Know-how for Horticulture™

Increasing the competitiveness of the Australian processing pea industry through minimising the economic impact of collar rot disease (Ascochyta)

Lloyd Williams
Horticultural Technical Services

Project Number: VG00058

VG00058

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Final Report

Project Number:	VG00058 (Wednesday 31 March 2004)
Project Title:	Increasing the competitiveness of the Australian processing pea industry through minimising the economic impact of the Ascochyta fungus.
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This is the final report on the three-year project title: Increasing the competitiveness of the Australian processing pea industry through minimising the economic impact of the Ascochyta fungus.

Project funded by Horticulture Australia, Vital Food Pty Ltd and the Kendenup Pea Growers association

Wednesday 31 March 2004

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Media Summary

Ascochyta (*Mycosphaerella pinodes*) is a fungus that occurs in processing pea crops. The objectives of this project were to identify the reasons Ascochyta fungus appears and whether its incidence can be minimised with the use of chemical and non-chemical treatments or cultural practices. Five methods of research were undertaken and are summarised below.

1. Minimising the incidence of Ascochyta through the reduction of herbicide applications:

Field trials were conducted over a three-year period (2001, 2002 & 2003) to assess the effect of a number of broadleaf herbicides to minimise the number of applications required to control weeds through the life of the pea crop. With a reduction in the number of herbicide applications, the incidence of Ascochyta would be lower as minimal physical damage to the vines would occur.

The trials demonstrated that Command and Frontier Optima:

a) as a combination pre-emergent herbicide was the most effective treatment in the trials and had the longest activity spectrum of all of the herbicides

b) as a single pre-emergent spray can suffice against broadleaf weed emergence.

c) reduced the number of herbicide sprays to a single application from a previous industry standard of two applications with Bladex.

2. The relationship between soil compaction & Ascochyta

Field trials were conducted over two years (2001 & 2003) to measure the degree of soil compaction in pea crops in those areas of contact with farm machinery and in areas with no contact. Farmers observed that areas of high soil compaction displayed high levels of Ascochyta activity that resulted in poor yield. Methods of removing and reducing soil compaction and the resulting Ascochyta infection were investigated.

a) Data obtained from the Bureau of Meteorology for the trial sites shows a direct observational comparison between rainfall and compaction. As rainfall increases, the soil becomes less compact.

b) The research demonstrated that farm machinery caused compaction of the soil and damaged the crop resulting in potential yield losses of up to 25% in areas where machinery had come in to contact with the crop. With losses potentially much greater due to the onset of Ascochyta, the implementation of permanent roadways was introduced.

c) The introduction of permanent roadways resulted in no damage to pea vines and reduced the risk of Ascochyta infection.

d) Crop trash may have a buffering potential against the incidence of compaction in both the roadways, tramways and within the commercial crop.

3. The effectiveness of fungicides in controlling Ascochyta

Field trials were performed to assess a range of fungicides and a foliar fertiliser that were effective against Ascochyta. Tasmanian researchers had identified Bravo 720 to have some effect against Ascochyta in pea crops.

a) Bravo 720 was the only fungicide to show any preventative effect against Ascochyta.

b) Bravo 720 remains the sole preventative measure against the Ascochyta fungus.

c) Preventative fungicide treatments for the control of Ascochyta are limited.

4. Sap composition of pea vines

Vines from twelve sites were collected and their sap composition analysed to provide data to the farmer for future diagnostic assistance and to identify if there were any nutrient deficiencies. If any deficiencies were identified, then a possible link to the incidence of Ascochyta could be investigated.

a) There was no significant relationship between sap composition of pea vines sampled and their sample sites.

b) There was no clear link between pea vine sap levels and the incidence of Ascochyta in the pea vine samples.

