RURAL INDUSTRIES RESEARCH
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Evaluating and managing lucerne seed wasp in lucerne seed crops

A report for the Rural Industries Research and Development Corporation

by James De Barro

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Living with the enemy: managing lucerne seed wasp in lucerne seed crops
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Foreword

The lucerne seed wasp has influenced the Australian lucerne seed industry for several decades but no quantified understanding of its impact has been determined. The industry lacks a management plan, which has resulted in indiscriminate use of insecticides that have not controlled the pest. There has been a failure to understand the wasp's biology in the context of seed production.

The research aims to quantify peak presence of the wasp in lucerne seed crops and its cost to lucerne seed producers and the industry. It will determine the influence of sanitation and closing date of lucerne seed crops on wasp population development. The research will provide the information for the development of a management plan.

This publication evaluates the impact lucerne seed wasp has on the lucerne seed industry by quantifying the damage to seed production by this insect and focuses on the pest's management. A seed wasp management plan has been produced in the form of a booklet available from RIRDC and allied seed industry organisations.

This project was funded from industry revenue which is matched by funds provided by the Federal Government.

This report, a new addition to RIRDC's diverse range of over 700 research publications, forms part of our Pasture Seeds R&D program, which aims to facilitate the growth of a profitable and sustainable pasture seeds industry based on a reputation for the reliable supply, domestically and internationally, of a range of pasture species.

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Peter Core
Managing Director
Rural Industries Research and Development Corporation

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About the author

James De Barro is an entomologist who owns and manages the private businesses De Barro Agricultural Consulting and Australian Bee and Pollination Services. James holds an honours degree in Agricultural Science and a Graduate Diploma of Business and was awarded a Churchill Fellowship in 2000. James resides in Keith in South Australia and specialises in consulting to lucerne seed producers and industry regarding all facets of seed production in dryland and irrigated systems. James is responsible for the ongoing research focus of the business that finances several projects.

He who has a thousand friends has not a friend to spare,
And he who has one enemy will meet him everywhere.

Ali ibn-Abi-Talib c. 602-661: *A Hundred Sayings*

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Executive Summary

Horace writes in the Epistles: “you may drive out nature with a pitchfork, yet she’ll be constantly running back”. The essence of this quote is the key result of this research project. Management of lucerne seed wasp necessitates conceding that this pest can not be eradicated from the Australian lucerne seed production industry. Industry must learn to live with its presence and accept that a degree of damage is a normal aspect of lucerne seed production and that techniques such as sanitation and crop closure timing reduce the pest’s impact.

The research quantifies the economic impact of the wasp as well as providing evidence that sanitation practices and manipulation of crop closure timing reduce the impact of lucerne seed wasps on seed production. Financial losses attributable to seed wasps have been blindly accepted by industry over many years due to a combination of a lack of understanding of the damage caused by this small pest and, more particularly, a belief that spraying regimes have provided adequate control whereas they acted more as a placebo than anything else.

Chemical control of seed wasp is not a viable or sensible option and does not form part of its management strategy. The wasp is exposed for 6 months of the year, through the dryland and irrigated seed production season, to insecticides used in commercial seed production to manage other pests. Seed wasp resistance to insecticides including malathion, chlorpyrifos, a range of sythetic pyrethroids and endosulfan is commonly reported in the seed producing areas of South Australia and New South Wales. A similar scenario exists in lucerne seed producing areas of North America, where district wide sanitation practices are encouraged.

Producers of irrigated lucerne seed in the south east of South Australia experience financial losses of A$2.0 million per season and the Australian lucerne seed export industry loses A$5.18 million in potential exports. The quantified understanding of damage to seed production by this pest enables the Australian lucerne seed industry to determine whether a concerted effort to manage this pest and reduce its impact on seed production will be developed. The economic impact of this pest should direct the industry to promote the recommendations of this research.

Seed wasp population development is correlated closely with the presence of available host as wasps develop peak populations in response to quantity of available host at the susceptible stage. Whilst seed wasp presence has not been eradicated, sanitation practices such as mowing, grazing and herbicide spraying significantly reduce wasp presence in the seed crops by delaying population development. Australian lucerne seed producers can individually and in co-operation with adjacent landowners implement simple sanitation practices on a wide scale level to reduce seed wasp populations and hence the damage to seed crops. In combination with alterations in crop closure timing, both sanitation and closing date operate synergistically to diminish seed wasp populations.

The Australian lucerne seed production industry should encourage allies in the industry to assist in the management of seed wasp. Feral lucerne on roadsides and in wastelands such as vacant land blocks or council areas could be strategically managed to reduce wasp population development. Offal dumping in refuse tips should be monitored and managed by council or private owners. Graziers with lucerne for purposes other than seed production should be encouraged to reduce the incidence of lucerne setting seed in pastures in the context of stock management as well as community benefits.

The majority of irrigated seed producers prepare lucerne for seed production in December to have crops flowering in January/February when the warm/hot weather is optimal for pollination. However this management strategy causes maximum wasp damage as the wasps have developed populations in earlier flowering lucerne since hatching in October. Seed wasp population development is correlated closely with the presence of susceptible available host. The wasp develops its population peak in response to quantity of available host at the susceptible stage rather than any environmental condition such as day length or temperature. A key to reducing damage is to have the crop completed flowering before the wasp population reaches its peak in earlier flowering hosts.

