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& DEVELOPMENT CORPORATION

Coriander
- overcoming production limitations

A report for the Rural Industries Research and Development Corporation

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for the Coriander Advisory Group

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Foreword

Coriander spice seed has been grown in Australia since the 1970's and in 1998 production was estimated to be 5,000 tonnes worth $5.75 million in export income for the Australian economy. More recently, production has declined, principally through the effects of disease on yields and production costs. A major problem is bacterial blight which is widespread, very damaging and has no effective control in infected crops.

Development of the coriander industry has also been limited by a lack of availability of information to new growers. Most crop production knowledge has been developed by established growers and is not easily accessible. This has resulted in either a reluctance to grow the crop, or significant financial loss through poor knowledge of production and marketing requirements.

Despite this, a strong interest in coriander has persisted in Australia because of the potential high returns and it is likely that a rapid recovery and expansion would occur if these problems can be overcome.

This publication reports on research, development and extension efforts to develop disease control methods, and improve crop nutrition and weed control. It also considers the potential for developing new coriander varieties with better disease resistance and agronomic characteristics.

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Simon Hearn
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Contents

Executive Summary

Background

Coriander spice seed has been grown in Australia since the 1970's. Production in 1998 was estimated to be 5,000 tonnes, worth $5.75 million, with good prospects for expansion of the industry in SA, NSW, WA and Victoria. This, however, has not occurred and there has been a considerable decline in production in recent years. While market opportunities and seed price have contributed to this, a major reason has been the large yield fluctuations caused by disease which have resulted in reduced grower profitability, confidence and longer-term commitment to the crop. Development of the coriander industry has also been limited by a lack of availability of information to new growers. This has resulted in either a reluctance to grow the crop, or significant financial loss through poor knowledge of production and marketing requirements. Despite these issues, there has remained a strong interest in this crop by farmers and traders.

This project was undertaken with the objective to stabilise and expand coriander production in Australia by identifying and promoting options for controlling disease and improving crop management for optimum yield. This has resulted in a better understanding of the identity, extent and economic impact of coriander diseases and identified new opportunities for variety improvement. It has also provided best practice recommendations for crop nutrition and weed control and will lead to improved production through better disease control, weed control, and nutrition management.

Research Summary

A survey of 41 crops in 1999 to 2001 confirmed that disease is still the major constraint to coriander production with 50% of crops showing infection levels expected to cause significant yield loss. Bacterial blight is the most important disease because it is wide spread, can cause high losses (>50%) and severely downgrades the value of seed. This has been exacerbated by the widespread use of Moroccan type coriander which is extremely susceptible and develops significant disease from low incidence of seed borne or endemic bacteria. Infected seed is also still being used and there is a need for more rigorous seed testing and the promotion of disease free seed. *Microdochium* is emerging as a major disease problem which can cause extreme damage and yield loss. This is a new disease which has only been recorded in the south-east of SA and its epidemiology and source of inoculum is not known. Management information is limited but it should respond to fungicide applications. Other commonly identified diseases are *Septaria* and *Sclerotinia* but neither of these are likely to have significant effects on yields.

The feasibility of treating large quantities of coriander seed with dilute hydrochloric acid to reduce bacteria infection was established. Field trials, however, showed that while this seed treatment reduces bacterial levels in infected seed, it is only partially effective in reducing bacterial blight in crops and cannot be relied upon to always give effective disease control. It may have some application on farm when disease free seed is unobtainable but should be restricted to seed lots with initial low levels of infection (<1%), and only be considered as a last resort. Alternative treatments (bleach, steam) showed some potential but were not proven to be any more effective than the acid treatment. Trial results also emphasised that high levels of infection can develop in seed even though crop disease is low which reinforces the need to test seed for bacterial infection levels, irrespective of crop disease history.

Herbicide resistance and changes in weed spectrum are escalating coriander production costs from increased herbicide application rates. Post and pre-emergence herbicide trials have provided a greater clarity to herbicide choice and identified some new options for broadleaf weed control in coriander crops. Effective weed control can be achieved at a cost of $50/ha using a Linuron / Brodal mix compared to $100/ha for a high rate of Linuron. Trials also identified effective herbicide options (e.g 2,4-D Amine at 2.0L/ha) to control volunteer coriander in cereal crops. This has major implications since a nil tolerance to contamination can result in large financial losses through the inability to sell contaminated grain at premium prices.

Tissue analysis of a range of crops suggested current fertiliser recommendations are supplying adequate macronutrients for most coriander crops. They also established guidelines for expected macro and micronutrient levels in healthy coriander crops and produced a calibration for tissue tests which can be used as the basis for identifying nutrient deficiencies.

Several lines with better resistance to bacterial blight and *Microdochium* than Moroccan have been identified in glasshouse and field trials. The most outstanding is Seedco line SX5317 which has better resistance to both diseases. Since SX5317 is early maturing and large seeded, it has the potential to be used directly as a replacement for Moroccan in coriander production in Australia. It would also be a suitable parent for rapid transfer of resistance into other agronomically adapted varieties.

Outcomes

This project has resulted in the following outcomes which will lead to improved production and expansion in the industry through better disease and weed control, improved nutrition management and greater grower confidence.

- Identification of resistance to bacterial blight and *Microdochium*, the two most important diseases in coriander. This now provides the opportunity to stabilise yields and reduce losses through the development and use of disease resistant varieties.

- Tissue tests for identifying nutrient deficiencies in coriander crops. These will provide higher returns to growers through optimising fertiliser application. Yields will be improved by timely identification and correction of nutrient deficiencies while the cost of non beneficial applications will be avoided.

- New options for broadleaf weed control in coriander crops. This will reduce the cost of herbicide applications currently needed to counter herbicide resistance and changes in weed spectrum. The best options to control volunteer coriander in cereal crops have also been identified. This has major implications since contamination can effect the marketability of grain.

- New crop extension and promotion material through publication of a Coriander Fact Sheet and Disease Identification brochure. This will provide an increased knowledge base for current and prospective growers which will improve the chances of successful crop production. This will bolster confidence and encourage expansion in the industry.

Implications of Research

This research has confirmed that disease, particularly bacterial blight, is the major constraint to coriander production in Australia. An underlying reason for this is that most production is based on a single variety (Morroccan) which is very susceptible to this disease. Identification of varieties with better levels of resistance to bacterial blight and *Microdochium* has now created an opportunity to overcome this constraint by replacing Moroccan with more disease resistant, large seeded varieties. Development of a calibrated tissue test and new weed control options have also provided an opportunity to optimise fertiliser and herbicide application.

Outcomes of this project have the potential to benefit all sectors of the Australian coriander industry. Overcoming disease losses with more resistant varieties will benefit growers through increased yield and confidence to expand the area sown to coriander. Implementation of best management practices through better crop management information will increase yields and reduce production costs. Based on a possible 50% yield increase, the economic return to growers (based on a price of $900 per tonne) equates to an additional $600 per hectare. The market sector will benefit from greater stability and expansion in coriander production and a higher quality product.

This should lead to greater confidence to expand the industry and re-establishment of coriander as a significant alternative crop. A return to previous production levels would generate more than $5 million in export earnings annually for Australia.

Recommendations

This project has made considerable advances in overcoming production limitations in coriander, particularly with the identification of sources of resistance to bacterial blight and *Microdochium*. There is, however, a need to continue these efforts in order to capitalise on outcomes of this research and develop the coriander industry in Australia.

- Moroccan coriander needs to be replaced as soon as possible with more resistant varieties. The lines with best resistance to bacterial blight and *Microdochium* should be assessed for agronomic and market suitability as a direct replacement. These should also be used in crossing programs to develop new varieties with improved resistance and high agronomic and market acceptability. More coriander varieties should be collected and screened to identify alternative sources of resistance to bacterial blight and *Microdochium*.

