PT97010
Sustainable potato production in highland areas of NSW – Stage III

Sandra Lanz
Lanz Agricultural Consulting

Know-how for Horticulture™

PT97010

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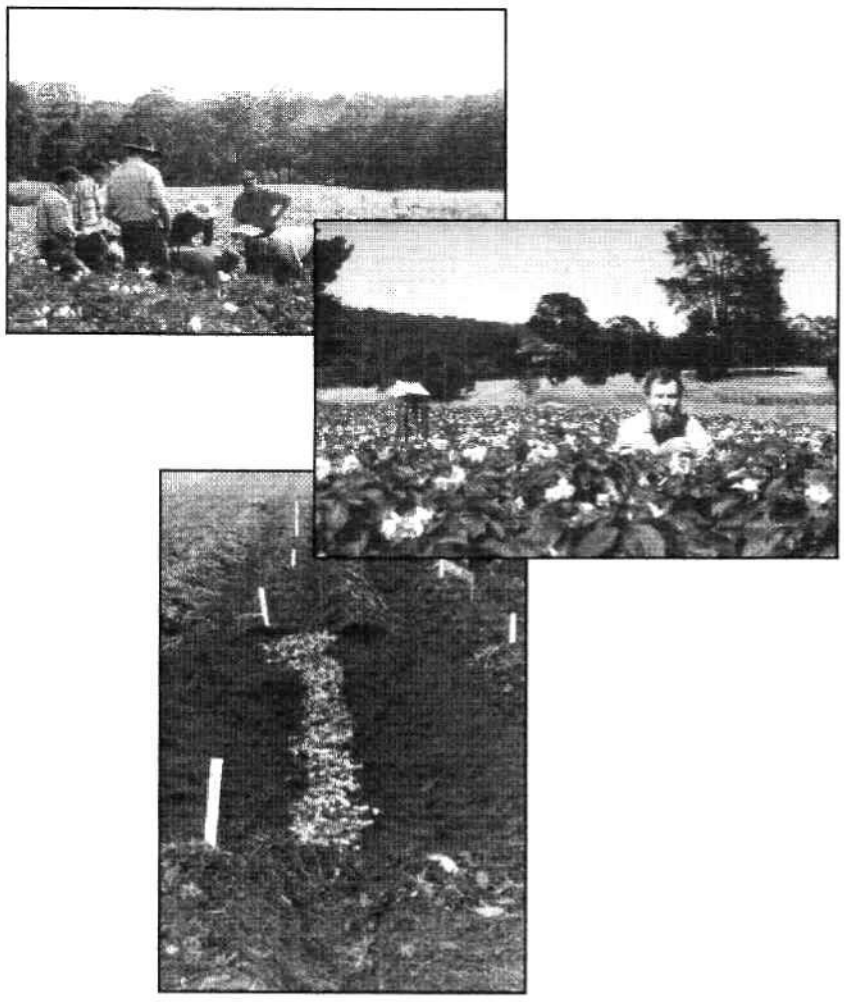
FINAL REPORT
HRDC PROJECT PT97010
(completion date June 1999)

SUSTAINABLE POTATO PRODUCTION IN HIGHLAND AREAS OF NSW – STAGE III.



Project Coordinator & Editor of the Final Report.
Sandra M Lanz
LANZ Agricultural Consulting
PO Box 406, PICTON, NSW, 2571.

PT97010 – FINAL REPORT

OCTOBER 1999

PROJECT FUNDING

Project PT97010 – "Sustainable Potato Production in Highland Areas of NSW – Stage III" has been funded through the:

- Horticultural Research and Development Corporation
- Robertson District Potato Advancement and Landcare Association
- Dorrigo District Potato Advancement and Landcare Group
- Guyra Potato Growers
- The National Potato Industry R&D Levy

RESEARCH AND DEVELOPMENT TEAM

- **SANDRA LANZ:** ***Project Coordinator***, LANZ Agricultural Consulting, PO Box 406, Picton, NSW, 2571. Ph/fax: 02 4677 0198, Email: slanz@acenet.com.au

- **ROBERT SPOONER-HART;** ***Integrated Pest Management***, University of Western Sydney – Hawkesbury, Bourke St, Richmond, 2753. Ph: 02 4570 1429, Fax: 4570 1314.

- **LEN TESORIERO:** ***Integrated Pest Management***, EMAI, NSW Agriculture, PMB 8, Camden, NSW, 2570. Ph: 02 4640 6333. Fax: 02 4640 6415.

- **MIKE ROBBINS:** ***Irrigation Management***, NSW Agriculture, Agricultural Research and Veterinary Centre, Forest Rd, Orange, 2800. Ph: 02 6391 3970, Fax: 02 6391 33899.

- **STUART LITTLE:** ***Soil P Management***, Department of Geography, Australian National University, GPO Box 4, Canberra, ACT. 2601.

- **RICHARD GREENE:** ***Soil P Management***, Department of Geography, Australian National University, GPO Box 4, Canberra, ACT. 2601.

- **PETER HOCKING:** ***Soil P Management***, CSIRO Division of Plant Industry, GPO Box 1600, Canberra, ACT, 2601.

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INDUSTRY SUMMARY

The project PT97010 Sustainable Potato Production in Highland Areas of NSW – Stage III commenced in July 1997 and was completed in June 1999.

The implementation of this project was a direct result of the success of Stages I and II of the project Sustainable Potato Production in Highland Areas of Australia. The project was also expanded to include Guyra and Dorrigo as well as the Robertson district.

Stage I and II of the project addressed such issues as gaining a good understanding of crop nutrient needs through comprehensive soil and plant testing. This soil and plant testing highlighted high levels of phosphorus (P) in the soil, which was not being taken up by the plant. A programme was developed in collaboration with ANU and CSIRO to investigate management strategies using cover crops to release this soil bound P.

The Robertson growers are located in a district which has a number of hobby farmers, small holdings, residential, tourist and "Pitt Street" farmers as neighbours. This makes the issue of using chemicals a very sensitive one. Growers felt that to remain viable in such an environment they must implement measures that are environmentally friendly. This led to the program of parasitic wasp releases to control potato tuber moth without having to use insecticides, and a monitoring program to determine its effectiveness.

Soil Phosphorus (P) Management.
The objective of this project was to determine the contributions a cover crop made in increasing phosphorus availability to a following potato crop. Of particular interest was the performance of a species of white lupin (*Lupinus albus* c.v. Kiev Mutant) in soils with high phosphorus adsorbing potential. White lupins secrete organic acids from specialised roots termed "proteoid roots". These organic acids release phosphorus that is locked up in the soil, making it available to the lupin plant. When the lupins are incorporated back into the soil, the phosphorus should become available for future crops. The white lupin was compared to oats, fodder rape, fodder rape + white lupin, and no cover crop, in a glass house and field trial.

Soil samples taken 8 weeks after potatoes were sown and fertiliser added showed that where the combination treatments were grown, the level of available phosphorus was approximately 17% higher than the oats and fodder rape cover crops.

Despite these differences final potato yield did not reflect the changes in soil available phosphorus. Results from this experiment do show that cover crops containing white lupin varieties have potential in improving phosphorus availability to the following potato crop.

Integrated Pest Management (IPM)
The objective of the IPM component of the project was to continue with the monitoring program begun in stages I and II of the project and to work with growers in utilising *Orgilus lepidus*, a parasitic wasp for the management of potato tuber moth.

Monitoring confirmed that during the season, there were no major insect pest problems that warranted insecticide applications. There was also no significant presence of vector-borne diseases. At one of the sites, the grower sprayed once and the other site was sprayed twice. In our view, neither was warranted. However, this still is a substantial reduction in the level of pesticide application used in the district prior to the commencement of the project.

Biological control of potato moth showed encouraging results. Consistently lower moth counts and slightly reduced number of leaf mines were found in crops where the wasp was released. This is the first time that comparative investigations of this kind have been undertaken in Australia.

As discussed earlier, the 1998-9 season had the highest number of beneficials recorded since we commenced monitoring in the district (1994). We attribute this not only to the favourable climate, but also the absence of broad-spectrum pesticides. On one site where *O. lepidus* was released for potato moth control no pesticides were applied during the entire season and both yield and tuber quality were good. This demonstrates that it is possible to grow potato crops of high quality, with minimal use of pesticide, provided cultural measures (such as clean seed and rotation) and pest monitoring are in place.

INTRODUCTION

The project PT97010 Sustainable Potato Production in Highland Areas of NSW – Stage III commenced in July 1997 and was completed in June 1999. This project has been funded by the Robertson District Potato Advancement and Landcare Association, The Dorrigo District Potato Advancement and Landcare Group, The Guyra Potato growers, the National Potato Levy and the Horticultural Research and Development Corporation. Technical support and expertise has been provided by NSW Agriculture, University of Western Sydney - Hawkesbury, Australian National University and CSIRO Plant Industries Canberra. The overall coordination of the project was undertaken by LANZ Agricultural Consulting.

The implementation of PT97010 was a direct result of the success of Stages I and II of the project Sustainable Potato production in Highland Areas of Australia.

Stage I and II of the project addressed such issues as gaining a good understanding of crop nutrient needs through comprehensive soil and plant testing. This soil and plant testing highlighted high levels of phosphorus in the soil which was not being taken up by the plant. Application of high rates of fertiliser containing phosphorus was not the answer, due to environmental and economic issues. These issues include off site contamination during high rainfall events, as well as growers wanting to utlise fully applied fertiliser.

This led to discussions with researchers at the Australian National University (ANU) and CSIRO regarding possible management strategies to unlock this soil P and make it available to the plant. This led to the implementation of an honours project looking at different cover crops before a potato crop. In particular white lupins which have a specialised root system which is able to release soil bound P through specific root exudates.

Growers in the Robertson district had also taken part in an insect monitoring program during stages I and II of the project. The growers were now aware of pests, beneficials, and incidental insects in their crops and how to identify them. They were also aware of work which had introduced biological controls for the management of potato tuber moth.

The Robertson growers are located in a district which has a number of hobby farmers, small holdings, residential, tourist and "Pitt Street" farmers as neighbours. This makes the issue of using chemicals a very sensitive one. Growers feel to remain viable in such an environment they must implement environmentally friendly measures. This led to the program of parasitic wasp releases to control potato tuber moth without having to use insecticides, and a monitoring program to determine its effectiveness.

During the course of Stage I and II, potato growers in the Dorrigo and Guyra districts became aware of the work undertaken in the Robertson district. These districts face similar environmental and production issues to those faced in Robertson, such as off site contamination, hobby farmers as neighbours, and the size of their enterprise.

Growers in these districts were also aware of research being undertaken using funds from the National Potato R&D levy. They felt that by supporting and involving themselves in this project would mean they had greater access to this research and the researchers.

The aims of this project were as follows:

- Implement biological control measures for the management of potato tuber moth in the Robertson district.
- Develop management practices for the control of White Fringed Weevil and African Black Beetle in the Guyra and Dorrigo districts.
- Develop phosphorus management strategies in the krasnozem soils in the Robertson district in order to utilise high levels of soil P and so minimise P fertiliser applications.
- Overall decrease in input costs of potato production by 10%.

This report details the work carried out and the results and recommendations from project PT97010 – Sustainable Potato production in Highland Areas of NSW Stage III.

TECHNOLOGY TRANSFER STRATEGY AND METHODOLOGY / ACTIVITIES.

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1) PROJECT STRUCTURE

PROJECT DEVELOPMENT

Grower meetings were held in Guyra, Dorrigo and Robertson in late 1996 and early 1997 to identify areas of investigation to improve economic and environmental sustainability of potato growers in those districts.