Producers need to assess their management concepts, a practice that has slowly commenced in the late 1990's but chiefly driven by the crops irrigation demands and irrigation restrictions. Closing a crop 2 –4 weeks earlier than normal permits harvest at 100% ripeness as opposed to 80-90% ripeness later in the season prior to autumnal rainfall. Seed wasp damage is reduced by earlier crop closure. Grazing management and weed control strategies are assisted by earlier closure with least impact on lucerne plant health. Aspects such as these need to be addressed by seed producers to compare the economics of management decisions that influence the susceptibility of seed crops to seed wasp damage in conjunction with yield returns.

The discovery of two species of wasps parasitic on the seed wasp requires further research, as both are potential biological control agents. Little is known about the biology of these wasp parasites but industry would need to determine if they considered that the economic impact of the seed wasp warranted further research.

There is not a lot of scope to the management of the lucerne seed wasp. Sanitation and crop closing date are the two fundamental parameters. Potentially the biological control option could be applied if industry funding is made available to commence the required preliminary research. The wasp is a highly evolved parasite with a life history that allows seed producers only the ability to manipulate the size of its population development. Unlike other pests of lucerne such as *Helicoverpa puntiger*, the wasp does not develop populations in defined intervals such as every 3-4 weeks. The wasp has continuing, overlapping generations, which means that all stages of the life cycle are present at any one time, and a spray to kill the adult will have no effect on the pupae which will imminently hatch after the spray has been applied. Hence manipulation of this pest's host is currently the primary way to manage its impact on seed production.

1. Introduction

1.1 Lucerne seed industry

The Australian lucerne seed industry produces in excess of 5,000 tonnes of seed per financial year of which over 90% is produced in South Australia. More particularly 85% of Australia's total lucerne seed production is produced in the Project's research region, Keith, South Australia, encompassing almost 11,000 ha of both irrigated and dryland area. The export value of lucerne seed exceeds $A 13.5 million a value which is double that of 3 years ago and is predicted to increase further. As a result of the increasing value of lucerne seed to the Australian pasture seed industry it is a commodity which requires research designed to improve both yields, grower returns and, being an intensive high input crop, sustainable practices which are acceptable with the environmental issues impacting on primary production in today's world.

1.2 Lucerne seed wasp - a key pest

Lucerne seed wasp (*Bruchophagus roddi*) is a phytophagous eurytomid wasp which requires the presence of lucerne seed (and to a lesser extent annual medic and clover seed) to permit it to complete its life cycle. It is this reliance on lucerne seed and in particular young, developing lucerne seed that makes the wasp a key pest of lucerne seed production. Consultants and producers associated with the lucerne seed industry in the Keith region of South Australia have noted a substantial increase in seed wasp presence and subsequent number of insecticide applications over the 1980's and 90's. The wasp is rated as equal to *Helicoverpa punctiger* as the number one pest of lucerne seed production in New South Wales and is regarded in Victoria and South Australia as a pest that is rivaling *H. punctiger* as the major pest concern (Flavell G. pers comm 1998).

The seed wasp is attracted to flowering lucerne and oviposits into immature seed in young developing pods. Pods are susceptible when flat and lengthening to one quarter swollen and fully lengthened and curled. Once the seed is starting to swell it is not susceptible to oviposition by the wasp. The wasp requires a flat soft pod through which to oviposit. The wasp larva requires the duration of the seed filling period to develop into a pre-pupa and pupa by feeding on the seed endosperm. Once the seed ripens the pupae hatches and the wasp chews out of the seed and pod. The wasp will stay in a prepupal stage in the ripened seed if it is late in the season and is induced into its winter diapause.

The wasp does not develop populations in defined intervals such as every 3-4 weeks, which are heralded by large wasp invasions. Seed wasp has continuing, overlapping generations, which means that all stages of the life cycle are present at any one time, in any one area in any one paddock. A spray to kill the adult will have no effect on pupae that will hatch imminently after the spray has been applied and almost immediately mate and continue the life cycle.

It is known that the wasp is more active in February than earlier in the seed crop season and that the presence of volunteer lucerne in the area surrounding the seed crop can augment the seed wasp problem however no detailed research to quantify the wasps peak periods and development of a plan to manage the wasp on a district scale (which is predicted to be the sustainable plan for control) has ever been addressed and it is this issue the project aims to undertake.

1.3 Impact on the industry

The rapid increase in the area of dryland lucerne seed production in the Keith district is providing an increasing area for the wasp to develop populations capable of infesting irrigated crops in the March period. This increase in pest presence is necessitating increased spraying and as the wasp is capable of multiple overlapping generations, the use of insecticides as the sole means of control is not sustainable. As a result there is a real threat to lucerne seed yields and returns to growers, exports and international market share.

The economic loss caused by the seed wasp has as yet been unquantified in the Australian lucerne seed industry. Based on the current knowledge about the wasp it is predicted that the wasp causes in excess of $1A million worth of seed loss across the Australian lucerne seed producing area. If the current

economic injury level threshold is lowered to attempt to reduce the seed wasp induced seed losses this would result in increased frequency of insecticide usage which in itself would potentially induce new and more costly pest related problems. The need for increased insecticide use is at odds with the current trend for more environmentally sensitive pest control solutions. Extended use of insecticides beyond the main control period of the key pests, *Helicoverpa punctigera* (native budworm) and *Creontiades dilutus* (green mirid) creates undue pressure on important beneficial arthropods. This may impact the next season's crop by reducing beneficial arthropod presence as well as imposing a severe selection pressure on the wasp itself. The increased level of insecticide usage is also an added risk to growers, spray contracting personnel and the community in general. Adoption of an alternative program to manage lucerne seed wasp could reduce insecticide applications required for seed production whilst maintaining yield and quality. Concurrently, these sound integrated strategies would increase returns and address the serious environmental issue of reducing chemical use.