5. Aerial Photography

Aerial photographs were taken of a commercial pea crop to identify potential areas that were not performing at an optimum level and were therefore susceptible to an outbreak of Ascochyta. Ascochyta is brought on by stress factors and it is hoped that by identifying these low performing areas, preventative measures could be taken to lessen the impact of any Ascochyta outbreaks.

a) The plant cell density image demonstrated that the crop was far from uniform. It also showed that less than 50% of the crop was at a maximum density.

b) The true image showed the machinery paths.

c) The false image demonstrates that approximately 20% of the crop contains an optimum density of healthy plant cells in their leaves and the remainder of the crop contains a much lower density.

d) The vigour image shows that up to 50% of the crop is unhealthy.

Technical Summary

Ascochyta (*Mycosphaerella pinodes*) is a fungus that occurs in processing pea crops. The objectives of this project were to identify the reasons Ascochyta fungus appears and whether its incidence can be minimised with the use of chemical and non-chemical treatments or cultural practices. Five methods of research were undertaken that investigated minimising the physical damage to pea vines, the effect of compaction, assessing preventative methods of fungicide control, the analysis of sap composition and site selection to reduce the incidence of Ascochyta.

Herbicide trials were conducted in commercial crops over a three-year period (2001,2002 & 2003). The combination of the pre-emergent herbicides Command (480gL clomazone) and Frontier Optima (720g/L dimethenamid-p) provided the least number of applications to control broadleaf weeds. Only one application of this pre-emergent treatment was necessary compared to the usual industry standard of two applications of Bladex (500g/L cyanazine), one pre-emergent and one post emergent.

The benefits of using Command (480gL clomazone) and Frontier Optima (720g/L dimethenamid-p) were twofold. Not only was Command and Frontier Optima the most effective broadleaf weed treatment, it also showed a longer activity spectrum compared to the other treatments. This characteristic enabled sufficient weed control with a single application.

The benefits of using Command (480gL clomazone) and Frontier Optima (720g/L dimethenamid-p) compared to other herbicides provides the pea industry with a significant breakthrough in reducing the incidence of Ascochyta. With only one narrow leaf weed treatment required post emergence, the physical damage to vines from farm machinery driving over the crop is minimal. This reduces the incidence of Ascochyta from infecting the vine. The financial aspects of introducing this treatment are great, as savings will occur from lower herbicide costs as well as the potentially lower fungicide costs and the increase in yield.

At present both of these herbicides are under review by the National Registration Authority (N.R.A.). The introduction of these chemicals to the processing pea industry is essential for the industry to remain competitive.

Farmers observed that areas of high soil compaction displayed high levels of Ascochyta activity that resulted in poor crop yield. A method for reducing the potential damage to vines is to provide roadways for all farm machinery to travel upon for the duration of the crop. With machinery travelling on the crop up to five times post sowing, the destruction is great, not only to established vines but also to emerging seedlings.

Field trials were conducted over two years (2001 & 2003) to measure the degree of soil compaction in commercial pea crops. Methods of removing and reducing soil compaction and the resulting effects on Ascochyta infection were investigated.

Climate as well as farm machinery plays a role in soil compaction. Data shows a direct observational comparison between rainfall and compaction; as rainfall increases, the soil becomes less compact.

Farm machinery increased soil compaction and damaged the crop resulting in potential yield losses of up to 25% in areas where machinery had come in to contact with the crop. With losses potentially much greater due to the onset of Ascochyta, the implementation of permanent roadways was introduced and evaluated. Permanent roadways resulted in no damage to pea vines and reduced the risk of Ascochyta infection.

Another method of reducing soil compaction is the use of crop trash from previous non-pea crops. Trash has the ability to absorb some of the machinery weight and also to act as a mulching agent in preventing moisture loss. These two characteristics provide a buffering potential against the incidence of compaction in both the roadways, tramways and within the commercial crop.

The adoption of permanent roadways is essential for the industry to minimise the incidence of Ascochyta and to reduce its reliance on fungicidal control. The potential risk of preventing infection with permanent roadways far outweighs the loss of cropping areas that come with their introduction.

Work by Tasmanian researchers demonstrated that Bravo 720 (chlorothalonil 720g/L) was effective against Ascochyta. Fungicides are presently the main preventative and reactive method of controlling Ascochyta in processing pea crops.