- Other control measures, particularly fungicides and seed treatments, should continue to be investigated and used to optimise disease control and provide back up to resistant varieties. This is especially important for *Microdochium* where there is currently little information on disease biology, and fungicide efficacy and application strategy.

- Seed testing should continue and be strongly promoted, irrespective of any improvement in varieties, to keep bacterial levels in sown seed as low as possible. The acceptance and value of this would be improved if an accurate and easily accessible quantitative test can be developed to replace the current test which does not distinguish between low and high levels of infection.

- Registration is needed for new herbicides in coriander so that they can be promoted and used as an alternative to linuron. Other weed management options such as sowing time and exploiting the slow germination characteristic of coriander should also be investigated.

- Tissue tests should be promoted to identify coriander crops with nutrient deficiencies now that basic plant nutrient levels have been determined. Further work is required to refine these levels and determine response thresholds for various elements under different soil types and growing conditions.

- Information packages, particularly disease identification and coriander production Fact Sheets, and new knowledge developed in this project need to be promoted widely in Australia to encourage a resurgence of interest in coriander and expansion of the industry.

1. Introduction

1.1 Background to project

Coriander spice seed has been grown in Australia since the 1970's and production in 1998 was estimated to be 5,000 tonnes worth $5.75 million in export income. There has, however, been a decline in production in recent years as a result of disease reducing grower profitability, confidence and longer-term commitment to the crop. The disease bacterial blight (*Pseudomonas syringae* pv *coriandricola*) is endemic in all production regions, can reduce coriander yields by at least 50% and cause devaluation of damaged seed. The crop can also be affected by fungal diseases which can cause significant losses if not properly managed. While growers are prepared to invest substantial funds on disease control, (up to $200/ha) this is often ineffective because of inaccurate disease identification and management advice.

Previous research has identified a potential method for treating bacterial blight infected seed with dilute acid. Commercialisation of this process would provide an opportunity to implement effective disease control which would provide stability and expansion in the industry. There is also an opportunity to produce higher and more consistent crop yields through more accurate disease identification and strategic fungicide applications, improved weed control, and nutrition management.

Development of the coriander industry has also been limited by a lack of availability of information to new growers. Most crop production knowledge has been developed by established growers and is not easily accessible. This has resulted in either a reluctance to grow the crop, or significant financial loss through poor knowledge of production and marketing requirements. Clear and consistent advice on crop agronomy, disease management and market opportunities would improve on-farm growing practices and returns.

1.2 Relevance and benefits

This research will benefit all sectors of the Australian coriander industry. Improved disease identification and control methods and better crop management information will benefit growers through increased yield and confidence to expand the area sown to coriander. Implementation of best management practices will increase yields and reduce production costs. Based on a potential 50% yield increase, the economic return to growers (based on a price of $900 per tonne) equates to an additional $600 per hectare.

The market sector will benefit from this information through increases and more consistent coriander production and higher quality product. There is an opportunity for considerable expansion of coriander production in Australia and a return to previous production levels would generate more than $5 million in export earnings annually.

2. Objectives

This project was undertaken with the general objective to stabilise and expand coriander production in Australia by identifying and controlling disease and improving crop management for optimum yield.

Specific aims were:

- Survey crops to identify diseases, determine their relative importance and implement appropriate control.

- Develop a commercial treatment method for bacterial blight infected seed.
- Improve crop nutrition and weed management knowledge base.
- Investigate variety differences for disease resistance.
- Facilitate better industry communication through best management practice information packages.
- Increase agronomic and market skills of growers, agribusiness and consultants in SA, NSW and Victoria.

3. Experiments and Trials

3.1 Disease surveys

INTRODUCTION

Several diseases which can cause significant production losses have been identified in coriander crops in Australia. The most important disease is bacterial blight which is endemic in Australia, occurs every year and is highly seed borne. Severe crop damage can also be caused by the fungal disease, *Microdochium*, which was first identified in 1998. Other less damaging diseases such as *Septaria* and *Sclerotinia* are also found in coriander crops. This has caused confusion among growers concerning disease identification and hence appropriate management. There is a need for seasonal crop surveys to clarify the occurrence, distribution and severity of diseases.

METHOD

A range of coriander crops, predominantly in the south-east of SA, were surveyed in 1999, 2000 and 2001 during flowering and seed development. These consisted of dry land and irrigated crops, mostly of Morrocan type and sown late to avoid frost, reduce disease development and improve weed control options. Crops were assessed for the percent of plants showing blight infection, and the severity of infection on plants as indicated by loss of seed development. The presence and severity of other diseases was recorded, as well as physical damage from frost and insects. Information on crop management and paddock history were obtained where possible, and in some cases a sample of the seed used was obtained and tested for bacterial blight infection. The low number of crops surveyed in 2000 and 2001 reflects the reduced area of coriander production since 1999.

RESULTS

Table.3.1.1 Summary of 1999-2001 crop disease surveys. (Full results Appendix 1)

Year	Location	No. Crops	Blight Infection	Microdochium Infection	Frost Damage	Other Damage
1999	Bordertown	9	7	0	4	Sclerotinia
	Padthaway	6	6	0	4	Septaria
	Eyre Pen.	2	2	0	0	Drought
	Mid-north	2	1	0	0	Aphids
2000	Bordertown	8	6	3	2	Nil
	Padthaway	1	1	1	1	Septaria
	Mid-north	1	1	0	0	Nil
2001	Upper south-east SA	8	7	1	1	Sclerotinia
	Lower south-east SA	2*	0	2	0	Nil
	WA	1*	1	0	0	Nil
	NSW	1 *	1	0	0	Nil

* =Submitted plant samples only.

Bacterial blight was found in most Moroccan crops in 1999, 2000 and 2001, irrespective of location, irrigation and sowing time. Some crops had estimated potential yield losses of 20-50% with the most severely affected often associated with high levels of frost damage. Seed tests showed some crops had been sown with bacterial blight infected seed. Bacterial blight was found in small seed type crops each year, but was usually at a much lower level than in Moroccan.

The most significant fungal disease was *Microdochium* which occurred in south-east SA in 2000 and 2001. This disease was very severe in some Moroccan crops, particularly in 2001 when its development was exacerbated by the wet spring. This disease were detected in other varieties but these were not as severely affected as Moroccan. Minor levels of *Septoria* were detected each year but did not produce significant crop damage and *Sclerotinia* was found in some irrigated crops. While the total area of crop affected by *Sclerotinia* was low, coriander mortality was high in the infected patches.

3.2 Development and evaluation of seed treatments

INTRODUCTION

Infected seed is the major cause of bacterial blight in coriander and infection levels of less than 0.1% can cause significant losses in crops. The disease is so widely distributed that it is now very difficult to find sources of disease free seed in Australia, or from overseas. Attempts to propagate disease free seed in isolated crops has also been unsuccessful. For this reason, research has been undertaken to develop methods of treating infected seed to eliminate, or reduce infection.

Laboratory studies have shown bacteria infection can be effectively reduced in seed by soaking in dilute hydrochloric acid. Limited field trials indicate this treatment also results in less disease and better crop production. Since this is essentially a simple, low cost process, it should be applicable for further development as a commercial seed treatment. Research was undertaken in 1999, 2000 and 2001 to develop and validate this process for treating commercial seed quantities. Other potential seed treatment processes were also investigated.

