Trichoderma koningii* T.k.7a, Simon, 1989).

The plants were inoculated with a range of soil-borne plant pathogens that included isolates of *Phytophthora* and a *Pythium* species as follows: Nil (no pathogen), *Phytophthora nicotiana* isolated from a nursery soil, a *Phytophthora* sp. from muntries, a *Phytophthora* sp. from quandong and an isolate of *Pythium ultimum* from a wheat cropping soil.

Results

At the time of reporting the plants are 4 weeks old. Preliminary statistical analysis indicates that the condition of the starting material (newly germinated seedlings) may be confounding the effect of the added pathogen on plant survival and growth. However, after 4 weeks there are indications that there is an effect of disease control treatment to improve quandong seedling height (Fig. 4.1) and survival (Fig. 4.2).

Banrot 40WP (BANROT) and *Trichoderma koningii* 7a (TRICHO) significantly (P<0.001) increased quandong seedling height compared to the Ridomil Gold Plus (RIDOMIL) and increased height compared to untreated control (NIL) plants by 29% though this was not statistically significant.

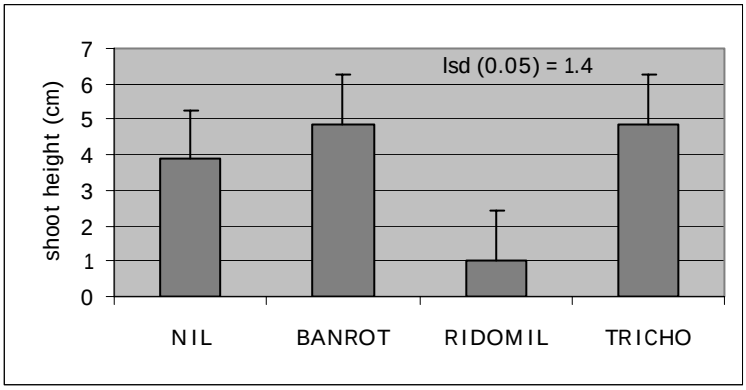

Fig. 4.1 Effect of control treatment on quandong seedling height

Quandong seedling survival was significantly (P<0.001) reduced when seedlings were treated with Ridomil Gold Plus (RIDOMIL) but was improved by treatment with Banrot 40WP (BANROT; 38% increase) and *Trichoderma koningii* 7a (TRICHO; 25% increase) compared to the nil control (NIL) (not statistically significant, but close to significant for Banrot).

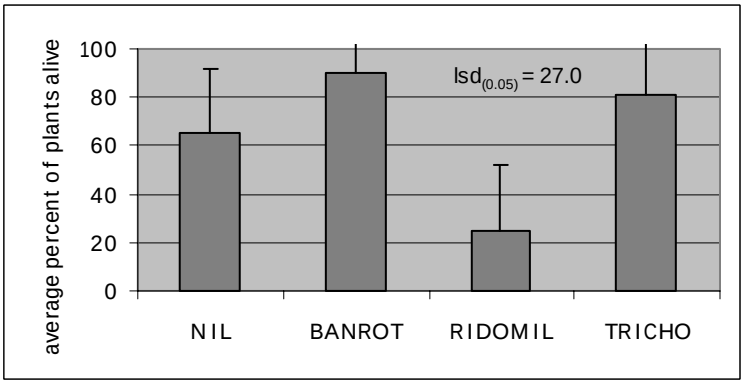

Fig. 4.2 Effect of control treatment on quandong seedling survival

In this experiment, the chemical fungicide Ridomil Gold Plus was applied to soil at rates derived from commercial recommendations for the control of *Phytophthora* on other plant species. It appears that quandong is more sensitive to the active ingredients (Metalaxyl-M / copper) than other plants.

Conclusions

Quandong survival and seedling height may be improved by the use of the biological and chemical treatments *Trichoderma koningii* 7a and Banrot 40WP when they are applied preventatively (upon transplant) to control disease. Ridomil Gold Plus will need to be tested at reduced rates compared to those used for disease control on other plants.

It should be stressed that the results of experiment 2 will need to be repeated before firm recommendations on treatments can be made. This is because of the prior infection of the seedling material with another (as yet unknown) pathogen, which led to variability in the results and to some extent confounded the aims of the experiment. Other potential treatments such as Fongarid could be trialled in future tests.

4.3 Experiment 3

The aim was to attempt to control the disease (of unknown cause) that was affecting the quandong seedlings that were purchased for experiment 2.