A replicated trial was performed to compare the effectiveness of Bravo 720 to that of Phosject (phosohonic acid), Mancozeb (mancozeb 800g/kg) and a foliar fertiliser mix, Fertimix as a preventative measure against Ascochyta. A follow up trial using Bravo 720 only, was repeated over the next two seasons. The effectiveness of each treatment was assessed by measuring total length of vine, total length of Ascochyta infection and total pea pod weights for ten vines.

Bravo was the only treatment to have a significant effect on reducing the incidence of Ascochyta. Bravo not only limited the effect of the Ascochyta on affected vines, but also demonstrated that it prevented the fungus from infecting other vines in the treatment areas. These results support the view of Tasmanian researchers that Bravo 720 was effective against Ascochyta.

Preventative treatments for the control of Ascochyta are limited. Bravo 720 remains the sole preventative measure against the Ascochyta fungus. With all trials performed in crops where the incidence of Ascochyta was low, the use of Bravo 720 should be limited to preventative applications. Further research is required to assess the effectiveness of Bravo 720 in crops where the incidence of Ascochyta is high.

Fungal infection and reduced yield in plants are often related to nutrient deficiencies. If any deficiencies were detected, then a possible link to the incidence of Ascochyta may arise. With little data available for the nutrient composition of processing pea vine crops over their growing season, a number of sap tests were performed for future reference as well as to identify if there were any nutrient deficiencies. Ten vines per site from twelve sites were collected at random for sap analysis. Twelve sites were located throughout the Kendenup District and did not discriminate between health, vigour or appearance of the crop. Some of the sites included outbreaks of Ascochyta.

Data indicated that sap composition was not affected by site but was affected by the factor of time for phosphorous, potassium, calcium, magnesium and manganese. In all cases nutrient concentration started high, dropped at the second sample date and then increased for the last sample date.

The lack of a significant relationship between sap composition and sample site demonstrates that there is no clear link between pea vine sap levels and the incidence of Ascochyta in the pea vine samples.

Aerial photography is used as a tool in many crops as a method of identifying areas within the crops that are not performing to an optimum level. Reasons for this reduced crop performance can then be investigated. Aerial photographs were taken of a commercial pea crop at the post flowering stage to identify these areas and to determine whether they are susceptible to an outbreak of Ascochyta. Ascochyta is brought on by stress factors and it is hoped that by identifying these areas, preventative measures could be taken to lessen the impact of any outbreaks.

The images obtained recorded that the pea crop was not uniform, with up to 50% of the crop categorised as being unhealthy. The images indicated areas of the crop affected by soil type and by machinery. Aerial photography is a useful tool in identifying areas that are susceptible to outbreaks of Ascochyta.

Recommendations

1. The introduction of the herbicides Command and Frontier Optima as a pre-emergent application is recommended.

   The combination of two herbicides was effective in controlling broadleaf weeds and demonstrated a longer activity spectrum compared to other herbicides. This treatment reduced the total number of herbicide applications for the life of the crop and potentially reduces the risk of Ascochyta infection due to less machinery damage to the pea vines.

2. The implementation of permanent tramways or roadways is recommended.

   Both of these practices would reduce the potential onset of Ascochyta by reducing the damage (up to 25%) to vine crops where machinery has traversed. With decreasing the physical damage to the vines, there would be a lower potential for the Ascochyta to infect the crop.

3. Further research is recommended for the introduction of retaining trash in paddocks where peas are to be sowed.

   Preliminary work has established soil compaction is reduced when trash from non-pea crops is retained. With reduced damage to the vines, the incidence of Ascochyta may also be reduced.

4. The fungicide Bravo 720 is recommended as a preventative application.

   When used prior to any Ascochyta infection, Bravo 720 restricted the spread of the fungus.

5. Aerial photography is recommended prior to crop sowing and at an early stage of the crop's life.

   Aerial photography has clearly demonstrated that there are dramatic differences within a pea crop that will ultimately affect crop yield and the incidence of Ascochyta.