METHOD

Acid treatment

A basic treatment recipe has been developed (PIRSA Fact Sheet: Disease management in coriander) which consists of soaking seed in 0.5% HCL for 24 hours, washing thoroughly in water and drying. This is a simple process with small amounts of seed but presents difficulties with larger quantities, particularly for adequate immersion and drying.
The potential to treat large seed quantities was investigated by placing 25 kg (1 bag) of seed in a 350 L vat with 60 L of dilute HCL added. After soaking for 24 hours the seed was drained, washed and dried in a glasshouse for 5 days on 2 square metres of shadecloth. A 1,000 seed sample of the untreated, and the dried treated seed, was tested for bacteria infection and germination. Germination was determined by sowing 100 seeds of each and counting emergence after 14 days in a glasshouse. A total of 100Kg seed was processed in this way as 4 batches of 25 Kg. This seed was used in field trials and a 6 ha commercial demonstration crop in 2000.

Field trials

In 2000, acid treated (using the process above) and untreated seed were sown at Turretfield and Roseworthy at approximately 15 kg/ha. Seed lots treated by steam, and by a sodium hypochlorite bleach were supplied by Seedco and also included in the Roseworthy trial. Coriander plots at both sites were separated by barley plots to reduce the possibility of cross infection and each treatment was replicated 3 times. Plots were assessed after flowering by using visible disease symptoms to estimate percent of infected plants and loss of flower and seed set. Plots were harvested and yields for each treatment determined. The level of bacterial infection of harvested seed was determined by testing sub-samples of 10, 25, 50 100 seeds from each plot.

A 6 ha crop with overhead irrigation was sown at Mundulla in July using acid treated seed at 11kg/ha on a site which had not previously had coriander. Part of the area was used for IAMA (Wesfarmers) herbicide trials and the rest was managed as a demonstration crop using current best commercial practice.

Acid treated and untreated seed were sown at Turretfield and Bordertown in 2001. The Bordertown trial also included a bleach treatment from the same batch of infected seed and disease free seed

(clean) from a different source. The bleach treatment was applied by soaking seed in 1.5% sodium hypochlorite for 10 minutes then drying at 70C for 24 hours. The seed for these treatments was harvested from an infected crop and had an infection level of approximately 5%. The clean seed was from a commercial seed sample tested by SARDI Diagnostics to have <0.01% bacterial infection. Plots were sown at 15 kg/ha, separated by beans at Bordertown and barley at Turretfield and replicated 6 times at Bordertown and 3 times at Turretfield.
Plots at both sites were assessed for bacterial blight after flowering by using visible disease symptoms to estimate percent of infected plants and loss of flower and seed set. Plots were harvested for yields and the level of bacterial infection of harvested seed from Turretfield was determined by testing sub-samples of 10, 50, 100 and 200 seeds from each plot.

RESULTS

Acid treatment

Untreated seed had a bacterial infection level of >1% and a germination of 80%. There was no indication of the pathogenic bacteria in treated seed at 0.01% test level. There was some loss of viability in the process but this was not significant and germination % of each treated batch ranged from 54% to 80% with an average of 66%. The greatest difficulty in treating large batches was drying seed quickly enough to avoid germination and mould development.

Field trials

Table 3.2.1 Effect of acid seed treatments on plant infection and yields.

Location	Treatment	Disease score	Plot yield (t/ha)	Seed infection
Roseworthy 2000	Nil Acid	24 15	2 2.07	>10% >10%
Turretfield 2000	Nil Acid	3.2 0.4	0.95 1.3	10% <1%
Turretfield 2001	Nil Acid	6.7 0	1.63 2.54	6% 5%

Disease Score = % infected plants x % loss/plant /100

High levels of bacterial blight developed at Roseworthy in 2000 and infected 90% of plants in untreated plots. There was some reduction in bacterial blight in acid treated seed compared to untreated but this was not significant. The effect of acid seed treatment was more obvious at Turretfield but disease development was low and there was no significant effect on yield at both sites. Steam and bleach treatments had the least disease at Roseworthy but their efficacy could not be evaluated because there was no untreated control for these seed lots.
High levels of bacterial blight developed in only one plot (nil treatment) at Turretfield in 2001. Acid treated plots produced a higher average yield than untreated plots but the effect was not significant.

The demonstration crop at Mundulla in 2000 remained disease free until October when it was hit by a severe frost during mid-flowering. Bacterial blight subsequently developed throughout the whole crop which yielded 0.742t/ha.

Post harvest seed infection levels showed some correlation with crop infection in both years but were high in both untreated and treated plots and at levels which would be expected to produce significant disease in subsequent crops.

Table 3.2.2 Effect of treatments on plant numbers, infection and yields Bordertown 2001

Treatment	Plants/M^2	Disease score	Yield T/ha
Nil	65	2	1.924
Acid	60	0.83	2.113
Clean	127	1.17	2.252
Bleach	22	0.33	2.167
lsd P= 0.05		1.09	NS

Disease Score : 0= no disease 5 = severe infection through whole plot

Analysis of results showed lower average yields and significantly higher disease for untreated seed compared to other treatments. Disease development, however, was lower than expected and uneven in the trial with high levels of blight occurring only in nil plots in replicates 1 and 3. Disease score were also higher in other treatments in these replicates suggesting cross infection may have occurred. High plant densities occurred in clean seed treatments because of the higher germination % of this seed lot compared to the one used for other treatments. Bleach treatment severely reduced plant survival and establishment but this did not affect final yields.

3.3 Herbicide tolerance

INTRODUCTION

Linuron (as Linuron or Afalon) is the only herbicide currently registered for broad leaf weed control in coriander which has high tolerance to this product. While this is still generally effective, extensive use in some areas has resulted in more resistant weed populations requiring higher application rates. This has highlighted a need to investigate alternative herbicide options for cost effective weed control in coriander without compromising crop tolerance.

Volunteer coriander can be a problem in cereals because of a nil contamination requirement. There was, therefore, a need to evaluate the effectiveness of various herbicides for the control of volunteer coriander in cereals.

All herbicide trial work for this project was undertaken by Wesfarmers Landmark based at Naracoorte SA.

METHOD

In 1999 a coriander herbicide tolerance trial was conducted at Padthaway in a Moroccan crop sown in August at 7 Kg/ha. In 2000 this trial was located at Bordertown in a commercial crop grown from acid treated seed sown at 11 Kg/ha. The 2001 trial was also at Bordertown, but incorporated pre-emergent herbicide treatments. The post-emergent herbicides were applied at the 4 leaf stage.

Volunteer coriander control was investigated in a trial at Padthaway in 1999 in a Moroccan crop sown at 7 Kg/ha. The herbicides were applied to the coriander at the 4-6 leaf stage and the extent of crop damage determined.

Herbicides in all trials were applied with a hand boom and their effects determined by visual ratings of weed control and crop damage. Crop yields were obtained from 1999 and 2001 trials. Herbicides and their application rates for each trial are shown in Appendix 2.

RESULTS

Table 3.3.1 2000 Post emergence weed control in coriander (Full details in Appendix 2)

Herbicide	Application rate/Ha	Weed control	Crop tolerance	Cost ($/ha)
Nil	-	1	7	0.00
Broadstrike	20g	4	9	12.76
Brodal	150ml	2	7	24.09
Linuron	3.0Kg	7	8	99.00
Linuron + Brodal	1.0Kg + 100ml	6	8	49.06

Note: Subjective scores 1 (very poor)---10 (very good)

Accumulated results from 1999, 2000 and 2001 trials showed that a mix of Linuron and Brodal @ 1.0 kg/ha and 100 ml/ha respectively was more cost effective for broad leaf weed control than the commonly used rate of Linuron (3 kg/ha). Broadstrike at up to 20g/ha and Brodal at up to 150 ml/ha also provided low cost weed control with no significant crop damage, although their efficacy was not as good as Linuron and the Linuron-Brodal mixture.