Materials and Methods

As mentioned above, the quandong seedlings obtained for experiment 2 appeared to have become infected with either fungal or bacterial pathogens prior to establishing the experiment. The less severely infected seedlings were chosen for an additional experiment to test the potential for several biological and chemical treatments to control disease when applied curatively (after infection). Seedlings were transferred from the cells in which they were grown, treated and transplanted into a potting mix that consisted of 2 parts coarse sand and 1 part peat moss. The experiment was conducted in 300ml non-draining plastic pots. Soil moisture level was maintained at 10% by watering to starting weight three times a week. Plants were grown in a controlled environment chamber at 25C and 12 h light / 12 h dark. There were 8 plants in each treatment.

The seedlings were treated with the following biological and chemical agents to assess their ability to control disease:

1. Nil
2. P. BILAIAE (*Penicillium bilaiae*, S. Wakelin, CSIRO)
3. P. RADICUM (*Penicillium radicum*, Whitelaw et al., 1997)
4. TRICHO (*Trichoderma koningii* 7a; Simon, 1989)
5. STREP (Streptomycin sulphate 100ppm, antibacterial)

Note that both of the *Penicillium* species are plant growth-promoting fungi, which show some evidence of being able to control diseases on other plants.

Results

At the time of reporting the plants are 4 weeks old. Initial inspection of the data indicates an effect of treatment on quandong seedling survival (Fig. 4.3).

Quandong seedling survival was improved when treated with *Penicillium bilaiae* (P. BILAIAE) (75%) and *Trichoderma koningii* (TRICHO) (87.5%) although this was not statistically significant ($P = 0.678$). There was no effect of *Penicillium radicum* or the antibiotic streptomycin (STREP).

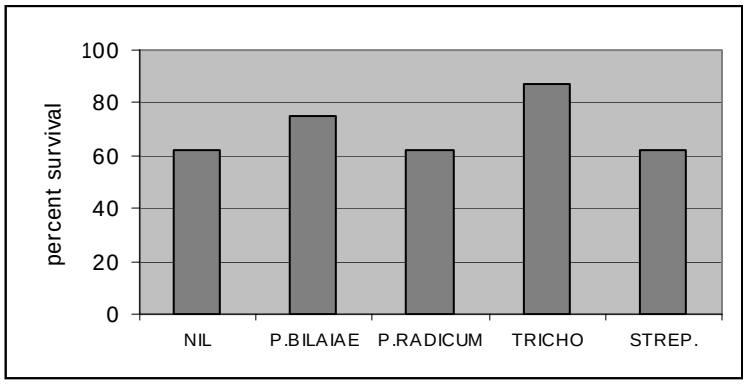

Fig. 4.3 Effect of biological and antibiotic treatment on quandong seedling survival

Conclusions

Use of formulations of *Penicillium bilaiae* and *Trichoderma koningii* may have a beneficial effect on quandong seedling survival when they are applied curatively (after infection).

It should be stressed that identification of the pathogen associated with the disease symptoms is highly desirable. In addition, the results of experiment 3 will need to be repeated before firm recommendations on treatment of this serious seedling disease problem can be made.

5. General Discussion

Based upon experience gained in the experimental work reported here and some earlier studies, we recommend that potting media used for propagating quandong should be well draining and easily re-wet after drying. The potting mix used in the initial experimental work became resistant to re-wetting, and this effect could easily lead to seedling death, especially if there are pathogen problems. A more suitable medium would contain less organic matter, which seemed to be responsible for the resistance of the growing medium to re-wetting. The mix that was used in later experiments contained 2 parts coarse sand and 1 part peat moss, which would be more suitable.

The research reported here was done without a host plant for the quandong. Indeed, many commercial nurseries supply quandong seedlings without host plants, which can be supplied separately. Whether the presence of a host plant in the pot with the quandong plant would have changed the results obtained in the experimental work is a valid question, which may be addressed in future research.

Indications are (experiment 2) that quandong is more sensitive to the active ingredients (Metalaxyl-M / copper) than other plants. The rates of Ridomil Gold for the potential to control *Phytophthora* on quandong need further investigation.

6. Communication

The results of this research were communicated at the CSIRO Land and Water Future Farming Systems Science Meeting on 20.08.03 as well as the annual Conference of the Australian Quandong Industry Association in Port Augusta on 23.08.03.