Technology Transfer

Conducted research forums prior to the growing seasons of 2000, 2001 & 2002 to extend findings of the seasons work to Kendenup farmers and Vital Food Pty Ltd extension officer.

Conducted field walks during to the growing seasons of 2000& 2001 to extend findings of the seasons work to Kendenup farmers and Vital Food Pty Ltd extension officer.

Project final report completed and sent to Horticulture Australia, Vital Food Pty Ltd and the Kendenup Pea Growers Association.

Project recommendations and technical summary sent to the Vital Food Pty Ltd extension officer.

Introduction

The processing pea industry is highly competitive with imports from New Zealand placing economic pressure on producers to continually improve their management practices to remain viable against cheaper imported product. The production areas of Tasmania and southwest Western Australia are further disadvantaged by having a growing season confined to winter and spring rather than the usual spring and summer season found overseas. These growing conditions provide a very high incidence of the Ascochyta fungus (*Mycosphaerella pinodes*), particularly in Western Australia (Pritchard, 1993).

Conventional treatments for the control of Ascochyta in processing peas have predominantly focussed on chemical and seed treatments (Pung *et al*., 1998). These treatments have demonstrated only minor success in controlling the fungus. In an effort to gain an edge over our overseas competitors, alternative methods of control require investigation. These alternatives are focussed on reducing the incidence of disease without necessarily relying on costly chemical control as the only method of control.

Past processing pea research in Australia undertook a direction aimed at understanding how widespread the fungus is and how much of an impact it has throughout the Australian industry (Pung *et al*., 1998). The objectives of this project are to try and identify the reasons why the Ascochyta fungus appears and whether its incidence can be minimised with the use of chemical and non-chemical treatments or cultural practices.

One of the greatest infection opportunities for the Ascochyta fungus occurs, when the pea crop is damaged due to farm machinery continually crushing the vines when agronomic treatments are applied. The most frequently applied treatment is that of herbicides both pre and post emergent. By investigating new herbicide chemistry, it may be possible to reduce the number of passes over the crop and therefore lessen the opportunities of Ascochyta infection.

The forward planning of sowing a paddock will be investigated to try and minimise the incidence of Ascochyta. Avoiding areas within a paddock such as trees, dramatic changes in soil types or waterlogged areas (Proctor, 1958), can all cause crops to stress and potentially allow the Ascochyta fungus to enter and spread, if left untreated.

Moisture stress leading to potential Ascochyta outbreaks in processing pea crops (Proctor, 1958) is a potential threat to the industry in the Kendenup District as no irrigation is used in growing the crops. Growing processing pea crops in stubble from previous crops will be investigated in an effort to retain moisture throughout the season and providing a less stressful environment for the pea crop.

Fungicides are presently the main preventative and reactive method of controlling Ascochyta in processing pea crops. Previous work by Tasmanian researchers has demonstrated that Bravo 720 (chlorothalonil 720g/L) was effective against Ascochyta. Other treatments will be screened along side Bravo to identify any further treatments that may be effective against the fungus.

These objectives are fundamental in providing the industry with guidelines in how they can practically reduce the incidence of Ascochyta in their processing pea crops and to remain economically viable in an ever increasingly competitive market.

1. Minimising the incidence of Ascochyta through the reduction of herbicide applications

Aims

During the life of a processing pea crop, a total of four or more herbicides are used to control a range of weed species. Each application is not only an economic cost but also leads to potential introduction of Ascochyta through the crushing of the vine. If herbicides can be found to control the weeds prior to the pea crop emerging, then not only will a cost saving from minimal applications be made but also potential yield losses could be reduced.

Four pre-emergent herbicides were applied to commercial pea crops over three cropping seasons throughout the Kendenup District. The herbicides were not registered for use in processing pea crops but have shown potential in previous experiments both in Western Australia and Tasmania.

The herbicides screened were; Authority (750g/kg sulfentrazone), Brodal 500 (500g/L diflufenican), Command 480EC (480gL clomazone), Frontier Optima (720g/L dimethenamid-p)/Frontier (900g/L dimethenamid) & Raptor WG (700g/kg imazamox). Bladex (500g/L cyanazine) was used as the control treatment (industry standard).