Post sowing pre-emergence trials showed Brodal at rates up to 120ml/ha caused little crop damage while coriander was sensitive to Sencor (metribuzin) at recommended rates of 400ml/ha. The trial clearly highlighted that care needs to be taken when using pre-emergent herbicides.

Results from the 1999 Padthaway trial suggest that 2,4-D Amine at 2.0 L/ha and Barrel at 1.4 L/ha would provided the most effective control of volunteer coriander in cereal crops.

3.4 Nutritional requirements

INTRODUCTION

Fertiliser recommendations for coriander have evolved from long term production experience and are currently based on those for wheat or canola. Some growers routinely apply foliar micronutrients although their value has never been verified. It is possible, therefore, that persistent production losses may be occurring through nutrient deficiency. There may also be loss of profits from the cost of excessive fertiliser. Leaf tissue tests are an effective method of detecting nutrient deficiency but require knowledge of adequate levels for each nutrient.
Since this information is not currently available a study was undertaken to better quantify coriander nutrient requirements and develop guidelines to identify nutrient deficiency from tissue tests.

METHOD

In 1999 an irrigated trial to determine micronutrient responses was set up at Padthaway. Moroccan type coriander were sown in August at a rate of 7 kg/ha with 100 kg/ha DAP Sulphur Cote applied at seeding and micro nutrient treatments (see Appendix 3, Table 1) applied prior to bolting using a hand boom in 80 L/ha of water. Each treatment was replicated 6 times and trials were harvested for yields in December.

In 2000 and 2001, plant tissue was collected from crops at different locations and analysed for levels of major and minor elements. A representative collection of plants at 6-8 leaf stage were obtained from each sample site and submitted as a composite sample. Crown leaves only were taken from each plant to avoid soil contamination. Crops which had been sprayed by fungicide were sampled but levels of Mn and Cu were excluded from nutrient level calculations. Tissue samples were tested by Analitical Crop Management Laboratory (ACML), Loxton.

RESULTS

No significant grain yield benefit resulted from micro nutrient applications in the 1999 Padthaway trial.
A comparison between tissue test results for 2000 and 2001 for main elements is shown in Table 3.4.1. (Full results of these trials are in Appendix 3)

Table 3.4.2. Average nutrient levels and their range from crop samples in 2000 and 2001

Element	Average	Range	Element	Average	Range
N (%)	4.3	3.1 - 5.8	Zn (mg/kg)	29.21	24 - 43
P (%)	0.47	0.27 - 0.72	Mn (mg/kg)	40.29	22 - 51
K (%)	4.82	2.6 - 6.7	Fe (mg/kg)	260.75	72 - 637
Ca (%)	1.06	0.68 - 1.8	Cu (mg/kg)	9.22	4.0 - 18.0
Mg (%)	0.32	0.18 - 0.45	B (mg/kg)	26.5	17 - 53
Na (%)	0.31	0.14 - 0.57	S (mg/kg)	0.39	0.23 - 0.54
Cl (%)	1.15	0.57 - 1.9			

Note: 11 crops sampled in 2000 and 6 in 2001

Table 3.4.3 Comparison of 2000 and 2001 sample results

Element	Average 2001	Average 2000	Range 2001	Range 2000
Nitrogen (N)	4.0%	4.50%	3.1 - 5.8	3.5 - 5.2
Phosphorus (P)	0.46%	0.47%	0.27 - 0.72	0.28 - 0.58
Potassium (K)	3.95%	5.29%	2.6 - 5.4	3.4 - 6.7
Zinc (Zn)	24.93 mg/kg	31.53 mg/kg	19.0 - 31.1	24.0 - 43.0
Manganese (Mn)	39.52 mg/kg	40.6 mg/kg	22 - 47.8 (115)	25.0 - 51.0 (88)
Copper (Cu)	10.38 mg/kg	9.59 mg/kg	6 - 12.2 (74)	4.0 - 18.0

Figures in brackets for fungicide sprayed crops.

There was a high level of consistency between paddocks in 2000 and 2001 although levels of K and Zn were considerably higher in 2001.

3.5 Variety evaluation

INTRODUCTION

Comparison of disease development in coriander crops suggests there may be variation in resistance to bacterial blight between coriander varieties. Moroccan appears to be very susceptible compared to other varieties, especially small seeded types. This variation has been difficult to verify in the field since disease development is compounded by frost damage which is influenced by crop agronomy and physiology.

Frost has important implications since the mechanical damage it causes to plants allows entry and systemic development of bacteria and hence disease development. The bacteria can also trigger freezing at higher temperatures causing more severe frost damage. Better frost tolerance should, therefore, help reduce the development and severity of bacterial blight.

Microdochium has produced severe disease in some coriander crops in recent years. So far, these have been Moroccan type which is very susceptible to the disease. It is unclear whether other varieties have better resistance or have avoided infection because of the smaller areas grown. Since this is a new disease, there have been no previous studies, and the potential for more resistant varieties is currently unknown.

Comparative studies under controlled conditions were, therefore, needed to verify field observations and identify any new varieties with improved resistance to bacterial blight and *Microdochium* and/or better frost tolerance.

METHOD

Frost tolerance

The varieties TR9042, R74088, R04169, R04180 (supplied by Seedco) plus Moroccan were tested for tolerance to frost by exposing them to various times at -6C. Each time of exposure was replicated 3 times and lines were tested at rosette (approx 6 leaf) and early flowering stages. Two testing times were needed for frost tolerance at flowering to encompass early and late flowering types. Plants were scored for frost damage 24 hours after treatment.

Bacterial blight

The same varieties used for the frost tolerance experiment were inoculated with *P. syringae* pv *coriandricola* at 1-2 leaf stage by dipping a needle in a bacteria culture then pushing it through the plant stem. Inoculated plants were grown at 20C and scored for symptoms at 5 and 10 days. Other plants were inoculated at the 6 leaves stage by spraying with a bacterial suspension and incubating in plastic bags for 3 days. These were assessed for symptom development at 12 days after inoculation.

In 2001, 31 coriander entries were screened for bacterial blight resistance in a field trial at Turretfield. These consisted of 23 lines from Seedco coriander collection, 3 lines from growers, 4 accessions from Germany and the standard Moroccan type. Seed of each entry was sown in a single 50 cm row with each row adjacent to a spreader row of infected Moroccan seed. The trial was sown in July and each test line was replicated twice. Initial disease scores were made in early October when the earliest flowering varieties, such as Moroccan, were at the early bolt stage. The trial was also scored in November and December to assess disease in mature plants and allow for differences in plant development between varieties.

The 23 Seedco lines were also sown at Bordertown in single plots to increase seed and assess plant type and yield characteristics. These became infected with disease and were scored for bacterial blight in December when the early flowering types were at the green seed stage.

Microdochium

The same lines screened for bacterial blight at Turretfield were assessed for resistance to *Microdochium* in a glasshouse test. Plants at 5 - 6 leaf stage were inoculated by spraying a suspension of *Microdochium* spores onto the leaves. hey were then covered with plastic bags for 3 days and incubated in the glasshouse. The plants were scored for disease after 2 weeks when clear symptoms had developed. Disease development ranged from no symptoms (score = 0) to dead leaves (score = 3).

Microdochium also developed in the plots at Bordertown and these lines were scored for this disease at the same time as scoring for Bacterial blight.

RESULTS

Frost

There was no significant difference between varieties for frost tolerance but all varieties were more tolerant at the rosette stage than at flowering.