2. Objectives

2.1 Research aims

The research aims to quantify the peak presence of lucerne seed wasp in lucerne seed crops and its cost to lucerne seed growers and the industry and determine the influence of sanitation and closing date of lucerne seed crops on wasp population development. A management plan for lucerne seed wasp will be produced for lucerne seed growers and industry related personnel.

By quantifying the damage caused by the lucerne seed wasp, calculating the losses to lucerne seed producers and studying the population development o the wasp, the industry can make educated decisions on the importance of the pest and the value of future management practices.

The research will document the wasp's life history in commercial lucerne production and encourage producers to reduce the use of insecticide and increase cultural control practices. A decline in spray use by 20% of the average number of insecticide applications currently used by many producers could be equivalent to an annual reduction of at least $A100, 000 in insecticide usage. The lucerne seed growers as well as allied industries such as lucerne management consultants will have less exposure to insecticide as would spray contracting personnel and the community in general.

The ultimate aim of the research is to amalgamate all the research findings and information from commercial production fields to create a management plan specifically designed for an integrated approach to controlling seed wasp. This management plan could be used as a model for other agricultural industries that, at present, rely heavily on insecticide use to manage pests. The plan will provide an example of an industry acting in a proactive manner to control pests in a sustainable and environmentally tolerated manner without organisations outside the industry itself forcing changes to management that may not be in the industry's best interests. The project will foster an understanding of the wasp, determine the best course of management and in turn improve the sustainability of lucerne seed production via an environmentally acceptable management program.

3. Methodology

3.1 Determination of peak presence

Determination of the peak presence of the wasp was determined as a date/period where the wasp population is at its greatest. Peak presence, influence of sanitation and closing date on wasp population development was achieved by sampling many lucerne seed crops (irrigated and dryland) in the Keith and Bordertown district on a regular basis throughout the seed production period.

Sampling was done with a standard sweep net (38.0 cm hoop on a 119 cm handle) and was completely randomised. Seed wasp count was calculated as the average number/samples taken/paddock. Average wasp numbers and the dates collected were recorded over three seasons. Data collected from regular crop sampling in the course of commercial monitoring of crops prior to the commencement of the research project was used in conjunction with the collected research data. This data was used to fine tune the peak date of seed wasp presence as well as the time of their initial arrival into lucerne crops and the growth stage of the paddocks sampled at these times. This information provided seed wasp population development over concurrent seasons.

3.2 Determination of economic losses

To quantify the economic losses associated with seed wasp a replicated small plot field trial was designed. Located 4 km west of the centre of Keith the field trial was established in a two year old stand of flood irrigated Pioneer L90 lucerne.

The trial comprised of 24 plots (10 x3 m) arranged in 4 rows of 6 plots. The trial site was configured at the commencement of each of the three seasons over which the research project was conducted. All

plots were treated the same as the entire commercial field in respect to all management practices such as irrigation, fertilising, pest and weed management and desiccation. The plots were individually harvested with a small plot harvester. The seed off each plot was bagged and labeled. The offal extruded out of the back of the harvester for each plot was collected in a wool pack that was attached to the rear of the harvester.

Individual plot seed samples were sieved through a 3mm punch hole sieve to remove pods and stalks. The refined samples were weighed and a sub sample taken. The sub samples were screened to count the seed wasp affected seeds.

Offal samples from individual plots were initially treated by removing stalks and pods. The sample was sieved through a 3mm punch hole sieve to remove pods and small stalks. The refined samples were weighed and a sub sample taken. The sub samples were screened to count the seed wasp affected seeds.

These procedures were undertaken for three seasons to quantify damage specifically attributed to seed wasp.

3.3 Determination of sanitation influence

A large field trial was established for the three seasons of research in the Laffer area west of Keith. The site was a single property covering 18 square kilometres comprising 3495 ha. 44% was lucerne pasture and the balance was puccinella, scrub and swamps. This property produces dryland lucerne seed from 230 ha and has a history of seed wasp presence. Apart from the seed crops the pasture lucerne, lucerne on raceway verges, around sheds and fence lines was grazed, mown or sprayed to prevent any seed set. The seed wasp presence was monitored with randomised sweep net sampling in the course of regular field inspections and compared to past seasons.

Assessment of the population distribution pattern of the seed wasp over seasons 97/98, 98/99, 99/00, and 00/01 was conducted by plotting the presence of seed wasp on a district map.

3.4 Determination of closing date influence

A second field trial involved four adjacent landowners all producing lucerne seed off a percentage of their land. The majority was dryland seed production with some irrigated production. The trial area covered 16 square kilometres with over 750 ha of seed production. Date of crop closure, flowering, harvest and initial seed wasp presence and population development of seed wasp was recorded. Influence of date of crop closure on wasp development was determined over the three seasons.

3.5 Assessment for parasites or predators of seed wasp

One kilogram random samples of offal were collected from seed cleaners in 1999 and 2000 for the purposes of offal rearing seed wasps and any possible seed wasp parasites. The offal is the waste component of the seed cleaning process and contains weed seeds, dead seeds and seed wasp infected seed. The origin of the samples was recorded. Individual samples were placed in sealed cardboard boxes and three holes were punched into the top of the box. 12mm glass vials were inserted open end into the holes in the box with the majority of the vial exposed to the outside. Boxes were monitored through winter, spring and summer and any wasps hatching from the offal would be attracted to the light and be seen in the vial. The wasps were collected and preserved in ethyl alcohol in labeled specimen tubes. Collected wasps were sent to CSIRO Entomology in Canberra for sexing and identification.