The aim of this trial was to evaluate the effectiveness of each pre-emergent herbicide at recommended rates in controlling a range of potential weed species in commercial processing pea crops.

Materials & Methods

Pre-emergent herbicides were applied to three properties over the three pea seasons located throughout the Kendenup District. All trials were applied with a three-metre boom over a range of plot sizes measuring from $100m^2$ to $1000m^2$ with three replicates. Herbicides were applied to the crop post sowing but prior to seedling emergence. Each chemical was used at recommended rates with volumes of 200L/ha of water (Table 1.1). The control was sprayed with water only.

The effectiveness of each treatment in controlling weeds was assessed using the ERWS Scale with ratings from 1 – 9 (Table 1.2). Measurements using this scale were taken throughout the life of the crop. The raw data has been statistically determined using ANOVA, means of each treatment and finally by the “Greenhouse-Geiser Correction Factor” to determine the effect of time on each significant treatment.

Table 1.1 - Herbicide rates.

Herbicide	Recommended Rate	Water Volume
Authority	500g/ha	200L/ha
Bladex	200ml/ha	200L/ha
Brodal	200ml/L	200L/ha
Command	500ml/L	200L/ha
Frontier	1.5L/ha	200L/ha
Frontier Optima	1.0L/ha	200L/ha

Table 1.2 –ERWS Scale.

Rating	Percentage Effect	Weed Control
1	100	Complete weed control
2	99.9 – 98	
3	97.9 – 95	
4	94.9 90	
	----------	Limit of commercial acceptability
5	89.9 – 82	
6	81.9 - 70	
7	69.9 – 55	
8	54.9 – 30	
9	29.9 - 0	Little to no effect on weeds

Results

The combination of Command and Frontier or Command and Frontier Optima was significantly more effective in controlling weeds than the other treatments including the industry standard of Bladex. The herbicides, Brodal and Authority achieved similar levels of control to each other but were not significantly different to the control (Figure 1.1).

The chemistry of Command and Frontier or Command and Frontier Optima continued to control emerging weeds for an extended period compared to the other treatments measured over the same period of time (Figure 1.4).

Each chemical treatment showed a different proportion of surviving weed species after application (Figure 1.2). With all treatments, ryegrass (*Lolium perenne*) was consistently the largest surviving weed followed by fumitory (*Fumaria muralis*).

Figure 1.1 The significant difference of Command & Frontier Optima over other herbicides in controlling weeds.

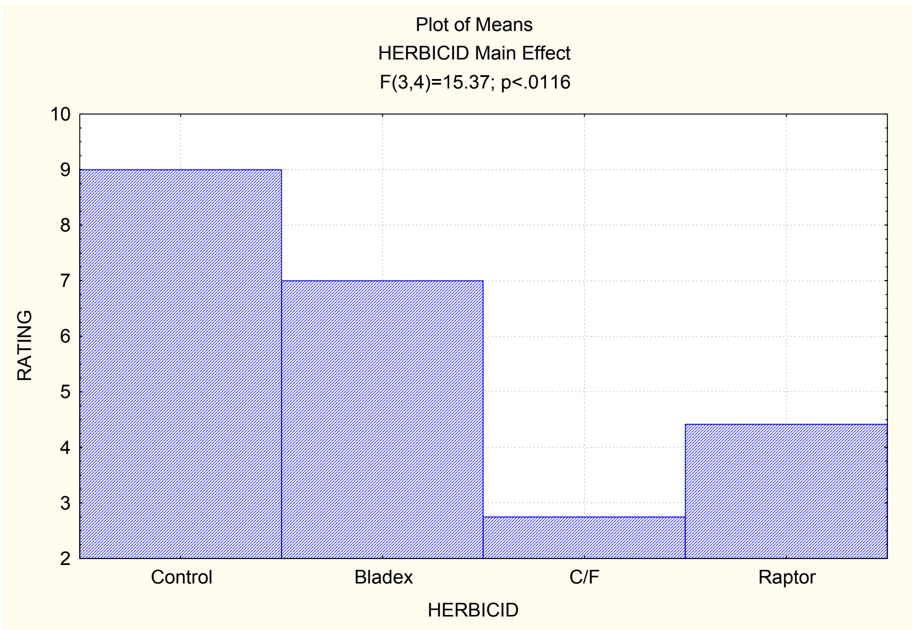


Figure 1.2 Average percentage contributions of weeds remaining after treatment (Dates and times averaged).