Table 3.5.1: Variety reaction to freezing times

Variety	**Score averaged over range of exposure times**	
	rosette stage	**early flower stage**
Moroccan	0.5	3.0
TR9042	0.9	3.1
R74088	0.9	3.0
R04169	0.9	3.3
R04180	0.4	2.9

Note: Score is average of plants scores for each time of exposure to freezing (-6C)
0= no effect ; 1 = few leaves damaged ; 2 = most of plant damaged
3 = all plant damaged but still alive ; 4 = plant dead

Bacterial blight

All varieties developed symptoms from bacterial infection by needle or spray inoculation in the glasshouse tests. Line TR9042, however, showed a reduction in disease compared to the others (Table 3.5.2). Neither of the small seeded varieties (R04180 and R04169) were more resistant than Moroccan. Lines TR9042 and SX5317 were more resistant than Moroccan in field trials in 2001. While a range of disease levels was observed in field trials, bacterial blight development was generally greatest in the early maturing varieties which were predominantly large seeded. (See Appendix 4. for full table of results).

Table 3.5.2: Variety reaction to bacterial blight infection.

Variety	Seed type	Growth type	Needle Inoculation	Spray Inoculation	Field score
Moroccan	Large	Early	93	1.2	4
TR9042	Large	Early	83	0.5	2
SX5317	Large	Early	not tested	not tested	2
R74088	Large	Early	100	1.6	4
R04180	Small	Early	100	1.3	2.5
Mercado	Small	Late	not tested	not tested	1
R04169	Small	Late	100	0.8	2

Needle inoculation: scores as % of plants with symptoms.
Spray inoculation : 0=0; 1= few small brown spots on some leaves
2= brown spots on most leaves ; 3= large black/brown spots on most leaves
Field scores: 0 = no disease 1 = few leaf spots 2 = extensive leaf infection 3 = systemic leaf/stem infection 4 = high leaf and seed loss

Microdochium

Lines TR9042, SX5317 and CORI 9/77 were more resistant than Moroccan in glasshouse tests (Table 3.5.3). Most varieties, irrespective of seed size and maturity type, were very susceptible to *Microdochium* (see Appendix 4. for table of results). Disease development in the field at Bordertown was uneven and since varieties were not replicated, low scores were unreliable. High scores, however, gave confirmation of susceptibility in varieties scored in other tests.

Table 3.5.3: Variety reaction to Microdochium

Variety	Seed Type	Growth Type	Yield (gm/plot)	Glasshouse	Bordertown
Moroccan	Large	Early	NS	2.5	NS
TR9042	Large	Early	NS	0.5	NS
SX5317	Large	Early	891	1	1
CORI 9/77	Small	Mid	NS	1	NS

NS = not scored 0 = no disease 1 = few leaf spots 2 = extensive spots on leaves / stems 3 = dead leaves

4. Extension and Promotion

INTRODUCTION

Difficulty in easily obtaining up to date information relevant to Australian conditions has impeded the ability of established growers to deal quickly and effectively with production constraints, particularly disease. Development of the coriander industry has also been limited by a lack of information to new growers. This has resulted in either a reluctance to grow the crop, or significant financial loss through poor knowledge of production and marketing requirements. Improved disease identification and best practice crop production information would benefit growers through increased yield and confidence to expand the area sown to coriander. To achieve this, there is a need to improve growers knowledge by developing clear and consistent advice on crop agronomy, disease management and market opportunities and presenting this in an easily accessible form.

While this project has predominantly focused on the research and development of new information, a communications and adoption component has been included to facilitate the transfer of information to all sectors of the Australian coriander industry.

METHODS AND ACTIVITIES

Each year trials were established to evaluate and demonstrate the effectiveness of disease control strategies, herbicides and nutritional inputs. These were used as focal points for field days where results and their broader implications were discussed with growers and industry representatives. Results were also published and discussed in newsletters and used to updated fact sheets and information brochures.

Grower field walks were held each year in coordination with farmers, consultants and industry representatives. They examined topical issues and investigated production practices of experienced growers as well as extending new research and development findings. These field walks were coordinated with disease surveys and infected crops used to teach disease identification skills. Location and date of the crop walks is listed below, with most in the Upper South East of SA, targeting an area with a high proportion of coriander growers.

> Padthaway (10/11/1998; 24/9/1999; 18/11/1999) Roseworthy (6/10/2000) Bordertown (15/9/2001)

A pre-season half day workshop covering coriander production and marketing issues was also held at Padthaway (21/4/1999). These activities were generally well attended by established and potentially new growers.

Three newsletters were published and aimed at providing timely information on growing and marketing coriander. The newsletters were distributed to growers, consultants, agribusiness and industry personnel throughout Australia using a coriander industry contacts list compiled by the Coriander Advisory Group. Newsletters were published in December, 1999, July, 2000 and November 2001. (see references for availability of newsletters)

A ‘Growing Coriander’ best management practice Fact Sheet has been produced and distributed to coriander industry contacts. This and a "Disease management in coriander" Fact Sheet are also available from PIRSA offices, Primary Industries SA web site and PrimeNotes CD. These Fact Sheets are regularly updated as new information becomes available.

A colour guide to coriander disease identification is in the process of publication and will be distributed freely to growers. This will provide pictorial and descriptive information, which will be important for assisting accurate disease identification and subsequent decision making for effective disease management.

Latest information has been extended to growers from individual farm visits, telephone enquiries and follow up from disease identification samples. The Coriander Advisory Group has received enquiries and requests for information from all states of Australia and New Zealand, indicating the penetration of the information and knowledge generated by the project, and the extent of its distribution.

5. Implications of Research

5.1 Disease status and importance

This research has confirmed that disease is still the major constraint to coriander production with 50% of surveyed crops showing infection levels expected to cause significant yield loss.

Bacterial blight is the most important disease because it is wide spread, can cause high losses (>50%) and severely downgrades the value of seed. Moroccan appears to be extremely susceptible with significant disease development from low incidence of seed borne or endemic bacteria. Other varieties, especially small seeded types, were usually less affected suggesting these may be more resistant than Moroccan. It was evident that infected seed had been used for several crops which highlights the need for more rigorous seed testing and the promotion of disease free seed.

Microdochium is emerging as a major disease problem because although it currently has a limited distribution (south-east of SA), it can cause extreme damage and yield loss. Since this is a new disease and its epidemiology and source of inoculum is not known, management information is limited. It should, however, respond to fungicides and crops will need to be monitored for early signs of the disease and an intensive fungicide program applied to avoid severe losses.

Other commonly identified diseases were *Septaria* and *Sclerotinia* but neither of these were likely to have significant effects on yields. *Alternaria* was not identified in any crops surveyed in 1999 to 2001 and is probably less important than previously thought.

Crop surveys have shown that frost is not a predisposing factor for bacterial blight infection but can greatly exacerbating disease development. There is a greater chance of severe loss to bacterial blight in regions with a high frequency of late frosts. It is also clearly evident that delayed sowing does not prevent significant disease development. Since this can reduce yield potential, particularly in dryland crops, its continued practice as a disease control measure is questionable.

5.2 Acid seed treatment

It is now evident that while acid seed treatment reduces bacterial levels in infected seed, it is only partially effective in reducing bacterial blight in crops. Sufficient bacteria apparently survives in treated seed for damaging levels of disease to develop in crops even though no bacteria can be detected in post treatment seed tests. Acid seed treatment usually reduces disease development but it clearly cannot be relied upon to always give effective disease control.