Areas identified at these meetings covered management of insect pests, irrigation management and the management of soil P.

Discussions with Robert Spooner-Hart, Entomoligist from UWS-Hawkesbury and Len Tesoriero, Plant Pathologist, NSW Agriculture were had to develop an IPM prohram suitable for each district. A program to investigate irrigation management was developed with Mike Robbins, Irrigation Officer, NSW Agriculture, and Richard Greene, Soils specialist, ANU and Peter Hocking, Research Scientisit, CSIRO developed a field and glass house research program to investiagte the management of soil P.

To encourage grower interaction a series of meetings and discussion forums were organised in each district.

PROJECT MANAGEMENT COMMITTEE

A committee was set up which consisted of a representative from each district plus the project coordinator to manage the day to day running of the project.

This committee met 2 times per year in Sydney at the conclusion of the NSW Potato Advisory Council meetings.

SUMMARY OF RESULTS

Articles have been published in Potato Australia detailing the progress of the project and the final results.

Two articles will be prepared for inclusion in Eyes on Potatoes detailing the results of the P management work and the IPM work.

END OF PROJECT SURVEY

To gain an indication of how successful the project had been a short grower survey was conducted at the conclusion of the project.

2) INTEGRATED PEST MANAGEMENT (IPM)

Robert Spooner-Hart[A], *and Len Tesoriero*[B].
[A]*University of Western Sydney – Hawkesbury, Richmond, NSW.*
[B] *NSW Agriculture, EMAI, Camden, NSW.*

INTRODUCTION AND BACKGROUND

There is increasing awareness of the limitations and side effects of a total reliance on chemicals for a quick-fix. Problems include concern for human health and safety, the environmental damage caused by some pesticides, the elevation of organisms to pest status through the elimination of natural or native suppressive agents, and widespread resistance in insects, mites and pathogens to synthetic pesticides. With a number of crop plants, phytotoxic injury from pesticides is a major problem.

In fact, the rate at which new pesticides are being developed and registered is not keeping pace with the rate at which others are being withdrawn from the market. As well, increasing legislative controls will further limit the use of those still available.

For two reasons this presents greater risks to potato growers than to many other primary producers, namely:

1. The proximity of production areas to encroaching subdivision and urbanisation, and
2. The fresh sale or the snack nature of the processed product.

While some consumers look for organically grown or pesticide-free produce, such products often have major limitations for commercial production, and this concept is therefore unrealistic for a number of crops. A realistic alternative is to adopt methods which lead to a reduced use (rationalisation) or replacement of pesticides, while still ensuring adequate, profitable yields of quality produce. The most comprehensive approach is Integrated Pest Management (IPM).

IPM involves the development of systems of managing rather than attempting to eliminate pests, that monitor pests (or their damage) as well beneficial organisms, and use these data for decision making. Some of the strategies that can be incorporated into IPM systems include:

- Biological methods [use of predators, parasites and pathogens]
- Cultural methods (including good hygiene and sanitation, selection of disease resistant or tolerant varieties, modifications to production methods, and design of growing structures)
- Physical and mechanical methods
- Genetic methods (such as resistant varieties)
- Synthetic versions of natural compounds (such as pheromones)

and

- synthetic pesticides, that are used only when necessary, and where their selection is based on causing minimum disruption to other control methods.

A review of IPM in potatoes in Australia has been recently published (Horne and Spooner-Hart, 1998).

At the end of the initial project "Sustainable Potato Production in Highland Areas of Australia" the following achievements had been made (A Growers Handbook of Best Practice):

1. Potato growers in the Robertson district were able to recognise the common pest and beneficial insects in their crops.

2. They were aware of the methods they can use to monitor potato crops, and the importance of constant monitoring and accurately recording data.

3. They better understood the role of all methods, including pesticides in developing IPM programs. This was confirmed the high marks achieved in the IPM section of the National Chemical Farm User's Course which 9 participating growers undertook as an outcome of the project.

Work undertaken in this project in Robertson showed that potato moth was present throughout the growing season, peaking in mid summer. Even early in the season, numbers were reasonably high. This means that growers needed to be on the lookout for foliar mining in the earlier part of the season, and as tubers form, they are adequately protected from tuber moth by hilling and well-timed irrigation.

This phenomenon also confirmed that potato moth survived from one season to the next in the district, and all alternative breeding sites such as crop debris, volunteer plants and closely related weeds needed to be eliminated via implementation of appropriate cultural controls to reduce pest pressure for the following season. On the other hand, the presence of potato moth provided conditions more likely to be suitable for establishment of biological control agents such as parasitic wasps.

Because of these achievements and the results of the monitoring work, the Robertson growers wished to expand their IPM program by incorporating the use of biological control methods, in particular the parasitic wasp *Orgilus lepidus* for the control of potato tuber moth. They had been introduced to successful work previously undertaken in other districts an part of the earlier project. Field monitoring and a field survey of potato mines during the previous season failed to record the presence of this species in the district.

In addition, Dorrigo and Guyra potato growers had seen the results of the initial IPM work in Robertson, and wished to develop a similar program as they had similar environmental and social issues to the Robertson district.

MATERIALS AND METHODS

Robertson

In 1997-8 two sites were used for the release of the parasitoid *O. lepidus* for the control of potato tuber moth , Tony Strode's and the Hills, and each had an additional non-release paddock which was comparatively monitored for the moth as well as other species. Two full-season releases were ordered from Dr Paul Horne, IPM Technologies, Victoria. *O. lepidus* was initially released on the 22nd December,1997 at both properties, once the crop had fully emerged. A total of 5 approximately weekly releases of 1000 adult parasitoids at each site (approx 10-15 hectares) were made over a seven week period. This is in line with recommended release procedures. These crops were compared with the similar non-release site. Monitoring stations consisting of potato moth pheromone delta traps, and yellow and blue sticky traps were set up in release and non-release crops, and replaced approximately fortnightly. The traps were forwarded to UWS-H for identification and counting of captured species. All major pests and beneficials were assessed. Traps continued to be returned until crops were harvested.

In addition, the relative number of leaf mines in each crop was assessed by sampling 100 metre length rows late in the season, and mines were collected and taken to UWS-H, where species emergence was observed.

In the 1998-9 season, a second set of *O. lepidus* releases were made at the two growers' properties (viz. Strode and Hill). At Strodes, the same release and non-release paddocks as for the previous season were used; the Hill's sites were adjacent to the former sites. The first release occurred on 23rd December, 1998 and 4 further releases were made over the next 7 weeks. These releases were irregular, because of difficulties experienced by the organisation rearing the *Orgilus*. Monitoring stations were set up in all paddocks prior to release of the parasitoid. Traps continued to be returned fortnightly until 14th March 1999, except for the Hill release paddock which was terminated several weeks earlier.

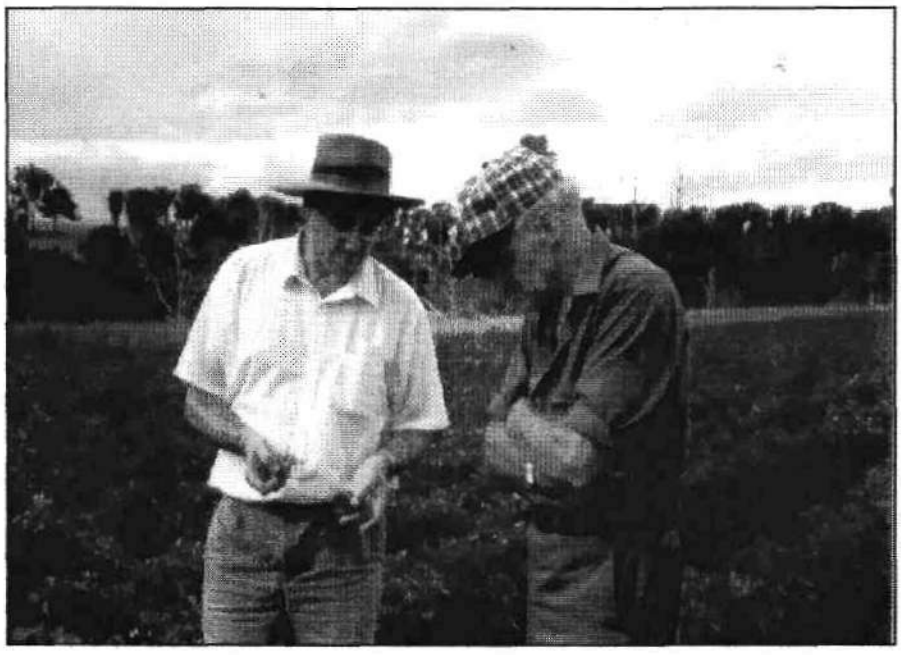
Field walks were organised so all growers had the opportunity to see the parasitic wasp being released. Feedback was given to all growers participating in the project through discussion evenings and seminar sessions (see Appendix – Field days, Seminars and Discussion evenings).

Robert Spooner-Hart releasing the parasitic wasp. Yellow and blue sticky traps and a Potato Moth delta pheromone trap can be seen in the background.

Dorrigo and Guyra

To enable growers to obtain a better understanding of IPM in potato production, crops were monitored for pests and beneficial species in both districts. Prior to the commencement of each season, growers were visited and the aim of the project and the methodology to be used was explained. Monitoring devices used were yellow and blue sticky traps (Agrisense® supplied by Dunluce International, Killara, NSW) and potato moth delta pheromone traps (Agrisense®). Traps were to be located in crops after hilling at approx. 1-1.5 metres height. They were to be replaced fortnightly, and sent to UWS,H where the captured specimens were identified and counted. The identity of specimens was divided into three categories: pest, beneficial, and incidental.

In initial meetings in 1997-8, growers in both districts expressed concern about the level of damage occurring from soil insect pests. It was indicated that in Guyra the major pest was whitefringed weevil, *Graphognathus leucoloma*, and in the Dorrigo district both whitefringed weevil and black beetle, *Heteronychus arator*. To obtain a more accurate definition of this problem, monitoring for presence of these two beetle species and their damage was included in the field walks. In addition to identification of pest species and damage, this gave an opportunity to identify sites for future demonstration/trials for beetle control. A talk/discussion session on potato soil-borne beetle pests was also provided for growers to inform them of research undertaken overseas and Australia (especially Sproul *et al* in Western Australia).

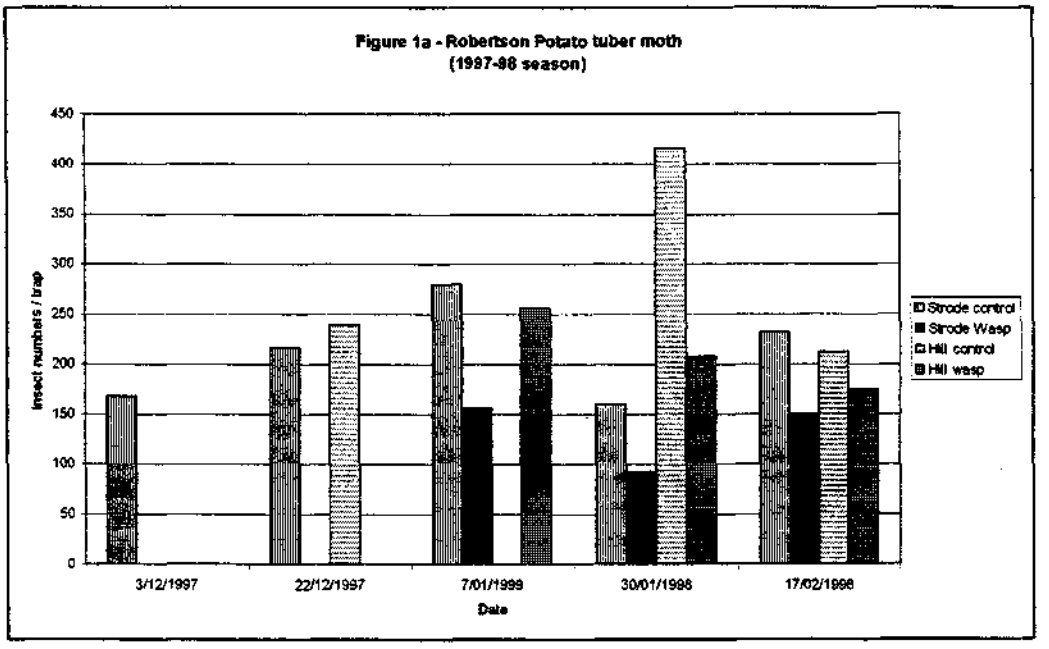


Len Tesoriero discussing disease issues with John Holmes (potato grower, Guyra.)