4. Results

4.1 Determination of peak presence

Seed wasp population development was recorded and assessed for the 1997/98, 1998/99, 1999/00 and 2000/2001 seed production seasons. The collected data reflected previous season's understanding about seed wasp population dynamics from which the need for this research developed.

Seed wasp is consistent in the date in which it invades lucerne seed crops. From the offal rearing experiment and field sampling the wasps hatch in the final week of October each season which is the time of the first lucerne bloom. Their diapause is broken over an extended period with wasps hatching until late December.

Table 1: Seed wasp population development indicators over four consecutive seasons

Season	1997-98	1998-99	1999-2000	2000-01
Range of dates seed wasp first sampled per paddock assessed	13/11/97 – 20/2/98	16/11/98 – 27/2/99	2/11/99 – 19/2/00	21/11/00 – 26/2/01
Peak period of first seed wasp sampling/paddock	5/1/98 – 17/2/98	10/1/99 – 11/2/99	2/1/00 – 6/2/00	9/1/01 – 13/2/01
Peak population period/paddock sampled	3/2/98 – 12/3/98	7/2/99 – 25/2/99	2/2/00 – 17/2/00	9/2/01 – 19/2/01

From season 1997-98 to 2000-01 the arrival of seed wasp to a lucerne seed crop occurred at similar times over a similar time period (Table 1). This presence coincides with the seed crop being in full flower with pod development in progress. Due to staggered crop closure and indeterminant crop growth the time of initial seed wasp presence in a crop varies.

Lucerne seed wasps flights increased in early January and continued at peak levels for 5-6 weeks (Table 1). This is due to the development of wasp populations in dryland lucerne seed crops that are ripening from mid January to later February when they are harvested. The wasps leave the maturing dryland lucerne and relocate in flowering irrigated lucerne which is beginning to set pods and provides a source of food and oviposition sites.

Within individual lucerne seed crops the peak seed wasp population period is in the month of February (Table 1). 1997-98 was a season of unusually high seed wasp presence and their populations peaked for a fortnight longer as the lucerne flowering period was longer than average. Seasons 98/99, 99/00, and 00/01 represent typical seasonal population development (Table 1). These population peaks represent the periods in which lucerne seed crops are 50% post flowering with 25% of seeds filled and early set pods beginning the ripening process. Wasps are hatching from infected ripened seed as well as new wasps arriving from earlier crops in search of forage and oviposition sites. The population tapers off as available host disappears and wasp larvae enter diapause in the pre-pupal stage.

Seed wasp population development is correlated closely with the presence of susceptible available host. The wasp develops its population peak in response to quantity of available host at the susceptible stage rather than any environmental condition such as day length or temperature.

4.2 Determination of economic losses

Over the three seasons the average seed loss directly caused by the seed wasp was 67.39 kg/ha (Table 2). This loss is a combination of seed wasp affected seed detected in harvested seed samples, and seed husks and seed wasp infected seed isolated from harvest offal (Table 2). The relative yield loss is defined as the total seed loss as a percentage of the total clean seed produced per hectare (Table 2).

Table 2: Seed wasp associated seed losses for three consecutive seasons including averages.

Season	Seed Assessment Losses (kg/ha)	Offal Assessment Losses (kg/ha)	Total Seed Loss (kg/ha)	Relative Yield Losses
1998/1999	61.65	29.69	91.34	22.5 %
1999/2000	35.06	21.26	56.32	20.37 %
2000/2001	28.79	25.71	54.50	59.0%
Seasonal Averages	**41.83**	**25.55**	**67.39**	**34.0%**

Seed wasp population development recorded in the trial site in the course of commercial pest management sampling was consistent across the three seasons. It was apparent that from 1998/99 when the crop was in its second year of production to 2000/01 that lucerne plant population and plant vigor diminished noticeably by 2000/01. This had an impact on seed production with clean seed production falling from 405 kg/ha in 1998/99 to 90 kg/ha in 2000/01. Consequently the relative yield loss increased significantly in season 2000/01 (Table 2). The total seed loss for seasons 1999/00 and 2000/01 is indicative of the annual seed yield loss that is expected for irrigated lucerne where seed wasp is sampled in areas with nearby dryland lucerne seed production or significant seed producing feral/pasture lucerne (Table 2). As yield increases the total seed loss increases but the relative yield loss remains about 20%, which is evident when comparing seasons 1998/99 and 1999/00 (Table 2).

The average total seed loss of 67.39 kg/ha at a value of A$3.00/kg to the producer equates to a financial loss of A$202.16/ha. With approximately 9700 ha of irrigated seed production in the south east of South Australia which is susceptible to infestation by the seed wasp creates losses to producers in the area in the vicinity of A$2.0 million per season.

In 1999/00 a total of 4993 tonne of the lucerne seed at a value of A$3.63/kg was exported, equating to a value in excess of A$18.2 million. 4200 tonne is estimated to be the proportion produced from irrigated seed production in the period of peak wasp population development and hence susceptible to infestation by the seed wasp. With 34.0% relative seed yield losses a total of 1428 tonne or A$5.18 million of export loss is attributable to the lucerne seed wasp.