While these studies demonstrated the feasibility of treating large quantities of coriander seed with dilute hydrochloric acid, the lack of reliability would make this process unattractive for commercialisation. It may have some application on farm when disease free seed is unobtainable but is most likely to be effective if restricted to seed lots with initial low levels of infection (<1%). Alternative seed treatments such as heating with steam, or soaking in sodium hypochlorite bleach showed some potential but were not proven to be any more effective than the acid treatment in reducing disease development.

Trial results also emphasise that high levels of infection can develop in seed even though crop disease is low which reinforces the need to test seed for bacterial infection levels, irrespective of crop disease history.

Implications of this research are that only seed which has been tested as free of bacterial blight should be used for crops. Infected coriander seed can be treated on farm in commercial quantities but this may not prevent significant disease development and should only be considered as a last resort.

5.3 Herbicide tolerances

Results from herbicide trials have provided a greater clarity to herbicide choice and identified some new options for broadleaf weed control in coriander crops. (Appendix 2). This is particularly important since herbicide resistance and changes in weed spectrum are escalating coriander production costs from increased herbicide application rates. For example, effective weed control can be achieved at a cost of $50/ha using a Linuron / Brodal mix compared to $100/ha for a high rate of Linuron. It must be emphasised, however, that Linuron and Afalon are currently the only herbicides registered for use in coriander and use of other products would be completely at the users risk.

This research has also identified effective herbicide options to control volunteer coriander in cereal crops. This has major implications since a nil tolerance to contamination can result in large financial losses through the inability to sell contaminated grain.

5.4 Fertiliser requirements

Current fertiliser recommendations, based on macronutrient requirements for wheat, appear to be working adequately for coriander crops. Tissue analysis of a range of crops suggested most had access to their full requirement of the nutrients tested indicating fertiliser applications were sufficient for the crop's needs.
This study has now established guidelines for expected nutrient levels in healthy coriander crops and produced a calibration for tissue tests which can be used as the basis for identifying nutrient deficiencies in coriander crops. This does not provide deficiency thresholds where crop response will occur but it can be assumed that crops with tissue test levels significantly below these ranges will be deficient in the particular element and benefit from further application. Conversely, further applications of fertiliser to crops within these ranges is unlikely to provide any benefit.

The implications of a calibrated tissue test are higher returns to growers through optimising fertiliser application. Yields will be improved by timely identification and correction of nutrient deficiencies while the cost of non beneficial applications will be avoided.

5.5 Variety evaluation

This research has major implications in the control of disease in coriander because it has shown for the first time that there is variation for susceptibility to Bacterial blight and *Microdochium* between coriander varieties.

Several lines with better resistance than Moroccan to bacterial blight and *Microdochium* have been identified in glasshouse and field trials. The most outstanding are Seedco lines SX5317 and TR9042 which have better resistance to both diseases. Since SX5317is early maturing and large seeded, it has the potential to be used directly as a replacement for Moroccan in coriander production in SA. It would also be a suitable parent for rapid transfer of resistance into other agronomically adapted varieties.

The results also support farmer observations that crops of small seeded varieties are usually less affected by bacterial blight. This, however, needs to be treated cautiously because of a possible interaction between plant development and field conditions which could influence infection and disease development. A similar caution needs to be applied to the results of the frost study which indicated there are no major physiological differences in tolerance to freezing between coriander types which could be exploited to reduce frost damage effects on bacterial blight development.

Potential to control both bacterial blight and *Microdochium* with plant resistance has now been identified and should be pursued as a high priority.

6. Recommendations

It is clear from this research that disease, particularly bacterial blight, is the major constraint to production of coriander in Australia by causing high yield losses, increased production costs and devaluation of grain. It is also now evident that an underlying reason for this is that most production is based on a single variety (Morroccan) which is very susceptible to this disease. While various techniques such as treating infected seed have been pursued, these have not been successful enough to overcome this problem. Better resistance occurs in small seeded varieties but this is a limited market and the future for the coriander industry will be dependent on replacing Moroccan with more disease resistant, large seeded varieties.

There is now an opportunity to pursue this through the identification of an early flowering, large seeded line (Seedco line SX5317) with better resistance than Moroccan to bacterial blight and *Microdochium*. This line is potentially direct replacements for Moroccan and its agronomic and market suitability should be determined as a high priority.
This resistance source should also be used in crossing programs to develop new varieties with improved resistance and high agronomic and market acceptability. More coriander varieties should be collected and screened to identify alternative sources of resistance to bacterial blight and *Microdochium* and the genetics of resistance studied to optimise breeding efficiency.

While disease resistance identified so far is significantly better than in Moroccan, it is only partially effective and could also break down with widespread exposure to pathogens. For this reason, other control measures should continue to be investigated and employed to optimise disease control and provide back up to resistant varieties. This is especially important for *Microdochium* where there is currently little information on disease biology, and fungicide efficacy and application strategy.

Irrespective of any improvement in varieties seed testing should continue and be strongly promoted to keep bacterial levels in sown seed as low as possible. The acceptance and value of this would be improved if an accurate and easily accessible quantitative test can be developed to replace the current test which does not distinguish between low and high levels of infection.

Crop monitoring should also continue in order to clarify diseases present in crops and provide early disease identification so appropriate control strategies can be applied before significant damage occurs.

There now seems to be little value in persisting with commercialisation of treatments for bacterial blight infected seed. They are only likely to be partially effective and should be seen as a "stop gap" measure until better control options, especially more resistant varieties are available. The treatments are most likely to be effective when initial infection is low and seed lots with low infection levels should be obtained for treatment.

This project has identified a range of herbicide options for weed control in coriander, but their promotion and use are currently limited by lack of registration. This needs to be resolved and alternatives to linuron pursued since this chemical is losing its efficacy in some regions requiring higher rates, greatly adding to the cost of production. Other weed management options such as sowing time and exploiting the slow germination characteristic of coriander should also be investigated.

Now that basic nutrient levels have been determined for coriander, tissue tests should be used to identify any crops with nutrient deficiencies. This, however, is still only a basic guideline and further work is required to refine these levels and determine response thresholds for various elements under different soil types and growing conditions.

Information packages, particularly disease identification and coriander production Fact Sheets, and new knowledge developed in this project need to be promoted widely in Australia to encourage a resurgence of interest in coriander and expansion of the industry.