RESULTS AND DISCUSSION

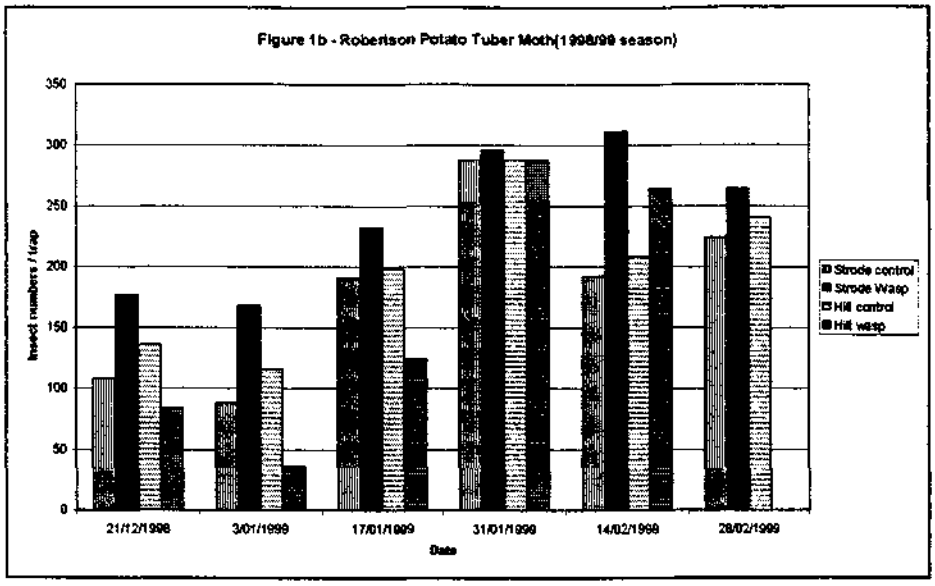
Robertson

The results of the potato moth trap counts in release and non-release sites are given in Fig 1a.

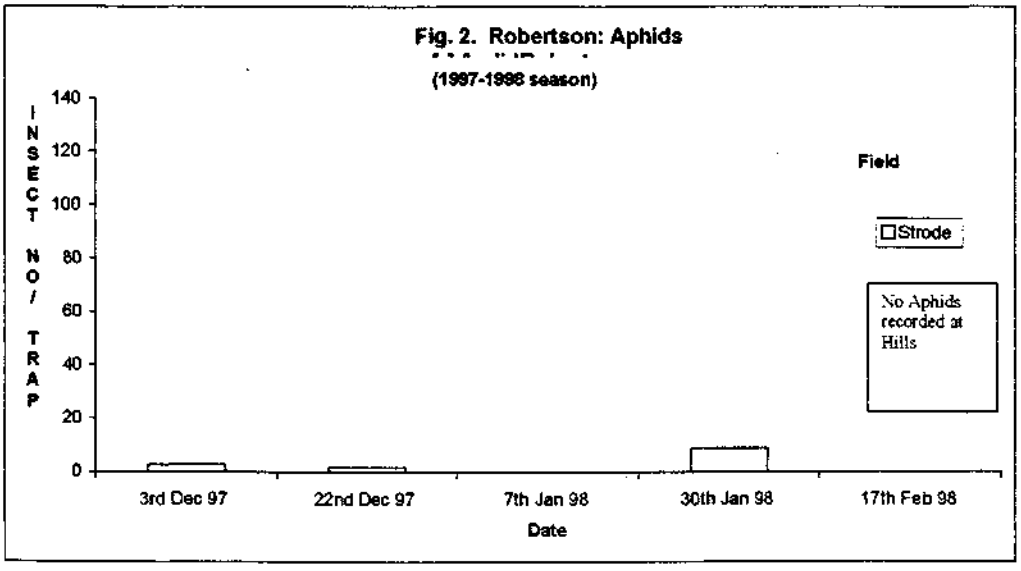


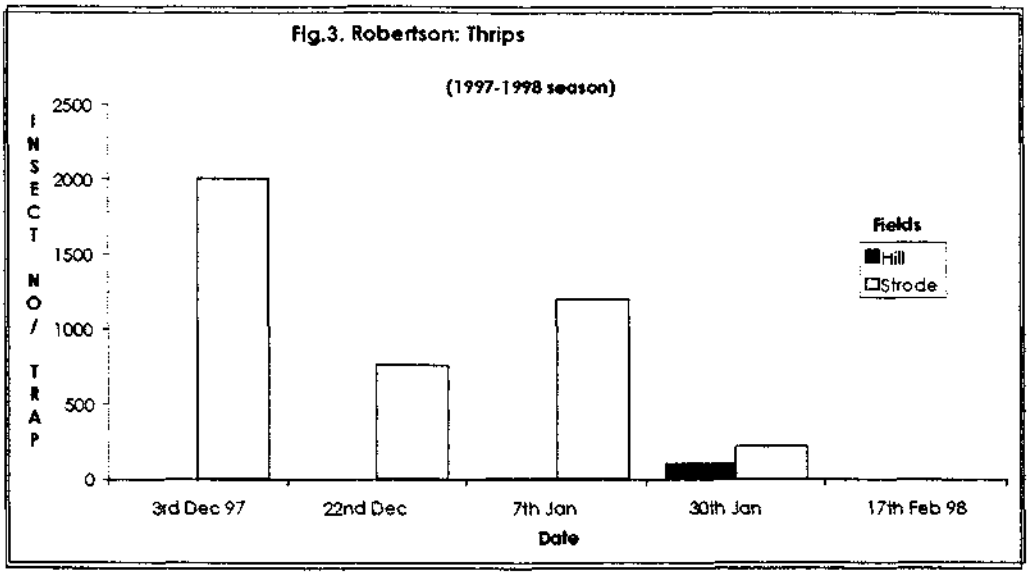
Although the crops were not fully synchronised, in the 1997-8 season there were consistently lower moth counts in the release crops. In addition, there was slightly reduced number of leaf mines in release crops (means 2.2 and 3.1 respectively). Three adult *O. lepidus* emerged from mines collected in the release crops, and only potato moth from the non-release sites, confirming establishment of the parasitoid during the season. While the above data look promising, the lack of replication prevents any definitive conclusions. Never-the-less, this is the first time that comparative investigations of this kind have been undertaken in Australia with this species. It was recommended that further investigations with *O. lepidus* releases be conducted next season.

In 1998-9, potato moth counts were slightly lower than in the previous season in all sites Fig 1b. The moth pressure was considered low. This was supported by a field count of leaf mines at crop maturity, in which only approximately 1-2 mines were recorded per 100 metres of row. There were, however, no significant differences in moth or mine numbers between release and non-release sites. No *Orgilus* emerged from field-collected mines It is unclear from these data whether the parasitoid has established in the district, and whether it is playing a role in suppression of potato tuber moth. Growers have expressed an interest in continuing with releases privately, even if funding for this program ceases. Releases of this species in Victoria have significantly reduced the need for pesticide applications against potato moth.

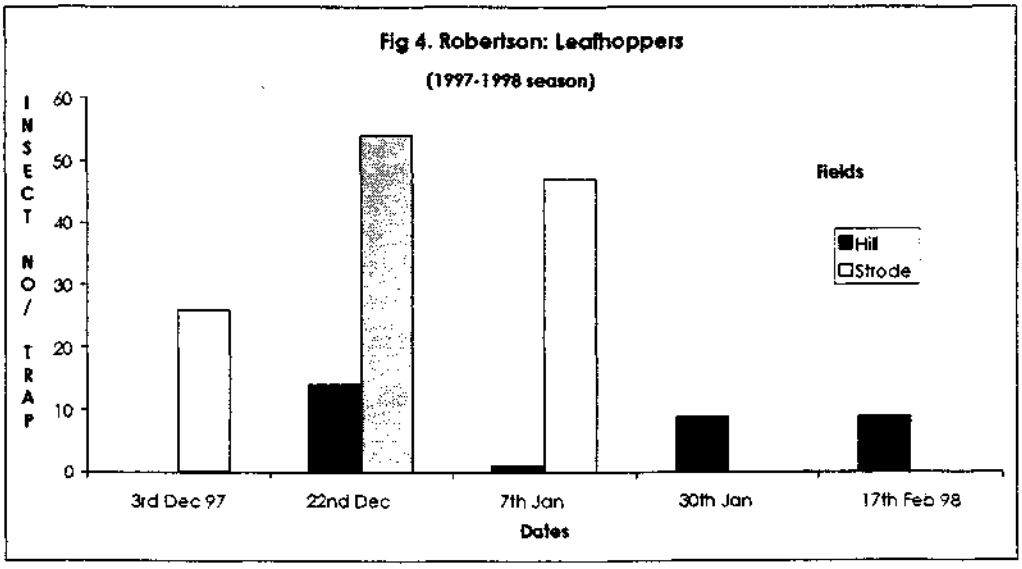


Results of monitoring for other pests in 1997/8 are presented as Figs 2-4. Aphids were not a problem, and there were no major aphid flights recorded this season. There were a few leafhoppers and psyllids, occasionally including brown leaf hopper, *Orosius*, a known virus vector.