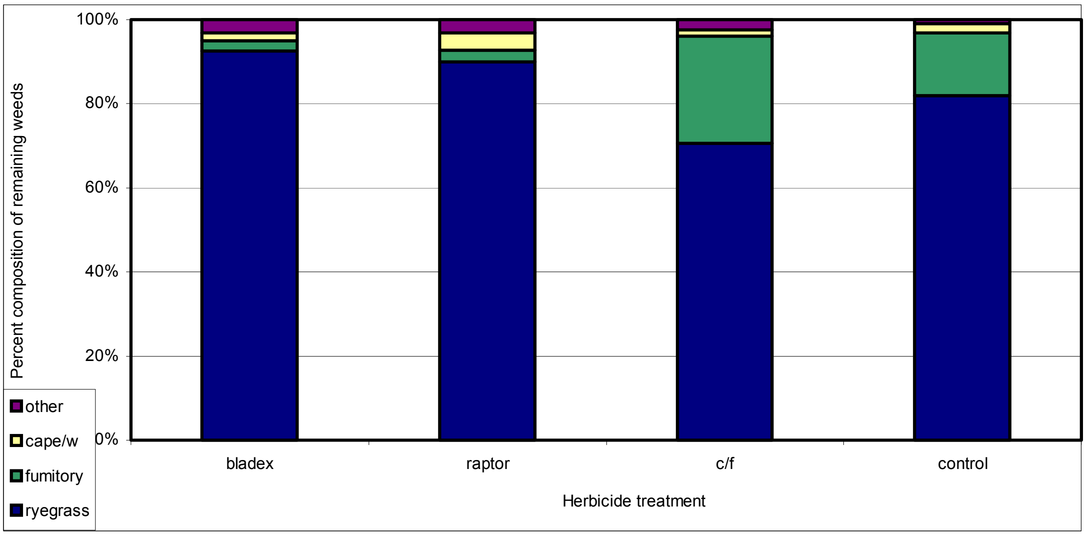


Figure 1.3 The significant difference of Command & Frontier Optima over the control treatment in controlling weeds.