7. Appendices

Appendix 1. Crop surveys 1999-2001

Year	Crop Id	Location	Type	Sown	Irrig.	Seed	GS	Frost	Blight		Other disease		Comments
									Severity	Loss	Cause	Severity	
	TR	Kongal	Small seed	July	Pivot	Seedco	4.3	Nil	90%	Low	Nil	Nil	coriander 1997
	PR1	Kongal	Small seed	Aug.	Flood	Seedco	5.1	Nil	0	0	Nil	Nil	
	PR2	Kongal	Small seed	Aug.	Flood	Seedco	4	Nil	0	0	Nil	Nil	
	PR3	Kongal	Moroccan	July	Pivot	Seedco	5.1	High	90%	High	Nil	Nil	
	KS	Kongal	Moroccan		Flood	Seedco	5.1	Nil	Low	Low	Nil	Nil	
	L1	Kongal	Moroccan		Dry	Seedco	5.2	High	90%	High	Nil	Nil	Infected seed
	L2	Kongal	Moroccan		Flood	Seedco	4.2	Nil	Low	Low	Nil	Nil	Steam treated seed
1999	PR	Mundulla	Small seed		Pivot	Seedco	4.3	Nil	Low	Low	Sclerotinia	Low	beans 1998
	H	Bordertown	Moroccan		Dry	Seedco	5.4	High	100%	High	Nil	Nil	Infected seed
	G	Padthaway	Moroccan		Flood	Seedco	5.1	Low	90%	High	Nil	Nil	
	BL	Padthaway	Moroccan		Pivot	Seedco	5.1	High	90%	High	Nil	Nil	coriander 1993
	E1	Padthaway	Moroccan		Flood	Seedco	5.2	High	90%	High	Nil	Nil	no previous coriander
	E2	Padthaway	Moroccan		Flood	Seedco	5.2	High	90%	High	Nil	Nil	Steam treated seed
	WE1	Padthaway	Moroccan	Aug.	Flood	Own	4.3	Nil	Low	Low	Nil	Nil	Acid treated seed
	WE2	Padthaway	Moroccan	Aug.	Flood	SARDI	4.3	Nil	Low	Low	Nil	Nil	Acid treated seed
	A1	Kapinie EP	Small seed		Dry	USA	4	Nil	Low	Low	Nil	Nil	Imported seed
	K1	Wadikee EP	Moroccan		Dry	S EAST	4	Nil	Low	Low	Nil	Nil	Infected seed
	PW	Pt Wakefield	Moroccan		Dry		5.3	Nil	50%	High	Nil	Nil	
	B	Blyth	Moroccan		Dry		5.1	Nil	0	0	Nil	Nil	
	RH	Lochiel	Moroccan	June	Dry	Seedco	5.1	Nil	100%	High	Nil	Nil	seed infected
	PR	Kongal	Small seed LS	Aug.	Pivot	Seedco	4	Nil	Low	Low	Nil	Nil	seed ex 1999 crop
	TH	Bordertown	Moroccan	May	Dry	Seedco	5.1	Low	90%	High	Nil	Nil	seed infected
2000	DD	Bordertown	Moroccan		Pivot	Seedco	5.1	Nil	50%	Low	Nil	Nil	late sown
	BK	Bordertown	Large seed	Late	Pivot	Seedco	5.1	Nil	0	0	Nil	Nil	very tall crop
	RM	Bordertown	Moroccan	June	Dry	SARDI	5.1	High	90%	High	Nil	Nil	Acid treated seed
	TR1	Kongal	C42 Moroccan	July	Pivot	Seedco	5.1	Nil	10%	Low	Microdochium	Low	few hot spots
	TR2	Kongal	Small seed CC	July	Pivot	Seedco	5.1	Nil	10%	Low	Microdochium	Low	few hot spots
	TR3	Kongal	Large seed	July	Pivot	Seedco	5.1	Nil	0	0	Microdochium	Low	few hot spots
	WE	Padthaway	Moroccan	June	Dry	Own	5.1	Low	90%	High	Microdochium	High	Acid treated seed/foliar sprays
	PR1	Kongal	Small seed LS	Aug.	Pivot	Seedco	4.2	Nil	90%	Low	Nil	Nil	seed ex 1999 crop
	PR2	Kongal	Small seed PAS		Pivot	Seedco	5.1	Nil	90%	Low	Nil	Nil	worse than LS
	DW	Kongal	Moroccan	May	Dry	Own	5.4	Low	100%	High	Nil	Nil	unspecified seed treatments
	CJ	Bordertown	Moroccan	May	Dry	Unreated	5.2	Nil	90%	High	Sclerotinia	low	disease variable in trial
2001	BK	Bordertown	Large seed	Late	Pivot	Seedco	5.1	Nil	0	0			crop not seen
	RM	Bordertown	Varieties	June	Dry	Seedco	?	Nil	Low	Low	Microdochium	Nil - high	variation between varieties
	TR1	Kongal	Small seed CC	July	Pivot	Seedco	5.1	Nil	Low	Low	Stem break	common	Kocide applied
	TR2	Kongal	Large seed	July	Pivot	Seedco	5.1	Nil	Low	Low	Stem break	common	Kocide applied
	TC	Naracoorte	Moroccan		Dry	Own	5.1				Microdochium	high	Sprayed with Bravo
	AB	Avenue Range	Moroccan				4.2				Microdochium	high	few plant samples
	WA	Meridin WA	Moroccan		Dry		4		High	High			few plant samples
	A	Narromine NSW	Moroccan				4.2		High	High			few plant samples

Appendix 2. Herbicide tolerance

Table 1. 1999 Post emergence weed control in coriander

Herbicide	Application rate/Ha	Grain Yield T/Ha
Nil	-	0.78
Broadstrike	25g	0.69
Eclipse	7g	0.21
Brodal	150ml	0.68
Brodal	200ml	0.51
Linuron	1.5Kg	0.43
Linuron	3.0Kg	0.58
Linuron + Brodal	1.0Kg + 100ml	0.70
Linuron + Brodal	1.5Kg + 150ml	0.35
Spinnaker + Hasten	250ml + 1%	0.05
MCPA Amine	1.5L	0.00
Buctril 200	1.2L	0.21
Brodal + Buctril	200ml + 300ml	0.57
Tigrex	500ml	0.41
Jaguar	150ml	0.61
	LSD	0.30
	CV	36.86%

Table 2. 1999 Volunteer coriander control

Herbicide	Application rate/Ha	Volunteer coriander control Score 0(dead)--10(alive)
Nil	-	10
Eclipse	7g	8
Eclipse + Barrel	7g + 1.2L	2
Eclipse + Tigrex	7g + 700ml	2.5
Affinity	40g	10
Affinity	60g	10
Tigrex	800ml	8
Ally + Tigrex	7g + 800ml	6
Ally	7g	5
Ally + LVE MCPA	7g + 750ml	4
2,4D Amine	2.0L	1.5
2,4D Amine (split)	1.5L + 1.5L	2
Eclipse + 2,4D Amine	7g + 1.5L	1
Barrel	1.4L	1.5
Lontrel	300ml	8
Atrazine + Uptake	2.0L +1%	4
Lontrel + Atrazine + Uptake	300ml + 2.0L + 1%	3.5

Table 3. 2000 Post emergence weed control in coriander

Herbicide	Application rate/Ha	Weed control	Crop tolerance	Cost ($/ha)
Nil	-	1	7	0.00
Broadstrike	20g	4	9	12.76
Broadstrike	25g	3	5	15.95
Broadstrike + MCPB	25g + 500ml	4	5	22.90
Brodal	150ml	2	7	24.09
Brodal	200ml	3	6	32.12
Brodal + MCPB	200ml + 500ml	3	5	39.07
Linuron	3.0Kg	7	8	99.00
Linuron + Brodal	1.0Kg + 100ml	6	8	49.06
Lontrel	80ml	2	6	4.84
Lontrel	200ml	1	3	12.10
Sniper	50g	3	6	NA
Raptor	45g	2	1	30.44
Jaguar	750ml	7	8	21.64

Note: Subjective scores 1 (very poor)---10 (very good)

Table 4. 2001 Post sowing pre-emergence (PSPE) and post-emergence weed control in coriander

Treatment	Application timing	Yield (t/ha)	Yield (% Control)
Untreated	N/a	2.35	100
Sencor 280ml/ha	PSPE	2.21	94
Sencor 400ml/ha	PSPE	2.63	112
Brodal 80ml/ha	PSPE	2.76	117
Brodal 120ml/ha	PSPE	2.43	103
Broadstrike 20g/ha	4 true-leaf	2.76	117
Broadstrike 25g/ha	4 true-leaf	2.56	109
Brodal 100ml/ha	4 true-leaf	2.40	102
Brodal 150ml/ha	4 true-leaf	2.40	102
Brodal 200ml/ha	4 true-leaf	2.87	122
Broadstrike 10g/ha + Brodal 180ml/ha	4 true-leaf	2.38	101
Broadstrike 20g/ha + Brodal 100ml/ha	4 true-leaf	2.55	108
Broadstrike 20g/ha + Brodal 150ml/ha	4 true-leaf	3.14	133
Linuron 3.0kg/ha	4 true-leaf	2.87	122
Linuron 1.0kg/ha + Brodal 100ml/ha	4 true-leaf	2.70	115
Linuron 1.0kg/ha + Broadstrike 20g/ha	4 true-leaf	2.71	115
	C.V. (%)		20.26
	L.S.D. (t/ha)		0.93