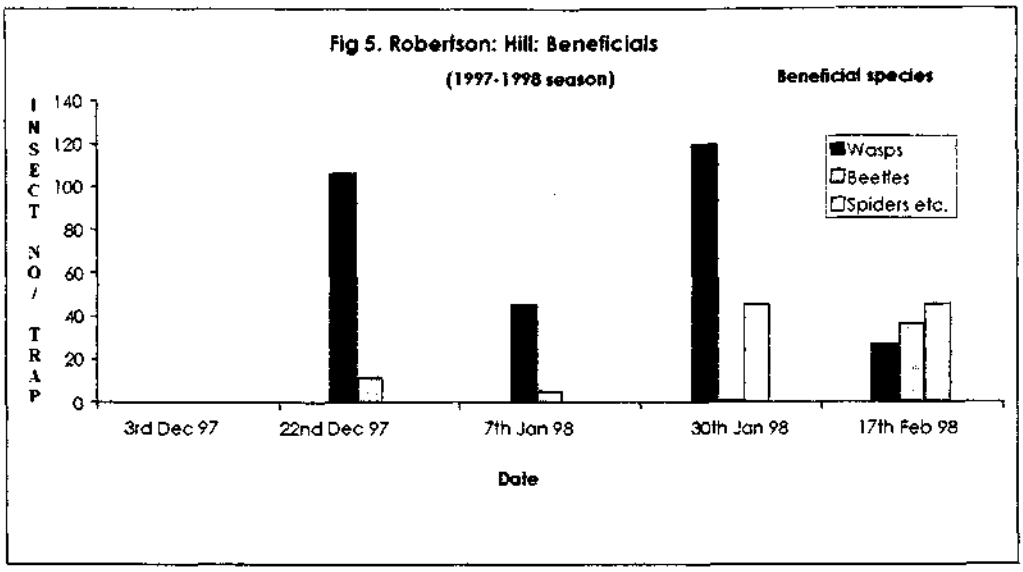


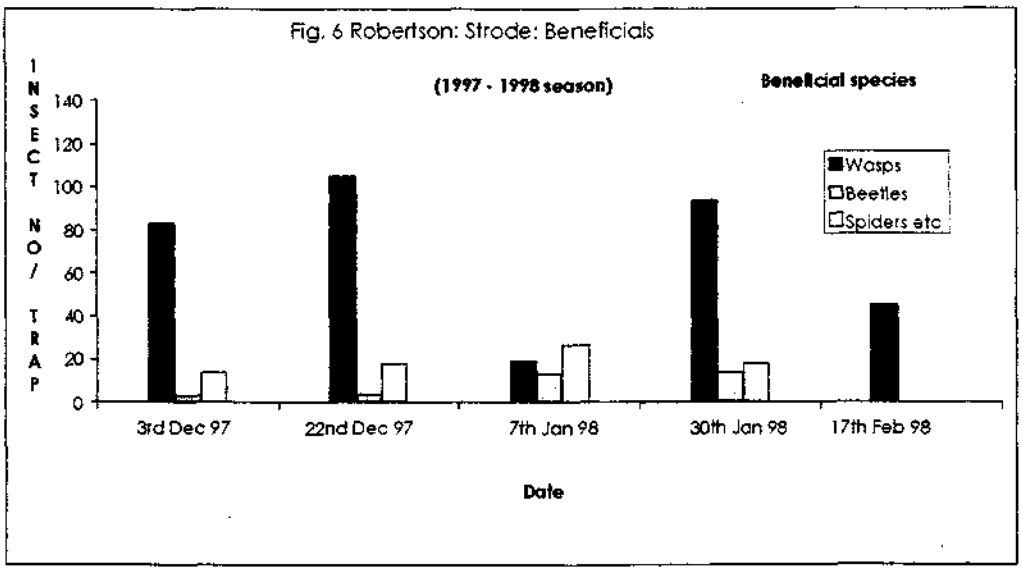


Thrips occurred in high numbers, especially during flowering. The most common thrips species early in the season was plague thrips, *Thrips imaginis*, but this is not regarded as an important vector of diseases in potatoes. Onion thrips, *T. tabaci*, a known vector of tomato spotted wilt virus (TSWV) was common throughout the season. A native flower thrips (*Frankliniella schultzei*) which is also a vector of TSWV was recorded in the district, but from only one sample. No Western Flower Thrips, *F. occidentalis*, were detected. No positive records were made of TSMV in any of the crops inspected. Some predatory thrips were also identified: these feed primarily on mite eggs and other small pests. The complex of thrips species, and their relationship to incidence of potato diseases in the field supports the need for close monitoring throughout the season.



Other beneficial species recorded (Fig 5 & 6) include small wasps, hoverflies and lacewings whose larvae feed on aphids and other small invertebrates, ladybirds and other predatory beetles and bugs, spiders, and larger wasps which are better sampled in light traps.





In 1998-9, thrips were present in all crops, but generally not in as high numbers as in the previous season. The dominant species was *Thrips imaginis* but *T. tabaci* was also recorded. Aphids were rare this season in traps and crops, except for one patch of *Macrosiphum euphorbiae.* Plant hoppers were in similar numbers to 1997-8, although the brown plant hopper (*Orosius*) was more common. However, its numbers remained low, so it was unlikely to pose a threat to potato crops.

One pest recorded for the first time since commencement of monitoring in the district (1994) was greenhouse whitefly, *Trialeurodes vaporariorum.* Numbers were generally low, with few nymphs and occasional adults on leaves.

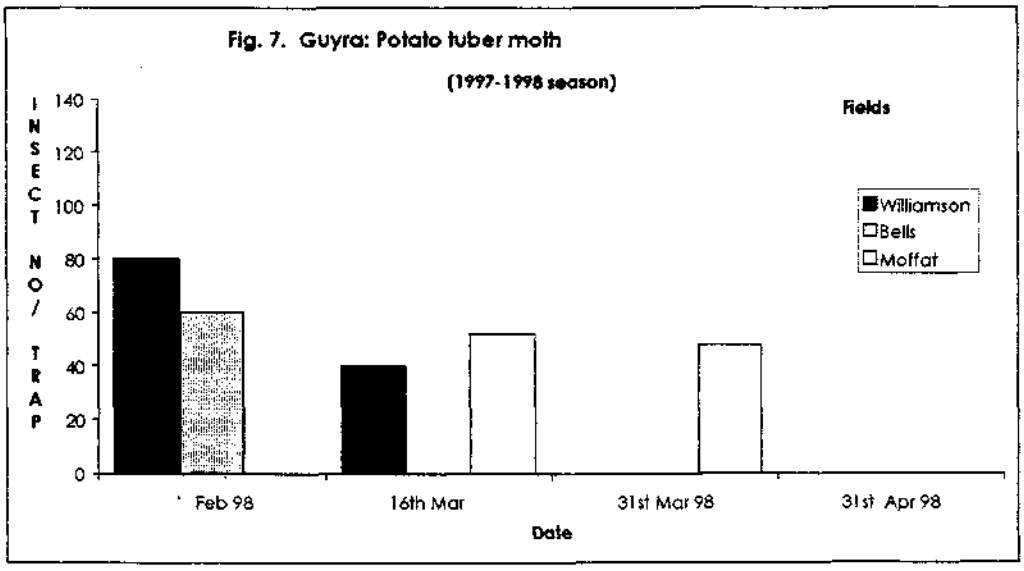
The environmental conditions this season appeared to be very conducive for beneficial arthropods, probably because of early and extensive flowering of plant hosts in spring. Many beneficial species feed on pollen and nectar, especially early in the season, and the absence of broad spectrum pesticides also allow for population buildup. In fact, this season had the highest number of beneficials recorded since we

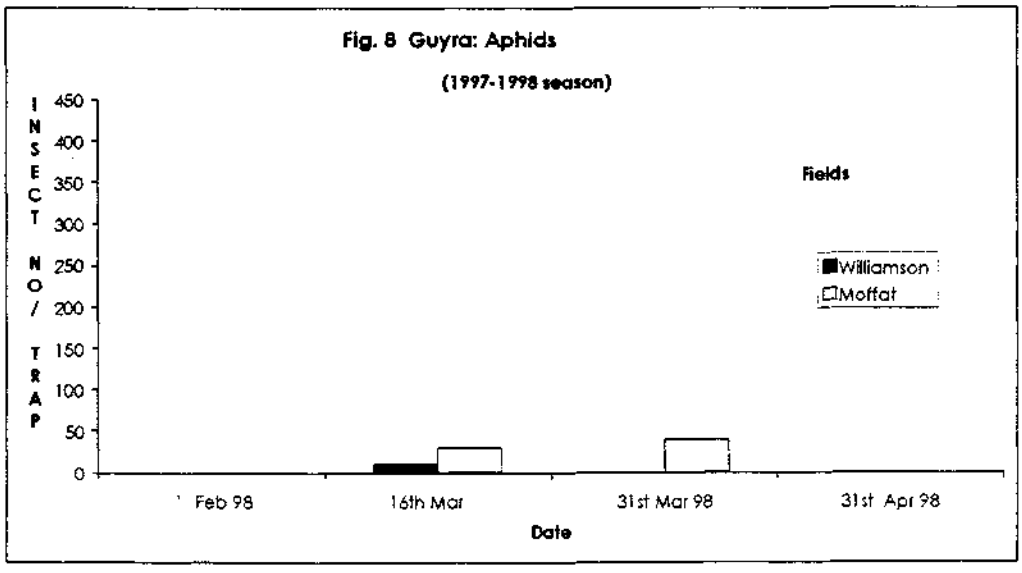
commenced monitoring in the district (1994). The most abundant predators were hover flies.

On one site (Hills parasitoid release) no pesticides were applied during the entire season. In addition, crop quality was very good, except for some late season target spot, *Alternaria solani*. This demonstrates that it is possible to grow potato crops of high quality, with minimal use of pesticide, provided cultural measures (such as clean seed and rotation) and pest monitoring are in place.

Guyra

We began receiving traps in January, which had been placed in the field on 1st January, 1998. Six sets of traps were received over the 3 months to the end of March. We also received 3 sets from a second grower in February and a further one in March. Results of the trap catches are given in Figs 7-11.





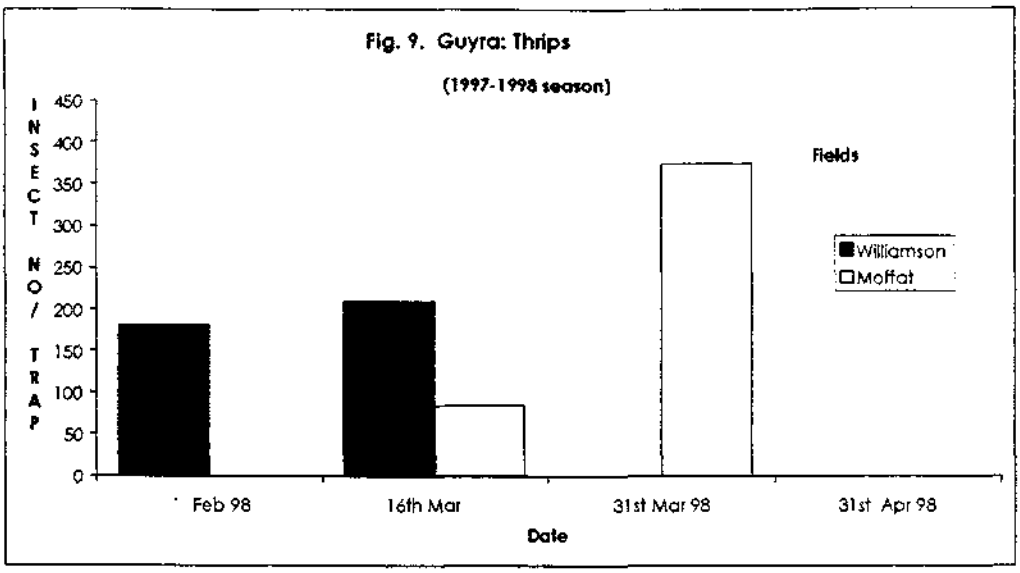


Fig. 9. Guyra: Thrips
(1997-1998 season)
INSECT NO/ TRAP
450
400
350
300
250
200
150
100
50
0
Fields
Williamson
Moffat
Feb 98
16th Mar
31st Mar 98
31st Apr 98
Date