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8. Appendices

Appendix 1 Changes in volumetric soil moisture of the potting medium before and after watering

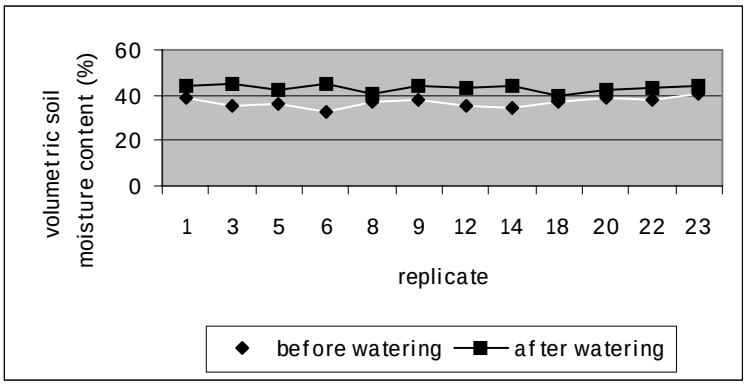

Figure A1. Changes in soil volumetric moisture content for waterlogged treatment; each point is the average of data collected over 12 weeks for that replicate (numbered)

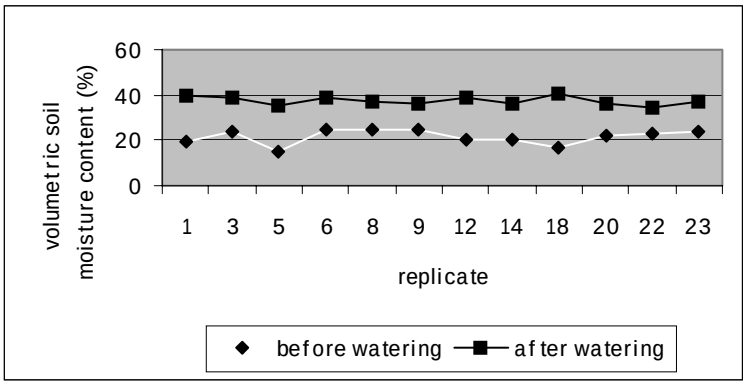

Figure A2. Changes in soil volumetric moisture content for adequate water treatment; each point is the average of data collected over 12 weeks for that replicate (numbered)

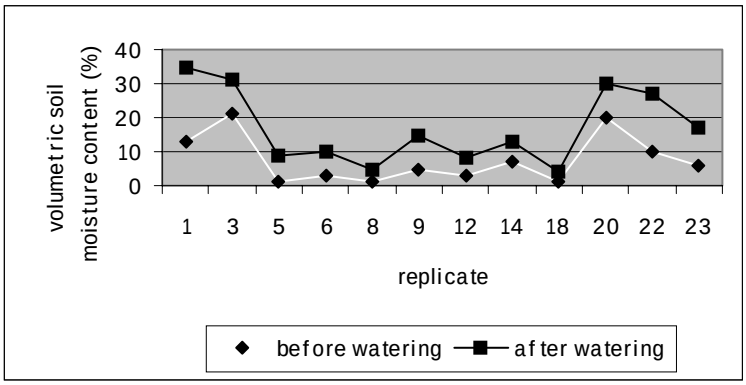

Figure A3. Changes in soil volumetric moisture content for dry treatment; each point is the average of data collected over 12 weeks for that replicate (numbered)

Appendix 2 Nursery practices review questionnaire

INTERVIEW WITH QUANDONG GROWERS

DATE _____ TEL

BUSINESS NAME_____ FAX

OWNER/MANAGER_____ MOBILE

NURSERY/ORCHARD_____ E-MAIL

Do you have any unexplained seedling or plant die-off?

Plants

PROPAGATION (seedlings/grafted?)

ANY OTHER SOURCE OF MATERIAL

SYMPTOMS OF SUDDEN DEATH

Nursery Practices

HOSTS USED

WATER

POTTING MIX

SLOW RELEASE FERTILIZERS (SRF) USED?

NOTICE ANY CONTAMINATION ON SRFs?

DISEASE PROBLEMS

MANAGEMENT of DISEASE

DISEASE PREVENTION MEASURES (Y/N)

Orchard Practices

HOSTS USED

SOIL TYPE

pH

IRRIGATION

SOIL DEPTH

CHEMICAL USE

HERBICIDES

FUNGICIDES

INSECTICIDES

DISEASE PROBLEMS?

SYMPTOMS

MANAGEMENT of DISEASE

SYMPTOMS OF SUDDEN DEATH

NOTES