4.3 Determination of sanitation influence

Assessment of seed wasp population distribution over seasons 97/98, 98/99, 99/00, and 00/01 indicates irrigated crop infestation is associated with locality to dryland seed producing areas. Crops within a 5 km radius of dryland seed crops or significant volunteer lucerne (pasture or wasteland) which produced seed are infested unless they matured at or shortly after the maturity date of the dryland crop. Areas outside the 5 km radius are not significantly affected regardless of the crops maturity date - especially if the crops in this region matured at a similar time. Irrigated lucerne seed crops within a 5 km radius that matured at a similar time to dryland seed crops were not as infested as crops in the same area radius maturing later on.

Based on observations over the past 12 seasons the presence of significant early maturing lucerne (either dryland seed crops or pasture/wasteland lucerne) is highly correlated with the wasp population being large enough to cause significant damage to seed production.

The large field trial located in Laffer west of Keith commenced in 1998/99 and operating continuously for the three seasons of research project was managed in conjunction with the property owner. Historically seed wasp had infested the dryland seed crops due to population development in the vast acreage of ungrazed volunteer lucerne in paddocks and laneways where it was permitted to flower and seed 4-7 weeks prior to the seed crops commencing flowering.

Property management practices were modified in 1998/99 to prevent pasture lucerne, lucerne in laneways, around sheds and fence lines from producing ripe seed. Management included grazing,

mowing and spraying. Lucerne was rarely permitted to flower for extended periods except in the seed crops that flowered in December and early January of each season. Seed wasp presence was monitored with randomised sweep net sampling in the course of weekly field inspections.

For the three seasons of seed production no seed wasp was detected in the seed crops from which it can be deduced that simple and well timed sanitation practices significantly reduce seed wasp presence to negligible population development.

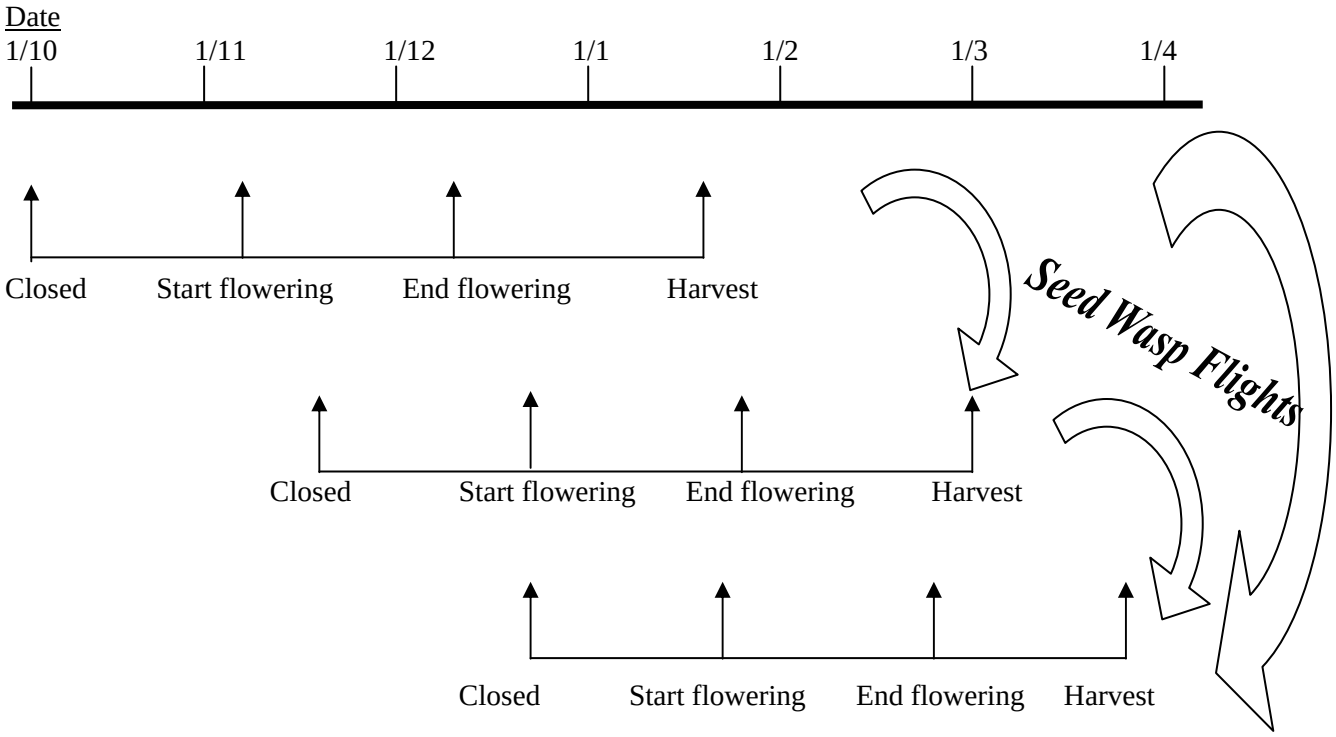
Since 1998/99 this type of trial has been duplicated on other seed producing properties involving dryland and irrigated seed production in the course of commercial management. Such properties have had a history of significant seed wasp infestations. Whilst seed wasp presence has not been eradicated, timely sanitation practices such as mowing, grazing and spraying have significantly reduced the wasp's presence in the seed crops. Coupled with alterations in closing date of the seed crop, further impacts on seed wasp presence were achieved.

4.4 Determination of closing date influence

The field trial involving four adjacent landowners all producing lucerne seed off a percentage of their land commenced in 1998/99 and operated continuously for the three seasons of research project.