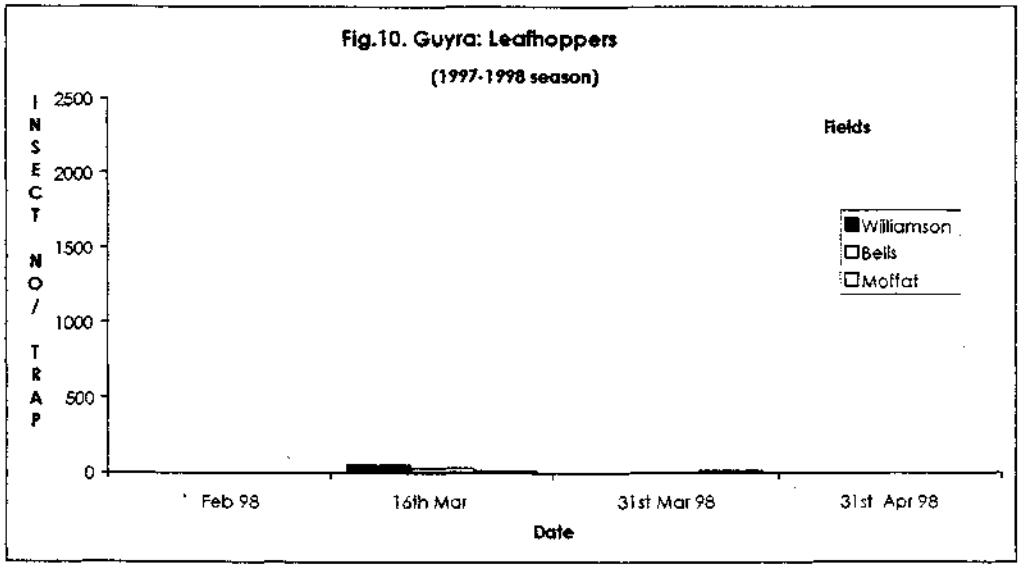


Fig.10. Guyra: Leafhoppers
(1997-1998 season)
INSECT NO/ TRAP
2500
2000
1500
1000
500
0
Fields
Williamson
Bells
Moffat
Feb 98
16th Mar
31st Mar 98
31st Apr 98
Date

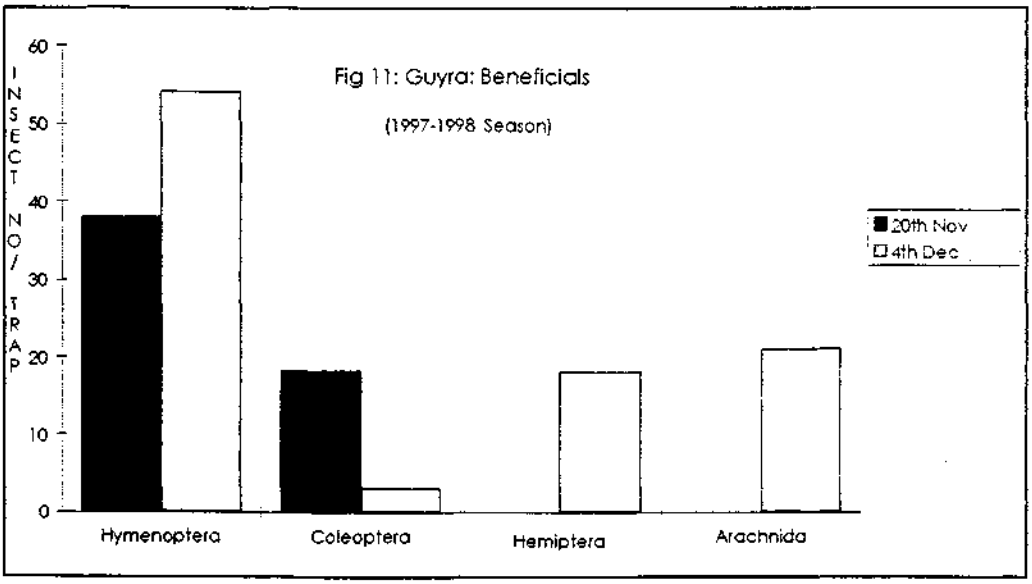


Fig 11: Guyra: Beneficials
(1997-1998 Season)
INSECT NO/ TRAP
60
50
40
30
20
10
0
20th Nov
4th Dec
Hymenoptera
Coleoptera
Hemiptera
Arachnida

At both locations, potato moth numbers were consistently low to moderate. Neither aphids nor plant bugs were present in damaging numbers, except for occasional brown leafhoppers, and a single high count of whiteflies, *Trialeurodes vaporiorum*, on one trap late in the season. Thrips, however, were in moderate to high numbers, being most common in the first half of February, with the next highest sample recorded at the end of March. Although the potential vectors (*T. tabaci)* were present, no TSMV was observed in any of the monitored crops.

A number of scarab beetle (family Scarabeidae) adults were also recorded, especially for a trap left in the field for longer than a two-week monitoring period. However, no black beetles were recorded. No whitefringed weevils were recorded, although this was expected as they do not fly.

There were a number of beneficial species recorded, particularly parasitic wasps, as well as some predatory beetles and spiders. In addition, hoverflies (several species of family Syrphidae) were also found: their larvae feed primarily on aphids.

No detailed assessment of tuber damage was made, as this was not an objective of the project. However, a preliminary assessment at 2 locations in the district confirmed whitefringed weevil as the predominant pest species. Damage was estimated by a participating grower to be up to 40% tubers damaged in one of his paddocks. This also assisted in identifying a location for further study in the next year.

In 1998/9, Guyra growers decided that because of relatively low pest numbers in the previous several years of monitoring, they would not set up monitoring stations, but would instead conduct a demonstration trial for control of whitefringed weevil. Unfortunately, the participating grower, John Holmes, was severely injured in a farm accident, and the trial was terminated. However, we were very pleased to see John, recovered, at the Dorrigo field day later in the season.

Dorrigo

In 1997-8, traps were received from two growers, in November-December and in April. As traps were not received regularly, it was difficult to accurately assess pest population trends during the season.

Early in the season, potato moth numbers were quite high, but by April they had declined. With regard to other pests, only a few aphids and leafhoppers were found (in one case, a brown plant hopper which is a known virus vector). Rutherglen bugs (*Nysius vinitor*) were occasionally present, but in low numbers. Thrips were, however, present in high numbers in December, probably correlated with flowering. Most thrips were *T. imaginis* but several *T. tabaci* were also recorded. Although these potential vectors were present, there was no evidence of TSWV or any other virus/phytoplasma diseases in any crop. Other pests recorded were small scarab beetles and click beetles (family Elateridae), the larvae of which are plant root and tuber feeders. Of the beneficial species recorded, small wasps were numerous, as well as hover flies, ladybirds (family Coccinellidae), other predatory beetles and bugs, and spiders.

At a field day, 4 paddocks were sampled for beetle larvae and tuber damage. Although this was late in the season, a few black beetle larvae and some tuber damage was noted. This assisted in identifying a site for the following season.

In 1998-9, traps were received from 5 growers, although they were not received regularly for the full season from any paddock. This again made interpretation of the trap counts difficult. In general, potato moth numbers were lower than the previous year, although thrips were more numerous. Aphid numbers were also low, although there was an increase in *Orosius* , which is implicated in transmission of purple top (cottony shoot). Of the beneficial species recorded, the most numerous species were hoverflies. Small species of wasps were, however, less numerous. A substantial reduction in their number in one paddock we attribute to a single application of the insecticide monocrotophos (Azodrin ®).

A demonstration site for control of black beetle was set up at North Dorrigo on a site leased by Greg Billing. This was an unreplicated trial in an 8 hectare paddock, with a nil treatment control and a treatment of Chlorpyrifos (50% EC) applied 5L/ha at planting. At the field day to assess damage and effectiveness of control, potatoes were dug and examined. There was only occasional tuber damage by black beetle in both treatment and control blocks (< 0.5%). Beetle larvae were also scarce, with only several found in each plot. Although this trial was unreplicated, there was no obvious difference in beetle control between treated and control plots.

Plant disease assessment

Following concerns about symptoms of disease, Len Tesoriero plant pathologist, Elizabeth Macarthur Research Institute NSW Agriculture, and Robert Spooner-Hart visited Dorrigo on April 7 1998 for field inspections, and to collect samples for testing. There was no evidence of pathogenic disease either in the field or laboratory examinations, and it was concluded the symptoms were consistent with a deficiency of calcium and boron associated with abnormally high soil temperatures and plant water stress.

Samples from Dorrigo for disease assessment for the 1997/8 season were:

SAMPLE NO.	GROWER	DIAGNOSIS
98/726	Doust & Sons	
98/594	Doust & Sons	powdery scab confirmed
98/484	Doust & Sons	lenticel breakdown
98/312	3 growers (5 samples)	negative for viruses, calcium and boron deficiency
97/639	Billing	powdery scab confirmed
97/577	D. Sharpe	rhizoctonia and rootknot nematodes

In 1998-9 monitoring and laboratory investigations for diseases continued in all the production districts. Most of these investigations concerned issues of seed quality, primarily focusing on Powdery Scab (*Spongospora subterranea*) and Black Leg (*Erwinia* spp). The presence of Black Leg was monitored as there had been some concern (especially in Dorrigo) in recent years with the spread of this bacterial disease with certified seed. Virus levels were negligible despite sporadic outbreaks of TSMV and Purple Top (Phytoplasma) in other NSW production areas. Samples collected from Robertson were tested by ELISA and found to be negative for aphid borne viruses (PVS and Potato Leaf Roll), along with PVX which is spread by mechanical means. This result reinforces the lack of insect borne problems over the duration of this project. Testing samples with leaf rolling symptoms was useful to negate the possibility of Potato Leaf Roll Virus. In all cases other environmental factors (eg. moisture stress) were identified that were likely to have been responsible for symptoms.

SAMPLE NO.	DATE	DISTRICT	SYMPTOMS	DIAGNOSIS
98/776	4/9/98	Dorrigo	scab & breakdown	neg. powdery scab
98/781	4/9/98	Dorrigo	tuber breakdown	fusarium, bacteria
98/1236a	22/12/98	Dorrigo	scab	powdery scab
98/1236b	22/12/98	Dorrigo	lenticel lesions	neg. powdery scab
99/48a	21/1/99	Dorrigo	tuber rot	Erwinia soft rot
99/48b	21/1/99	Dorrigo	scab	powdery scab
99/100	1/2/99	Dorrigo	tuber rot	black leg (likely)
99/169a	12/2/99	Robertson	purple top	neg. phytoplasma
99/169b	12/2/99	Robertson	wilt	bacterial wilt
99/299	4/3/99	Robertson	rolling leaves	neg.PLRV,PVS,PVX
99/300	4/3/99	Robertson	rolling leaves	neg.PLRV,PVS,PVX
99/301	11/3/99	Robertson	rolling leaves	neg.PLRV,PVS,PVX
99/215	1/3/99	Guyra	rolling leaves	neg.PLRV,PVS,PVX

CONCLUSION AND OUTCOMES

In Robertson, there were some very positive outcomes. The group of participating growers continued to maintain interest in the IPM work, and followed the monitoring results as well as the biological control trials for potato moth. The monitoring confirmed that during the season, there were no major insect pest problems that warranted insecticide applications. There was also no significant presence of vector-borne diseases. At one of the sites, the grower sprayed once and the other site was sprayed twice. In our view, neither was warranted. However, this still is a substantial reduction in the level of pesticide application used in the district prior to the commencement of the project.

With regard to biological control of potato moth, the results were encouraging. The consistently lower moth counts and slightly reduced number of leaf mines in release crops was supported by the recorded emergence of *O. lepidus* from mines collected in the release crops. This compares favourably with results from releases in other states (Paul Horne, personal communication). This is the first time that comparative investigations of this kind have been undertaken in Australia. It is recommended that further investigations with *O. lepidus* releases be conducted next season, and this has the support of the growers.

As discussed earlier, the 1998-9 season had the highest number of beneficials recorded since we commenced monitoring in the district (1994). We attribute this not only to the favourable climate, but also the absence of broad-spectrum pesticides. On one site where *O. lepidus* was released for potato moth control no pesticides were applied during the entire season and both yield and tuber quality were good. This demonstrates that it is possible to grow potato crops of high quality, with minimal use of pesticide, provided cultural measures (such as clean seed and rotation) and pest monitoring are in place.