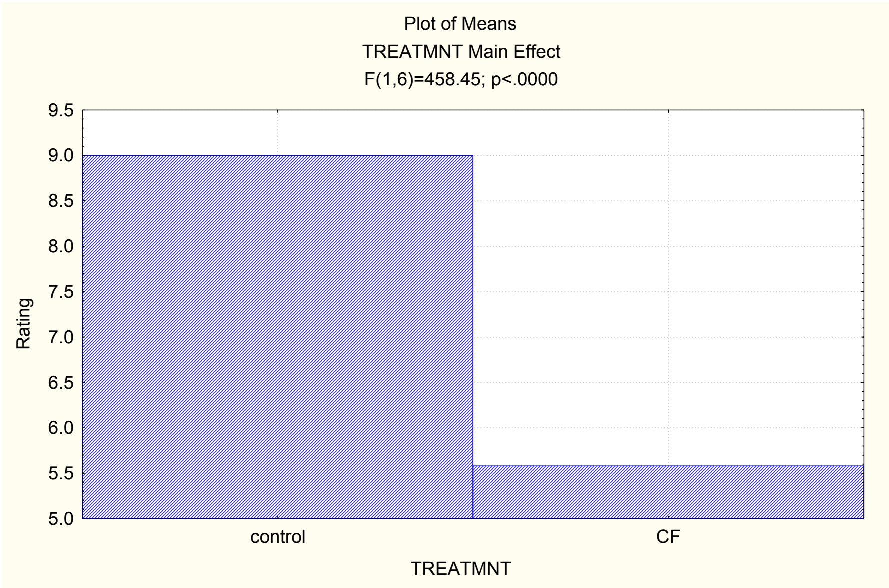
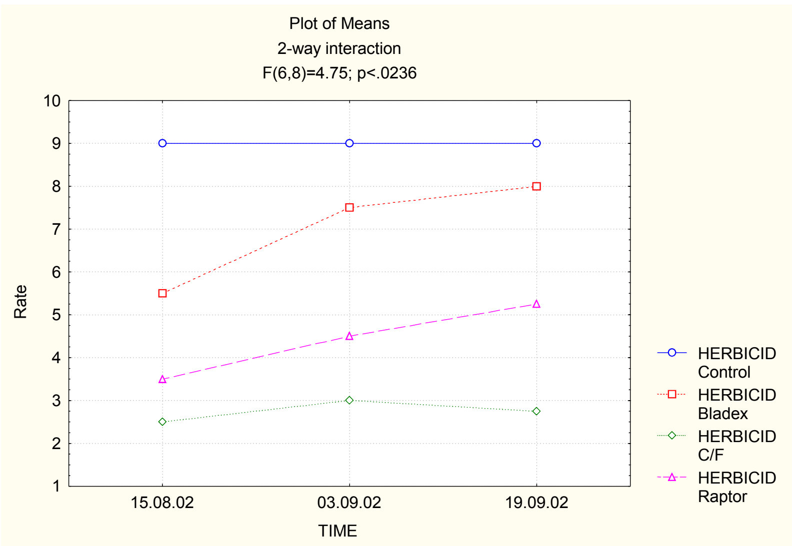


Figure 1.4 The effectiveness of each herbicide treatment over time in controlling emerging weeds.



Discussion

The chemistry of Frontier was changed in the second season of trials and the reformulated product was subsequently called Frontier Optima. The synergistic effect of Command and Frontier Optima produced an herbicide that was significantly greater to all other herbicides screened in controlling the weed populations over three successive seasons throughout the Kendenup District (Figure 1.1 & 1.3).

Compared to the industry standard of Bladex that is applied pre and post emergent, Command and Frontier Optima applied only once and prior to crop emergence, has provided the processing pea industry with a potent tool both in weed control but also in an economic sense due to only the single application required. With these advantages there is also the added effect of not having to drive over an emerged crop and therefore crushing the vine and exposing the crop to potential outbreaks of Ascochyta.

Brodal and Authority achieved similar levels of control to each other but were not significantly different to the control (Figure 1.1). Due to the lack of significant weed control, these two products were dropped from future trials to concentrate on Command and Frontier Optima.

One of the keys to the success of Command and Frontier Optima is that of the extended activity spectrum that this chemistry displays (Figure 1.4). Over the three years of testing, the herbicides continued to kill emerging weeds for a period of up to three weeks from application. This is an important aspect with processing pea crops as weeds such as doublegee *(Emex australis*), can germinate late in the crop causing problems when the peas are harvested. With a long activity spectrum, Command and Frontier Optima should replace all herbicides currently used in the industry.

The surviving weed species identified in these trials indicate a potential problem for future weed control in processing pea crops (Figure 1.2). Command and Frontier Optima although mainly effective against broadleaf weeds, does have some ability in controlling grasses. The commercial crops where these trials were located, all displayed very high populations of ryegrass (*Lolium perenne*) in the treatment and control plots. For commercial control of this weed species, a grass herbicide will need to be applied as well as the Command and Frontier Optima to provide a weed free crop. This would entail one pre and one post emergent herbicide application. A future concern may be that of ryegrass resistance that has shown up in some parts of the district.

Conclusions

Command and Frontier Optima as a combination pre-emergent herbicide was the most effective treatment in the trials and had the longest activity spectrum of all of the herbicides. In cropping situations where ryegrass has no previous history, Command and Frontier Optima as a single pre-emergent spray can suffice against broadleaf weed emergence.