Dryland crops closed for seed production no later than October 31 have a low seed wasp presence, (classified as 'background' population level), at the crop's susceptible stage. This is due to minimal lucerne in either a crop or pasture situation being advanced enough to develop a wasp population prior to the seed crops closed in October reaching the susceptible stage. Seed wasp presence increases in crops closed 5 or more weeks after an initial and nearby crop has been closed. For example if seed crops are closed on October 1, crops closed on November 15 and December 15, and within 5 km, will have higher seed wasp infestation (Flow Chart 1). Wasp presence is highest at the susceptible stage of early flowering to flower completion and when pods are recently set and just beginning to fill. A crop closed within 5 weeks of the earliest closed seed crop within 5 km will not develop a seed wasp population capable of significant damage as the later crop will be too advanced (i.e. minimal oviposition sites) for invading wasps to remain. An increasing wasp population leave the ripening early closed crop (some hatching from ripened infected seed from that crop) to infect the dryland or irrigated crop closed on November 15 which is well into flowering and setting pods (Flow Chart 1). They also migrate to the crop closed on December 15 that is beginning to flower, especially at the time of harvest (Flow Chart 1). Once the crop closed on November 15 completes flowering and begins to ripen the wasp population, which is now at peak levels, migrates to the crop closed on December 15 – the irrigated seed crop (Flow Chart 1). This crop sustains maximum damage.

Flow Chart 1: Growth stages of lucerne seed crops closed on three different dates – October 1, November 15 and December 20 and movement of seed wasp.



It is evident from this field trial and other examples from commercial experience that an earlier closing date for seed production reduces the severity of seed wasp presence and damage. This is particularly the case where dryland and irrigated seed production co-exist within a 5 km radius.

4.5 Assessment for parasites or predators of seed wasp

An average of 8 wasps per kilogram of offal was reared in 1999 and 2000. 99% of offal created in seed cleaning plants between March and August is currently transported out of the district for stock feed purposes. The remaining 1% is dumped at local refuse dumps in Bordertown and Keith. An estimated 700 – 1100 tonnes of offal are produced per annum resulting in approximately 10 tonne being dumped within the district. This localised dumping creates a potential hatching site for up to 80,000 seed wasps, although thousands would be buried too deep to hatch. However this practice of offal dumping enhances the survivorship and genetic spread of the wasp.

Two species of parasitic wasps were collected from the reared wasps. *Idiomacromerus perplexus* and *Pteromalus sequester* hatched in late November at a ratio of 2:1 females to males. These wasps were collected from offal from across the district providing evidence that they are widespread but in low populations. They have also been detected in Forbes and Deniliquin in New South Wales.

Very little is known about the biology of these wasp parasites but they are worthy of investigation as a biological control option.

5. Implications

The research provides a quantified economic impact assessment of the wasp as well as quantifying evidence that sanitation practices and manipulation of crop closure timing reduce the potential impact of lucerne seed wasps on seed production.

Financial losses of over A$200.00/ha to the majority of seed producers, especially irrigated seed producers, represents over A$2.0 million per season of lost capital to the major areas of seed production in Australia. These financial losses have been accepted by industry over many years due to a lack of understanding of the damage caused by this small pest.

A$5.18 million worth of export quality seed was destroyed by the lucerne seed wasp in 1999/00 and is predicted again for season 2000/01. With this information the Australian lucerne seed industry can determine whether a concerted effort is required to manage this pest and reduce its impact on seed production. Given the value of the losses, the industry would be advised to promote the recommendations of this research.

Seed wasp population development is correlated closely with the presence of susceptible available host as wasps develop peak populations in response to quantity of available host at the susceptible stage. Sanitation practices such as mowing, grazing and herbicide spraying significantly reduce the wasp's presence in the seed crops by delaying population development. Australian lucerne seed producers can individually and in co-operation with adjacent landowners/seed producers implement simple sanitation practices on a wide scale level to reduce seed wasp populations and the damage to seed crops. In combination with alterations in crop closure timing, both sanitation and closing date operate synergistically to diminish seed wasp populations.

Chemical control of this pest is not a viable or sensible option and does not form part of any management strategy of the wasp. The wasp is exposed to insecticides used in commercial seed production to manage other pests for 6 months of the year through the dryland and irrigated seed production season. Seed wasp resistance to insecticides including malathion, chlorpyrifos, a range of sythetic pyrethroids and endosulfan is commonly reported in the seed producing areas of South Australia and New South Wales. A similar scenario exists in lucerne seed producing areas of North America, where district wide sanitation practices are encouraged.

Many seed producers traditionally close lucerne for seed production in December to have crops flowering in January/February when the warm/hot weather is optimal for pollination. However this management strategy causes maximum wasp damage. Producers need to assess their management concepts. By closing a crop 2 –4 weeks earlier than normal permits harvest at 100% ripeness as opposed to 80-90% ripeness later in the season prior to autumnal rainfall. Seed wasp damage is reduced by earlier crop closure. Grazing management and weed control strategies are assisted by earlier closure with least impact on lucerne plant health. Aspects such as these need to be addressed by seed producers to compare the economics of management decisions that influence the susceptibility of seed crops to seed wasp damage in conjunction with net returns.

Australian industry should encourage allies to assist in managing the seed wasp. Feral lucerne on roadsides and in wastelands such as vacant land blocks or council areas can be strategically managed to reduce wasp population development. Offal dumping in refuse tips should be monitored and managed by council or private owners. Graziers with lucerne for purposes other than seed production should be encouraged to reduce the incidence of lucerne setting seed in pastures in the context of stock management as well as community benefits.

The two species of parasitic wasps are worth investigating as potential biological control agents. Preliminary research could assess the feasibility and practicality of this option. Industry would need to determine if they considered that the economic impact of the seed wasp warranted further research.