In Guyra, numbers of most insect pests were much lower than those recorded in other districts, but consistent with previous years in this district (Lanz, 1997). This should

be conducive to implementation of IPM in most potato crops, even for seed production. According to one of the growers, this project constituted the first extension activity in potatoes in the district in over 30 years. Numbers attending meetings and general interest seemed high.

In Dorrigo, there was a disappointing response in grower participation in monitoring and field extension, although there was a core of interested people. This resulted in inconclusive data being obtained from the district. The importance of constant and regular monitoring for pests and diseases was stressed by both Robert Spooner-Hart and Len Tesoriero.

The importance of soil insect pests was raised by potato growers in all three potato districts. While this project was primarily targeted at foliar pests (Except potato tuber moth), it provided the opportunity for preliminary investigations on these species in Guyra and Dorrigo. It is recommended that a project be developed that is specifically targeted at soil beetle pests in potatoes in NSW. The development of pest management programs

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3) SOIL PHOSPHORUS (P) MANAGEMENT

Stuart Little[A], *Peter Hocking*[B] *and Richard Greene*[A]

[A] Departmant of Geography, Australian National University, GPO Box 4, Canberra, ACT 2601.

[B] CSIRO Division of Plant Industry, GPO Box 1600, Canberra, ACT 2601.

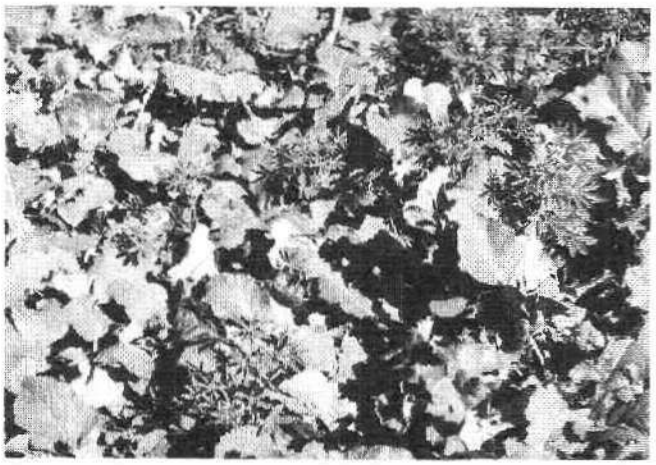
INTRODUCTION

In stages I and II of the project, soil testing throughout the district showed high to very high levels of soil available phosphorus. However, plant testing indicated that the plant was not able to access this soil phosphorus. This was supported through fertiliser trials showing significant crop responses to phosphorus fertiliser application.

Growers felt there must be a way to access this soil phosphorus and approached the Australian National University (ANU). Discussions with ANU have lead to the implementation of the soil phosphorus management project.

Cover crops to release Phosphorus.

The objective of this project was to determine what contributions a cover crop made in increasing phosphorus availability to a following potato crop. Of particular interest was the performance of a species of white lupin (*Lupinus albus* c.v. Kiev Mutant) in soils with high phosphorus adsorbing potential. White lupins secrete organic acids from specialised roots termed "proteoid roots". These organic acids release phosphorus that is locked up in the soil, making it available to the lupin plant. When the lupins are incorporated back into the soil, the phosphorus should become available for future crops. The work was run during 1998/99 in conjunction with the Australian National University and CSIRO. The research was conducted by Stuart Little, under the supervision of Dr Richard Greene (ANU) and Dr Peter Hocking (CSIRO) and in cooperation with the Robertson growers Trevor and Barry Donovan.



The objective of the P management component was to determine what contribution cover crops made in increasing P availability to the following potato crop.

Biofumigation, P release, and grazing potential.

A combination of a brassica and white lupin is the ideal cover crop providing biofumigation, phosphorus release as well as grazing potential. It is anticipated that the brassica will benefit from the phosphorus release by the white lupin due to its large mass of fine roots infiltrating the rhizosphere of the lupin and accessing the released phosphorus. With the large above and below ground biomass of the brassica combined with the biomass of the lupin, a large store of organic phosphorus is created. Which, when incorporated, will be released into the soil and made available to the succeeding potato crop. The cover crop option of a brassica - white lupin combination will still provide the benefits of traditional cover crops, such as grazing, soil conservation, and structural improvements, but has the potential to boost yields and profits per hectare by reducing fertiliser inputs and reducing losses caused by soil borne pests and diseases. The major off-site benefit is the reduction of phosphorus inputs into water catchments by reducing fertiliser applications and reducing the fixed phosphorus pool within the soil, therefore reducing the concentrations of phosphorus added to watercourses by erosion and runoff from potato growing areas.

EXPERIMENTAL DESIGN AND CROP MANAGEMENT

The field site was 7 km south west of Robertson in the New South Wales southern highlands. The soil at the site is derived from highly weathered basalts that underlie much of the Robertson district. The experiment consisted of four replicate blocks with 5 cover crop treatments as main plots randomised in each block, giving a total of 20 plots. Each plot was 10 m long by 3.6 m wide. The five cover crop treatments were: (1) no cover crop; (2) oats (*Avena sativa* cv. Blackbutt); (3) white lupin (*Lupinus albus* cv. Kiev Mutant); (4) fodder rape (*Brassica napus* cv. Rangi); and (5) a fodder rape/white lupin combination. The cover crops were broadcast sown by hand at the following rates: oats, 160 kg/ha; white lupin, 200 kg/ha; rangi rape, 6 kg/ha; and a 50:50 combination of white lupin and rape at 100 and 3 kg/ha, respectively. The seed was bulked up with sand to ensure even sowing. No fertiliser was applied to the cover crop treatments. Weeds on plots with no cover crop were controlled by hand at regular intervals, and removed.

The experiment consisted of three phases:

Phase 1 was the growth of the cover crops for 27 weeks from 25/2/98 to 1/9/98. At 16 weeks (26/6/98), all the cover crops were mulched at 30 cm above ground to prevent the lupins going to seed and to reduce the amount of material to be broken down during the incorporation stage.

Phase 2 consisted of mulching and then incorporating the cover crops to a depth of 15 cm using discs on 1/9/98. This was followed by a 7-week period to enable breakdown of the organic matter prior to sowing the potato crop. Plots with no cover crop were also cultivated using discs.

Phase 3 was the growth of the potato crop. Each main plot was split lengthwise into two sub-plots; a sub-plot consisted of a 'bed' 1.8 m wide with two rows of potato plants approximately 70 cm apart. One sub-plot received fertiliser, and the other received no fertiliser to determine if there were differences between the cover crops in increasing the availability of soil P. Seed potatoes of cv. Atlantic in two rows per sub-plot on 21/10/98. The fertiliser was applied as bands at planting at the recommended

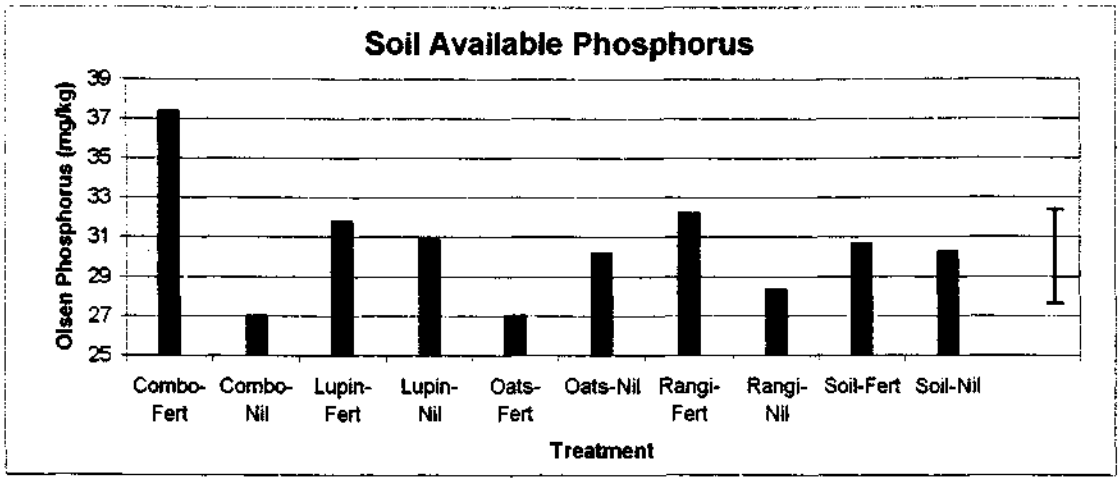
rates of 135, 112.5, 101.3 and 297 kg/ha for P, N, K, and Ca, respectively, as commercial granular fertiliser of composition 6.0%P, 5.0%N, 4.5%K, 13.2%Ca & 13.3%S. The potato crop was machine harvested at commercial maturity on 16/2/99.

Stuart Little discussing the pot trials conducted at ANU with RDPA&LA president Jon Hill.

RESULTS

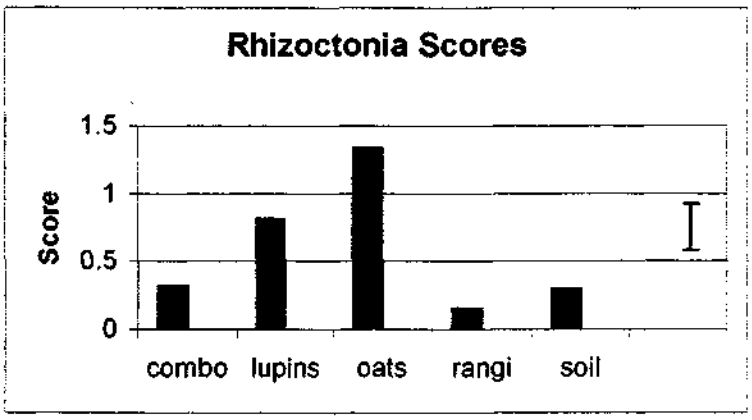
- The combination cover crop did accumulate greater biomass and total phosphorus than the pure lupin and pure oat cover crop treatments but not significantly greater than a pure cover crop of rangi rape. Results showed that pure rangi and the white lupin-rangi combination produced approximately 10 tonnes of dry matter per hectare whilst oats produced 5 tonnes per hectare. The pure lupins treatment died out when tops were removed to prevent the lupins from going to seed. The material incorporated had total phosphorus content of approximately 30kgP/ha for both the rangi and combination treatments whilst oats contained approximately 15kgP/ha.
- Soil tests taken before potato sowing showed that the addition of the organic material from the combination cover crop did NOT result in increased "available" phosphorus in the soil prior to sowing of the potato crop. Soil "available" phosphorus showed NO significant differences between the treatments before sowing of the potato crop.
- Soil samples taken 8 weeks after potatoes were sown and fertiliser added showed that where the combination treatments were grown, the level of available phosphorus was approximately 17% higher than the oats and rangi cover crops.

Figure 1: Results of soil samples taken 8 weeks after potatoes were sown.



- Despite these differences however final potato yield did not reflect the changes in soil available phosphorus. Whilst final tuber yield did not reflect the differences in soil available phosphorus between the cover crops, the results from this experiment show that cover crops containing white lupin varieties show some potential in improving phosphorus availability to the following potato crop.
- Incidence and severity of Rhizoctonia was significantly reduced by the presence of rangi rape plants compared to the pure oats and pure lupin cover crops. See Figure 2.

Figure 2: Incidence of Rhizoctonia on potatoes at harvest.