Appendix 3. Nutrition

Table 1. Effect of micronutrient applications on yield. Padthaway 1999

Micronutrient	Application rate L/Ha	Yield T/ha
Nil	-	0.61
Manganese PC	4.0	0.68
Zinc PC	2.0	0.64
Copper PC	2.0	0.66
Manganese + Copper	4.0 +2.0	0.63
Manganese + Zinc	4.0 +2.0	0.54
Zinc + Copper	2.0 +2.0	0.61
Manganese + Zinc + Copper	4.0 + 2.0 +2.0	0.61
Manganese + Zinc + Copper + Result	4.0 + 2.0 +2.0 + 4	0.74
Manganese + Zinc + Copper	4.0 + 2.0 +2.0	0.65
Hi Fol Cereal	7.0Kg/Ha	0.70
Nitra Sulf	6.0	0.55
Nitra Sulf + Manganese/Zinc/Copper	6.0 + 4.0 + 2.0 +2.0	0.73
Photrel	3.0Kg/Ha	0.60
	LSD	0.20
	CV	17.26%

Table 2. Coriander tissue test results 2000 and 2001
Tested by Analytical Crop Management Laboratory Pirsa Loxton

Year	Location	Sample	Variety	N	P	K	Ca	Mg	Na	Cl	Zn	Mn	Fe	Cu	B	S
				%	%	%	%	%	%	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%
	Padthaway	HP1 &2 Sample27	Moroccan	4.3	0.44	5.2	1.1	0.24	0.14	0.9	24	88	230	5	21	0.34
	Mundulla	Sample 28	Moroccan	4.2	0.41	6.7	1.3	0.25	0.2	0.57	24	43	190	7	21	0.33
	Mundulla	PaddockDD Sample 2	Moroccan	5.2	0.54	5.1	0.87	0.29	0.21	0.87	27	42	2094	13	17	0.43
	?	Paddock 15 Sample20	Coriander	3.6	0.44	3.4	0.68	0.18	0.22	0.72	37	25	159	4	21	0.23
	Mundulla	S &T	Various	5.2	0.48	4.6	0.78	0.32	0.14	1	36	47	213	7	17	0.38
2000	Bordertown	Pivot	Large seed	4.1	0.28	4.9	1.8	0.41	0.56	1.9	28	39	248	7	23	0.54
	Roseworthy	Roseworthy treated	Moroccan	3.5	0.49	5.7	1	0.34	0.56	1.6	32	34	172	13	53	0.36
	Roseworthy	Roseworthy untreated	Moroccan	4.1	0.52	4.9	0.97	0.37	0.54	1.4	33	34	133	18	24	0.41
	Turretfield	Turretfield treated	Moroccan	4.5	0.5	6.3	1	0.33	0.34	1.6	33	43	397	14	35	0.36
	Turretfield	Turretfield untreated	Moroccan	5.1	0.5	4.8	0.86	0.3	0.15	0.77	43	48	637	13	30	0.46
	Kongal	430 Wirreca	LS	5.5	0.58	6.7	0.83	0.27	0.15	1.5	30	51	464	5	25	0.41
		AVERAGE		**4.5**	**0.47**	**5.3**	**1.02**	**0.3**	**0.29**	**1.17**	**32**	**45**	**449**	**10**	**26**	**0.39**
													258[A]			
	Bordertown	SARDI Trial	Moroccan	3.4	0.38	2.6	1	0.38	0.52	0.7	19	46	87	12		
	Bordertown	Pivot	Large seed	3.1	0.27	3.4	0.84	0.27	0.24	1.1	23	22	72	6		
	Turretfield	Turretfield treated	Moroccan	5.8	0.63	5.25	1.15	0.45	0.57	1.04	22.5	47.8	452	11.3	32.1	0.42
2001	Turretfield	Turretfield untreated	Moroccan	5	0.72	5.36	1.08	0.37	0.16	0.66	31.1	42.3	555	12.2	25.5	0.39
	Mundulla	Pivot post Kocide	Large seed	3.8	0.41	3.5	1.6	0.36	0.33	1.6	29	115	80	74		
	Mundulla	Pivot post Kocide	Small seed	3.2	0.33	3.6	1.2	0.33	0.32	1.6	25	73	83	70		
		AVERAGE		**4**	**0.46**	**3.95**	**1.15**	**0.36**	**0.36**	**1.12**	**24.9**	**57.7**	**222**	**30.9**	**28.8**	**0.41**
														10.4[B]		

[A] Excluding single very high reading [B] Excluding post Kocide samples

Appendix 4. Coriander variety disease assessment

Variety	Type		Microdochium Scores		Bacterial Blight Scores		Yield gm/plot
	Seed	Growth	Glass house	Border town	Turret field	Border town	Border town
SX5315	Large	Early	2	3	4	4	826
SX5316	Large	Early	2.5	0	4	2	519
SX5317	Large	Early	1	1	2	1	891
SX5318	Large	Early	2.5	3	4	4	908
SX5319	Large	Early	2	3	4	3	783
SX5320	Large	Early	2	3	4	2	629
SX5321	Large	Early	1.5	2	4	1	980
SX5322	Large	Mid	1.5	3	2	2	794
SX5323	Small	Mid	2	2	2	0	492
SX5324	Small	Mid	1.5	3	2	0	630
SX5325	Large	Early	2	3	4	2	887
SX5326	Small	Mid	2	3	2	0	395
SX5327	Small	Mid	1.5	NS	2.5	NS	NS
SX5328	Large	Early	1.5	3	4	0	751
SX5329	Small	Late	1.5	2	2	0	1077
SX5330	Large	Mid	3	2	2.5	0	885
SX5331	Small	Late	2	2	1.5	0	355
SX5332	Small	Late	1.5	2	2	0	777
SX5333	Large	Early	2	3	4	0	796
SX5334	Large	Mid	1.5	3	2	1	798
SX5335	Small	Late	2.5	2	2	1	1314
SX5336	Small	Early	2	3	2.5	2	729
BURNBRAE	Large	Early	NS	2	NS	2	1257
R74088	Large	Early	2.5	NS	4	NS	NS
RO4180	Small	Early	1.5	NS	2.5	NS	NS
RO4169	Small	Late	2	NS	2	NS	NS
H-3501	Small	Mid	2	NS	2.5	NS	NS
CORI 9/77	Small	Mid	1	NS	2	NS	NS
CORI 38/83	Small	Late	2	NS	1.5	NS	NS
TR9042	Large	Early	0.5	NS	2	NS	NS
MERCADO	Small	Late	2	NS	1	NS	NS
MOROCCAN	Large	Early	2.5	NS	4	NS	NS

NS = not scored

Glasshouse scores at 5 leaf stage Field scores when early varieties at green seed stage

Bacterial blight scores: 0=no disease; 1= few leaf spots; 2= extensive leaf infection; 3= systemic leaf/stem infection; 4= high leaf and seed loss
Microdochium glasshouse scores: 0= no disease; 1= few leaf spots; 2= extensive spots on leaves/petioles; 3= dead leaves
Microdochium field scores: 0= no disease; 1= few spots on stems; 2= severe on stems;3= severe seed head loss

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