A key concept in the management of the lucerne seed wasp is to concede that this pest can not be eradicated due to the scale of lucerne production (seed and pasture crops) in Australia. Industry must learn to live with its presence and accept that a degree of damage is a normal aspect of lucerne seed production and that techniques such as sanitation and crop closure timing reduce the pest's impact.

6. Recommendations

On the basis of the research results the following recommendations are made to the Australian Lucerne Seed Industry:

1) Proceed with the production of a seed wasp management booklet as per the research's original plan.

2) Release and disseminate the booklet to lucerne seed producers across Australia. Educate producers on the impact of seed wasps on seed production and the implementation of wasp management strategies.

3) Utilise private seed production consultants, commercial agronomists, state government primary industry staff, seed cleaners, seed marketers and local government to be involved at various levels in the extension of the research results and the management booklet.

4) Promote no insecticide spraying for management of the seed wasp.

5) Investigate the two parasitic wasp species detected in the research as potential biological control agents. Develop an initial research program combining industry focus and guidelines with government available technology, equipment and staff.

6) Accept a degree of economic seed loss as part of annual seed production.

7. References

Flavell G. (1998). Pioneer Seeds Production Agronomist. Bordertown, South Australia

8. Appendix

8.1: Living with the Enemy Brochure

In addition to this detailed report on the project a full colour pocket sized guide *Living with the Enemy - managing lucerne seed wasp in lucerne seed crops* was also produced.

This booklet has been distributed widely to the industry and is available free of charge from RIRDC. If you would like a copy of this brochure please phone RIRDC on 02 6272 4819 or view it on our website www.rirdc.gov.au

This appendix reproduces a black and white version of this booklet.

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Australian lucerne seed production

The Australian lucerne seed industry produces in excess of 5,000 tonnes of seed per year of which over 90% is produced in South Australia. In Australia 85% of total lucerne seed production is produced around Keith in South Australia, encompassing more than 11,000 ha of both irrigated and dryland area. The export value of lucerne seed exceeds $A13.5 million per annum, a value which is steadily rising in combination with growing production area. The increasing value of lucerne seed to the Australian pasture seed industry has made it a commodity requiring research and management practices to improve yields and grower returns. Being a high input crop it requires sustainable practices that are acceptable with the environmental issues impacting on primary production in today's world.

What is a lucerne seed wasp?

Lucerne seed wasp (*Bruchophagus roddi*) is a phytophagous eurytomid wasp. The adult wasp is the size of a lucerne seed and is a shiny, jet black colour. (Figures 1 and 2)

Figure 1: *Adult seed wasp, pupa and larva*

Figure 2: *Lucerne seed wasp and lucerne seed husk*

What isn't a lucerne seed wasp?

In a lucerne seed crop many small wasps and flies exist that can be confused with a lucerne seed wasp. Most small wasps are good predators of aphids and heliothis and have long tail like features (ovipositors) which the seed wasp does not have. Many small flies such as midges are common in lucerne, especially irrigated crops. These midges are the insect that is most often misidentified as seed wasps because they are the same size and shape. However, midges do not have a shiny jet black abdomen but have a dull, grey white one. The other feature that makes them distinct to the untrained eye is that the midge flies away quickly when captured whereas a seed wasp tends to curl up and "play dead". The midge also has a bad habit of flying around people and animals on warm, humid days with the intention of getting in people's ears, eyes and noses. The seed wasp keeps well away from people.

How can I catch a seed wasp?

The easiest method is to use a sweep net. Sweep the net through the lucerne, give the net a little shake to knock the contents to the bottom and look inside. Seed wasp will be present in the net if any are in the field.

How is seed wasp a problem?

Seed wasp is attracted to flowering lucerne and injects an egg (oviposits) into immature seed in young developing pods. Pods are susceptible when flat and lengthening to one quarter swollen and fully lengthened and curled. Once the seed is starting to swell it is not susceptible to oviposition by the wasp. The wasp requires a flat soft pod through which to oviposit. The wasp larva requires the duration of the seed filling period to develop into a pre-pupa and pupa by feeding on the seed contents (endosperm). Once the seed ripens the pupae hatches and the wasp chews out of the seed and pod (Figures 3,4 and 5). The wasp will stay in a pre-pupal stage in the ripened seed if it is late in the season and is induced into its winter diapause.

Figure 3: *Lucerne pods with exit holes*

Figure 4: *Destroyed lucerne seeds with wasp exit holes*

Figure 5: *Ripe lucerne pods with seed wasp exit holes*

Unlike *Heliothis*, the wasp does not develop populations in defined intervals such as every 3-4 weeks, which are heralded by large adult wasp invasions. Seed wasp has continuing, overlapping generations, which means that all stages of the life cycle are present at any one time, in any one area in any one paddock. A spray to kill the adult will have no effect on eggs, larvae or pupae. Pupae can hatch immediately after a spray has been applied and mate almost immediately to continue the life cycle either in the same crop or elsewhere. This is the fundamental reason why insecticide usage to control the lucerne seed wasp is a waste of time and money.

Every wasp egg injected into developing seed renders that seed dead. The wasp develops enormous populations and the additive effect of each wasp's egg laying is the cause of reduced seed yield.

The initial spring hatching of seed wasp occurs in late October resulting in significantly lower wasp population presence through November, December and early January. The dryland seed crops and the presence of feral and pasture lucerne in the area near the irrigated seed crop provides the host for population development. The wasp is most active in late January and February at the time when irrigated lucerne crops are in the most susceptible period of completing flowering and are filling seed.