DISCUSSION

It is probable that the high level of "available" phosphorus present in the soil before the experiment commenced limited the effectiveness of the combination cover crop. High levels of "available" phosphorus restrict the development of the organic acid secreting proteoid roots by white lupin. The higher "available" phosphorus levels occurring in the combination and lupin treatments may be the result of a change in soil electrostatic charge, possibly through the action of citrate ions in the soil.

Benefits of Cover Crops / Green Manures

The benefits of a white lupin - rangi rape combination go beyond the potential for increased phosphorus availability.

- A white lupin-rape combination cover crop provides soil protection and can contribute to soil structural improvement by roots binding soil together and through organic matter addition.
- As lupins are a legume, they can also improve soil nitrogen providing that the seeds are inoculated with compatible rhizobia before sowing.
- Fungal and pest cycles can also be broken by the biofumigation provided by the rape component of a combination cover crop.

CONCLUSIONS

The combination of rape and a proteoid root producing lupin variety (eg. *Lupinus albus, L. consentinii*) has the potential to provide benefits not only on high phosphorus fixing soils but also on soils that have been run down by long cropping histories or between pasture and cropping phases in a paddock rotation.

FUTURE RESEARCH DIRECTIONS

- Compare the phosphorus releasing potential of a lupin-brassica cover crop on soils with high, medium and low levels of available phosphorus.
- Trials with different ratios of lupin plants to brassica plants.
- Examine the potential of fodder varieties of white lupin to withstand grazing pressure and produce greater biomass.
- Full investigation of the biofumigation potential of lupin-brassica combinations including compatibility of white lupin with new brassica varieties such as BQ Graze and BQ Mulch.

4) IRRIGATION MANAGEMENT

Stage I of the project identified that irrigation was often a limiting factor to crop production in the Robertson district in very hot dry years.

Growers in the district have limited water supplies and they recognised the need to ensure they achieve maximum efficiency with irrigation to ensure water was not wasted.

To achieve this a programme was developed in collaboration with Mike Robbins, Senior Irrigation Officer, NSW Agriculture. The programme developed is outlined below:

Robertson

The programme will include a survey of growers irrigation equipment, soil moisture monitoring through the use of an Enviroscan®, irrigation system performance checks to establish base line data. System modifications will be undertaken in consultation with the irrigation officer with the aim of improving irrigation system performance.

Dorrigo

A programme will be developed to increase growers understanding of their crops water needs throughout the growing season. This will be done through the use of tensiometers and an Enviroscan® to demonstrate to growers soil moisture changes throughout the growing season.

Guyra

Only 1 grower in the Guyra district irrigates his crops. This grower will be encouraged to participate in the Dorrigo irrigation programme as will all other interested Guyra growers.

Unfortunately at the end of the 1st year of the project growers in the Dorrigo and Robertson districts were unable to maintain the original level of voluntary contribution towards the project. This led to a review of the project objectives, and it was felt with the current process of Water Reforms and the initiatives by NSW Agriculture to work with farmers on improving irrigation efficiency through the Water Wise on Farm programme the irrigation management component of the project would not be continued into the 2nd season.

Mike Robbins, Senior Irrigation Officer, NSW Agriculture, demonstrating the use of Tensiometers, to potato growers.

EVALUATION AND MEASUREMENT OF OUTCOMES – IMPACT AND ADOPTION.

INTRODUCTION

MEASUREMENT OF OUTCOMES

- Monitoring
- Evaluation

RESULTS

DISCUSSION & RECOMMENDATIONS

CONCLUSION

APPENDICES

INTRODUCTION:

PT97010 was primarily to develop and demonstrate management strategies on farm for the control of potato tuber moth, management of soil born pests and to manage soil P without having to apply extra fertiliser.

The original outcomes / objectives of the project were to:

- Implement biological control measures for the management of potato tuber moth in the Robertson district.
- Develop management practices for the control of White Fringed Weevil and African Black Beetle in the Guyra and Dorrigo districts.
- Develop phosphorus management strategies in the krasnozem soils in the Robertson district in order to utlise high levels of soil P and so minimise P fertiliser applications.
- Overall decrease in input costs of potato production by 10%.

MEASUREMENT OF OUTCOMES:

Monitoring:

To gain an understanding as whether growers had made changes in their production strategies they were asked objective yes / no questions within a grower survey.

Evaluation:

In the same survey growers were asked to explain their answers to the yes / no questions. These answers give an indication as to what their changes in growing practices mean to them and the industry.

RESULTS:

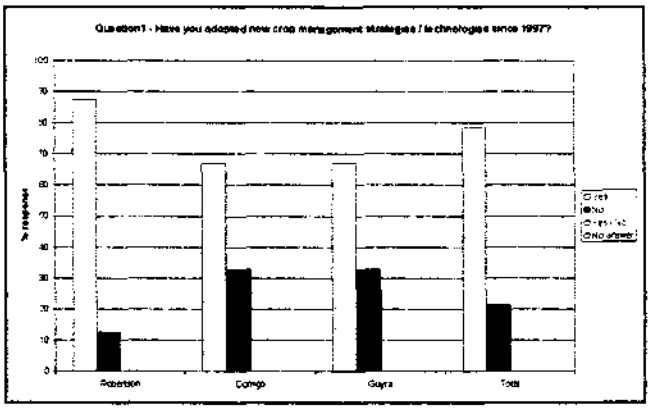
A total of 48 surveys were sent to all participating growers. Fourteen responses were received which is a 29% response rate. Table 1 gives a breakdown of the response rate for each district.

Table 1: Response to Grower survey

	Number sent	Number returned	% response
Robertson	12	8	67%
Dorrigo	13	3	23%
Guyra	23	3	13%
Total	48	14	29%

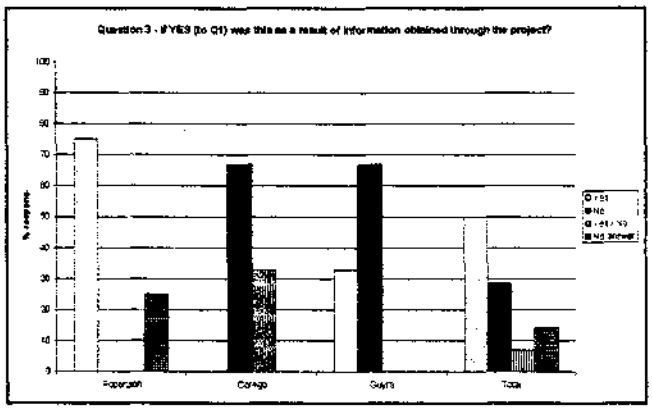
A number of Yes / No questions were asked and Figures 1, 2, 3, 4 & 5 illustrate the responses by district and overall.

Figure 1.



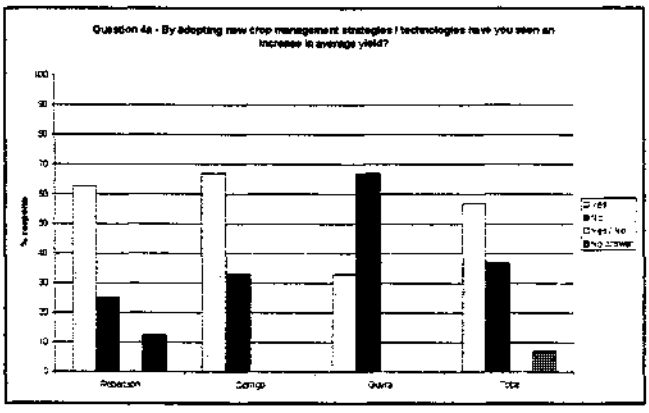
Nearly 80% of respondents have adopted new crop management strategies / technologies since the project began.

Figure 2.



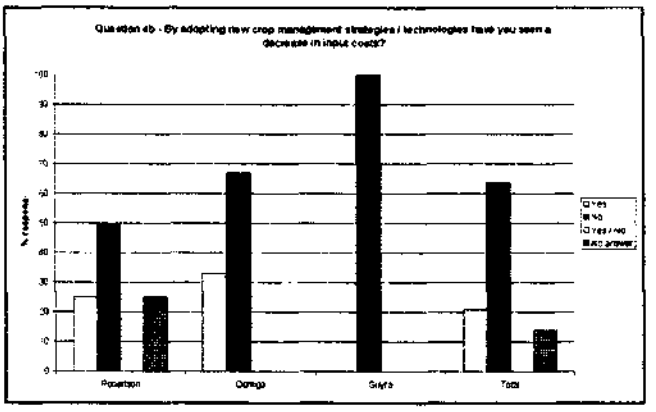
Half of all respondents adopted new crop management strategies / technologies because of information provided through the project.

Figure 3.



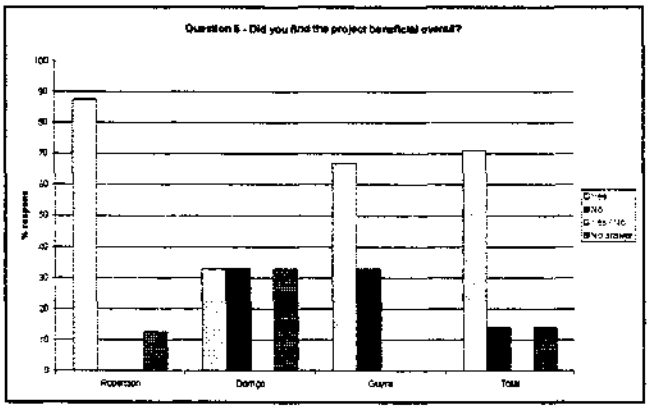
Nearly 60% of respondents have had an increase in yield.

Figure 4



Just over 20% of respondents had a decrease in input costs

Figure 5.



71% of respondents found the project beneficial overall.

Question 2 of the survey asked growers to list the areas in which they had adopted new crop management strategies or technologies since the beginning of Stage III of the project. The project had 3 areas where specific work was undertaken. These areas included Soil phosphorus management, Integrated pest management, and Irrigation management (in year 1 only). Responses to question 2 were divided up into these main areas to obtain an indication of a change in grower practices within the specific areas of work. Table 2 summarises the results.

Table 2: Adoption rate of new technology in project PT97010.

	% adoption.
Soil phosphorus management	42%
Integrated Pest Management	21%
Irrigation management	21%

The survey asked growers in what areas they found the project beneficial or not beneficial, following is a list of responses received.

Benefits:

- The release of parasitic wasp. P management trial was still beneficial even though the results were inconclusive.
- Group interest in the area for the area.

- Benefits: phosphorus cover crops, field days and new varieties, parasitic wasp.
- All areas, the project helped break down barriers between growers and made information help and advice flow freely
- Beneficial areas - QA talks, info seminar, Black beetle and White fringed weevil controls.
- Field walks with Robert & Len Tesoriero – information and help when we suspected we had a seed problem in autumn 1998. Information - QA, Eric Colman, Information on tensiometers.
- Found the field day at Bruce Moffats beneficial also QA in Marketing

Non – beneficial

- Non-beneficial – tensiometers
- All information presented I was already doing, except the tensiometers but they haven't made a difference to my irrigation programme

Growers were asked to make any other comments, following are the responses.

- Not knowing fully what the project was about and missing a fair amount of the activities I feel that I only gained a minimal amount of information
- White fringed weevil is still a major problem
- We really need to implement a quality assurance program to be able to maintain out existing markets and sustainablity.
- I have only been involved with the project for 1 season because I have only recently started growing potatoes.
- I feel that the overall objectives of the original ideas have not flowed through.
- Thank you Sandra for your time and effort, I wish I had more time available to participate in the project as in my opinion it was very worthwhile.
- I need to have assistance when we have a particular problem that we can not solve.
- In the 1999 we averaged $14 a bag delivered Guyra and this is regarded as one of our better years.
- Our main concern was White Fringed Weevil which we haven't had much success. John Holmes accident didn't help.