How much loss does the wasp cause?

Research work indicates an average of total irrigated seed loss of 67.39 kg/ha. A value of A$3.00/kg to the producer equates to a financial loss of A$202.16/ha. With approximately 9700 ha of irrigated seed production in the south east of South Australia which is susceptible to infestation by the seed wasp, losses to producers in the area are in the vicinity of A$2.0 million per season. In 1999/00 a total of 4993 tonne of lucerne seed at a value of A$3.63/kg was exported, equating to a value in excess of A$18.2 million. From research A$5.18 million of potential seed exports are lost due to the lucerne seed wasp.

How does seed wasp exist in my area?

Whilst not a native Australian insect the seed wasp is endemic wherever lucerne is grown and permitted to produce seed. The wasp is an excellent parasite of lucerne and develops its populations in response to availability of host rather than any particular environmental cue such as temperature or daylength. However, the wasp will go into winter hibernation (diapause) in response to cues in autumn. In simple terms, the more lucerne in seed production - the more seed wasp present.

Irrigated seed crops within a 5 km radius of dryland seed crops (or significant pasture or wasteland seed producing lucerne) are infested unless they mature within four weeks of the maturity date of the dryland crop. Areas outside the 5 km radius are not significantly affected regardless of the crops maturity date - especially if the crops in this region matured at a similar time.

Can I eradicate seed wasp?

Research indicates that eradication of seed wasp is not possible. Insecticide is not a means of permanent control. The wasp will always be present where lucerne is grown and the key to management is to live with the presence of the pest but make changes to management to reduce its impact on seed yield.

How can I manage seed wasp?

Seed wasps develop populations where lucerne is flowering and setting seed. Sanitation practices such as mowing, grazing and herbicide spraying significantly reduce the wasp's presence in the seed crops by reducing the availability of lucerne outside the seed crop for population development. Australian lucerne seed producers can individually and in co-operation with adjacent landowners/seed producers implement simple sanitation practices on a wide scale level to reduce seed wasp populations and the damage to seed crops.

Research has shown that by reducing the presence of flowering lucerne around sheds, gardens and stock yards, fence lines, irrigation channels and check banks as well as in stock raceways, along

roadsides and in grazing pastures, seed wasp presence in seed crops is reduced (Figures 6 and 7). Best results are obtained by maintaining these sanitation efforts from the time lucerne first flowers in October through to when seed crops have finished flowering. In practice this may require a combination of grazing, spraying and mowing two or three times in a single season.

Figures 6 & 7: *Non-seed crop lucerne growing around sheds and next to irrigated seed crops*

ates a potential hatching site for up to 80,000 seed wasps per annum, which enhances wasp survivorship and spread of their gene pool.

Graziers with lucerne for purposes other than seed production should be encouraged to reduce the incidence of lucerne setting seed in pastures by suitable grazing strategies. This is an extension of the sanitation component of seed wasp management.

The involvement of non-seed producers in the management of the seed wasp appeals to the community involvement in assisting the local seed producing industry.

When can I start my management plan?

The implementation of the management plan can be immediate. Consultation with nearby seed producers, neighbours, local advisers and council will develop the basis for a simple and on going management practice.

Seed wasp management is a simple but timely process. A key to wasp management is removing unnecessary host which otherwise only serves to increase the wasp population.

The future

Research has discovered two species of wasps, *Idiomacromerus perplexus* and *Pteromalus sequester*, which are parasitic on lucerne seed wasps. Little knowledge of the biology of these wasps is known but they are worth investigating as potential biological control agents. Preliminary research could assess the feasibility and practicality of this option. Industry would need to determine if they considered that the economic impact of the seed wasp warranted further research.

Key concept

The key concept in the management of the lucerne seed wasp is to concede that this pest can not be eradicated due to the scale of lucerne production (seed and pasture crops) in Australia. Industry must learn to live with its presence and accept that a degree of damage is a normal aspect of lucerne seed production and that techniques such as sanitation and crop closure timing reduce the pest's impact.

Many seed producers close lucerne for seed production in December to have crops flowering in January and February when the warm/hot weather is optimal for pollination. However this management strategy permits maximum wasp damage. Producers need to assess their management concepts. By closing a crop 2 -4 weeks earlier than traditionally (e.g. November) permits harvest at 100% ripeness as opposed to 80-90% ripeness later in the season prior to autumnal rainfall. Seed wasp damage is reduced by earlier crop closure due to lower wasp populations being present at flowering and seed set.

The net return from a seed crop closed in the traditional December period where the combination of seed wasp damage and the crop not permitted to reach complete ripeness prior to desiccation is often the same or less than the net return from a similar standard seed crop closed earlier which reaches full ripeness and has less seed wasp damage.

In combination with alterations in crop closure timing, both sanitation and closing date operate synergistically to diminish seed wasp populations. With a sanitation and closing date management program in operation the population of seed wasp in the area will decline over a period of seasons. Seed producers need to assess the economics of management decisions that influence the susceptibility of seed crops to seed wasp damage in conjunction with net returns.

How can non-seed producers assist?

The Australian pasture seed industry should encourage non-seed producing allies to assist in management of the seed wasp. Feral lucerne on roadsides and in wastelands such as vacant land blocks or council areas can be strategically managed to contribute to the reduction of seed wasp population development. Timely mowing or spraying of roadside verges along the main truck routes to seed processing plants as well as truck stops, gravel pits and other council managed areas would reduce the availability of flowering lucerne for wasps.

Offal dumping in town refuse tips should be monitored and managed by council or private owners. Currently this localised dumping cre-