DISCUSSION & RECOMMENDATIONS

The project had 3 distinct geographical areas; Robertson, Dorrigo and Guyra.

Each district was and still is at a different developmental stage regarding the grower group dynamics.

The Robertson group has been successfully working together since 1991 and could be classed as a simple mature group. The group is made up of potato growers only. Potato growing is the primary enterprise for the majority of these farmers.

The Dorrigo potato growers do have a formal association which has been meeting for a number of years. The structure of the group is complex as it is made up of potato growers and merchants based in the district. These merchants have different growers affiliated with them. This makes collaboration and cooperation between all group members difficult. This group could be classed as a complex mature group.

Guyra potato growers do not have a formal association. There does exist an association for seed growers which does not include ware crop growers. Potato growers in the district generally lease land for potato growing and unlike Robertson and Dorrigo potato growing is not their primary enterprise. This group would be classed as an immature formative group.

The orginal project PT337 saw the consultant / project coordinator working 3 days per week directly with the Roberston growers. This project also involved specialists undertaking work in the district as part of the project.

PT97010 had a consultant coordianting the project working 1 day per fortnight srvicing 3 districts. The results from the grower survey indicate the greatest response to the project and satisfaction from the project by the Robertson growers. This would be due to them having formed strong bonds as a group through the initial project and demonstrated to researchers their dedication and enthusiasm to participating in field trials. This led to researchers having confidence in achieving results and so preparedness to work with the growers.

In order for the Dorrigo and Guyra districts to reach the same level of group cooperation as Robertson it is recommended that with future work, demonstration trials be conducted on one growers property. These trials be monitored regularly, say once per month by a field officer / consultant and the growers be invited to view the trials each time the field officer / consultant is present.

CONCLUSION

The grower survey demonstrates that the adoption of recently developed and evolving crop management practices has occurred in all areas of the project including irrigation management, which only ran for 1 season.

The greatest response rate to the survey was from the Robertson district (67% response). The Robertson growers indicated the highest rate of crop management changes due to the activities of the project compared to other districts.

Robertson was the district, which had the highest satisfaction rate for the project as a whole.

This would be a direct reflection of the maturity of the group, and the preparedness of the group to work together as a team.

APPENDICES

Sustainable Potato Production in Highland NSW

Stage III.

Project Coordinator:
Sandra Lanz
LANZ Agricultural Consulting
PO Box 406, Picton, 2571.
Ph/fax: (02) 4677 0198, Mobil: 0411 035 138, E-mail: slanz@acenet.com.au

Grower Survey

1) Have you adopted new crop management strategies / technologies since 1997?

YES / NO (please circle your answer)

2) If YES what are they?

3) If YES was this as a result of information obtained through the project?

YES / NO (please circle your answer)

4) By adopting new crop management strategies / technologies have you seen an:

a) Increase in average yield? **YES / NO**
b) Decrease in input costs? **YES / NO**

5) Did you find the project beneficial overall?

YES / NO (please circle your answer)

6) Please explain what areas you found / did not find beneficial.

7) Please make any further comments in the space below.

Responses obtained from Grower Survey for PT97010 – Sustainable Potato Production in Highland Areas of NSW – Stage III

Grower No. and district	1 - Robertson	2 - Robertson	3 - Robertson	4 - Robertson	5 - Robertson
Question No.					
1) Have you adopted new crop management strategies/technologies since 1997? Y / N	Yes	No	Yes	Yes	Yes
2) If YES what are they?	I am using cover crops to gain better soil structure and to benefit from any biofumigation effects. I am also conducting more insect monitoring than in the past. More awareness regarding QA issues.		Change in the way the ground was prepared and the fertiliser strategies used.	To be more efficient and pre planning crop strategies.	The use of bio-technology.
3) If YES was this as a result of information obtained through the project?	Yes		?	Yes	Yes
4) By adopting new crop management strategies / technologies have you seen an:					
a- Increase in average yield? Y / N	Yes		Yes	Yes	Yes
b- Decrease in input costs? Y / N	No		No	Yes	
5) Did you find the project beneficial overall? Y / N	Yes	Yes	?	Yes	Yes
6) Please explain what areas you found / did not find beneficial.	The release of parasitic wasp. P management trial was still beneficial even though the results were inconclusive.		Not knowing fully what the project was about and missing a fair amount of the activities I feel that I only gained a minimal amount of information.	Group interest in the area for the area.	The use of the beneficial insects. Stuart Little's work was interesting even though no result was found.
7) Please make any further comments in the space below.	We really need to impliment a quality assurance program to be able to maintain out exisiting markets and sustainabiity.	I have only been involved with the project for 1 season because I have only recently started growing potatoes.	I feel that the overall objectives of the original ideas have not flowed through.		

Grower No. & district	6 & 7 - Robertson	8 - Robertson	9 - Dorrigo	10 - Dorrigo	11 – Dorrigo
Question No.					
1) Have you adopted new crop management strategies/technologies since 1997? Y / N	Yes	Yes	Yes	No	Yes
2) If YES what are they?	Use of cover crops.	IPM strategies, Irrigation, Cultivation	Used different Black Beetle control methods, Experimented with water, Changed fertility practices, altered ground preparation techniques.		Before 1997 I was very observant of what insect pests we had in a crop before we sprayed & now I am even more observant than ever, ie less chemicals used.
3) If YES was this as a result of information obtained through the project?	Yes	Yes	Yes and No	No	No
4) By adopting new crop management strategies / technologies have you seen an:					
a- Increase in average yield? Y / N	No	Yes	Yes	Yes	No
b- Decrease in input costs? Y / N	No	Yes	No	No	Yes
5) Did you find the project beneficial overall? Y / N	Yes	Yes	Yes	No	
6) Please explain what areas you found / did not find beneficial.	Benefits: phosphorus cover crops, field days and new varieties, parasitic wasp.	All areas, the project helped break down barriers between growers and made information help and advice flow freely.	Beneficial areas – QA talks, info seminar, Black beetle and White fringed weevil controls. Non-beneficial - tensiometers	All information presented I was already doing, except the tensiometers but they haven't made a difference to my irrigation programme	Field walks with Robert & Len Tesoriero – information and help when we suspected we had a seed problem in autumn 1998. Information – QA, Eric Colman, Information on tmsiometers.
7) Please make any further comments in the space below.		Thank you Sandra for your time and effort, I wish I had more time available to participate in the project as in my opinion it was very worthwhile.			I need to have assistance when we have a particular problem that we can not solve.

Grower No. & district	12 - Guyra	13 - Guyra	14 – Guyra
Question No.			
1) Have you adopted new crop management strategies/technologies since 1997? Y / N	Yes	No	Yes
2) If YES what are they?	Used round up as pre ground work up.		Improved irrigation techniques. Improved fertiliser practices
3) If YES was this as a result of information obtained through the project?	No	No	Yes
4) By adopting new crop management strategies / technologies have you seen an:			
a- Increase in average yield? Y / N	No	No	Yes
b- Decrease in input costs? Y / N	No	No	No
5) Did you find the project beneficial overall? Y / N	No	Yes	Yes
6) Please explain what areas you found / did not find beneficial.		Found the field day at Bruce Moffats beneficial also QA in Marketing	White fringed weevil is still a major problem.
7) Please make any further comments in the space below.	In the 1999 we averaged $14 a bag delivered Guyra and this is regarded as one of our better years.	Our main concern was White Fringed Weevil which we haven't had much success. John Holmes accident didn't help.	

APPENDICES

DISCUSSION NIGHTS / FIELD DAYS / SEMINARS

District	Date	Topic / Speaker	Venue
Robertson	2nd Oct 1997	Quality Assurance – Eric Colman	Burrawang Hotel
	17th Nov 1997	NSW Water Reforms – Guy van Owen	Burrawang Hotel
	20th Nov 1997	Irrigation System Testing – Mike Robbins	Jon Hill's property
	22nd Dec 1997	Release of parasitic wasp – Robert Spooner-Hart & Len Tesoriero	Tony Strode's property
	26th March 1998	Phosphorus management – Stuart Little Inovative Transport & disease control in potatoes – Stephen Morris	Burrawang Hotel
	28th May 1998	Inspection of field trial into cover crops for P management – Stuart Little	Trevor & Barry Donovan's property
	18th June 1998	QA in Fresh Market Potatoes – Eric Coleman	Robertson Bowling Club
	26th March 1999	Field Day and Seminar	Hill's property Belmore Falls Rd & Burrawang Hotel
	24th June 1999	Water Wise Program – Mike Robbins, John Okella-Okanya	Burrawang Hotel

Dorrigo	10th Oct 1997	IPM – Robert Spooner-Hart Installation & use of Tensiometers – Mike Robbins	Ken Tyson's property
	11th Feb 1998	Information evening – speakers included : Stuart Little (ANU), Robert Spooner-Hart, Len Tesoriero, Mike Robbins, Eric Colman	CWA rooms
	15th July 1998	QA in Fresh Market Potatoes – Eric Colman	Community Centre
	1st Oct 1998	White Fringed Weevil – Robert Spooner-Hart, Len Tesoriero	Meet Doust & son
	28th Jan 1999	White Fringed Weevil & African Black Beetle – Robert Spooner-Hart, Len Tesoriero	Summerhayes property 9 Greg Billings crop)
Guyra	10th Oct 1997	IPM – Robert Spooner-Hart	Guyra Shire Offices
	12th Feb 1998	Field walk & discussion evening speakers included : Stuart Little (ANU), Robert Spooner-Hart, Len Tesoriero, Mike Robbins, Eric Colman	Bruce Moffatt's property
	16th July 1998	QA in Fresh Market Potatoes	Guyra Bowling club
	30th Sept 1998	White Fringed Weevil – Robert Spooner-Hart, Len Tesoriero	Guyra Bowling Club.

PUBLICATIONS

Date	Publication	Story title	Author
September 1999	Potato Australia, Vol. 10	Cover crop / green manure contributions to soil fertility.	Stuart Little Australian National University.
December 1998	Eyes on Potatoes, Vol. 5	Out and About	
March 1998	Eyes on Potatoes, Vol. 3	A Farmers Experience with Soil Moisture Monitoring	Trevor Donovan, Potato Grower. Robertson
December 1997	Eyes on Potatoes, Vol. 3	Robertson Group	
September 1997	Potato Australia, Vol. 8	Robertson Yields Up 18%.	Sandra Lanz, LANZ Agricultural Consulting.
September 1998	Potato Australia, Vol. 9	Can your soil become a fertiliser?	Sandra Lanz, LANZ Agricultural Consulting, Stuart Little, Australian National University.
April 1999	The Market Link, No. 197	Potatoes for specific purposes at Robertson.	
January 20th, 1999	Southern Highland News	Wasp to battle spud moth – less pesticides in local potatoes.	
November 1998	Water Wise on the Farm, Update No. 1	Simple monitoring gives excellent results.	
October 1998	Town & Country Magazine, Vol. 14, No. 15	Unlocking soil goldmine.	Julian Lee. ANU reporter.
October 1998	WA Ag Memo	Mulch crops to release phosphorus.	Ben Rose
March 12th, 1998	The Guyra Argus	Guyra Potato Growers Join Forces	
March 4th, 1998	Southern Highland News	Organically tapping into soil phosphorus – an honours student's works starts at Robbo – Well red soil.	Catherine Kyngdon