2. The relationship between soil compaction & Ascochyta

Aims

Compaction from farm machinery is a problem in processing pea crops due to the damage to the vines throughout the growing season. Once a vine has been damaged by machinery the potential for disease entry is significant under the climatic conditions experienced around the Kendenup District.

A method for reducing the damage to vines is to provide roadways for all farm machinery to travel upon for the duration of the crop. With machinery travelling on the crop up to five times post sowing, the destruction is great, not only to established vines but also to emerging seedlings.

The aim of this trial is to measure the extent of compaction caused by farm machinery on roadways and tramways within the crop compared to areas with no permanent pathways. The method that allows minimal compaction will be recommended as an indirect way of reducing the risk of Ascochyta infection.

Materials & Methods

A hand held penetrometer with an attached weight of 10 kg was used to measure soil compaction. The number of times the weight was required to force the pole into the ground to a predetermined depth (30 cm) was counted and subsequently recorded.
Sites were measured in regular intervals throughout the length of the growing season. The raw data has been statistically determined using ANOVA, means of each treatment and finally by the “Greenhouse-Geiser Correction Factor” to determine the effect of time on each significant treatment.

Roadways measuring 80 metres in length and 4 metres in width were pegged within the commercial pea crop and remained for the life of the crop. Two roadways were sprayed with herbicides to kill the peas and another two roadways were left unsprayed. This provided roadways with pea vines and without pea vines. These roadways were designated for all farm machinery to travel upon.

Areas outside of the trial location were also marked for repetitive measurements throughout the season. Yield assessments were undertaken at the end of the pea crop’s life to determine whether compaction had an effect on yield.

The following season the use of tramways were introduced in addition to the other two forms of roadways. The seed drill not sowing the areas where tractor wheels run, achieved the laying out of tramways. Yield assessments were undertaken at the end of the pea crop’s life to determine whether compaction had an effect on yield.

Results

Initial trial results in 2001 showed a significant effect between the compaction of roadways and that of the areas within the crop. Roadways were more compacted than areas within the crop. Trial results in the 2003 season did not indicate any significant difference between the sites. There was a significant difference of compaction over time (Figure 2.2).

During the initial (2001) season, the yield difference from areas where farm machinery had repeatedly driven over the crop calculated a yield loss of 25% or only 2.35t/ha compared to the undamaged paddock yield of 3.1t/ha (Table 2.1).

Using permanent tramways in the 2003 season resulted in a yield loss of 18% or only 2.29t/ha compared to a harvestable quantity of 2.70t/ha (Table 2.1).

Figure 2.1 Total rainfall in Mt Barker for 2003.

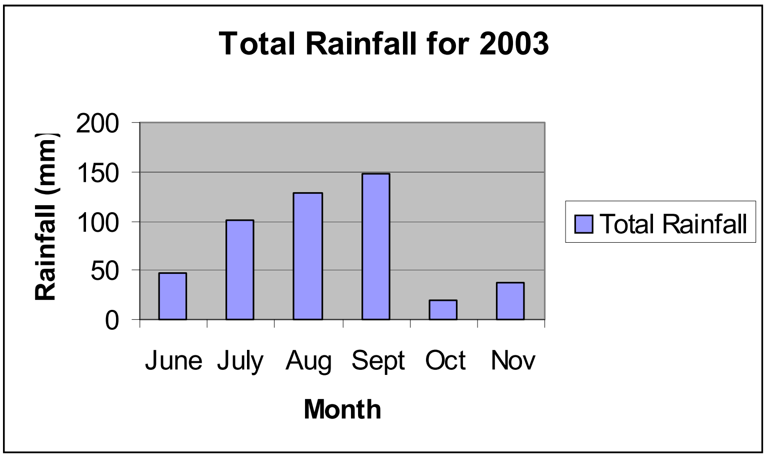


Figure 2.2 The effect of soil compaction over time during the 2003-growing season.

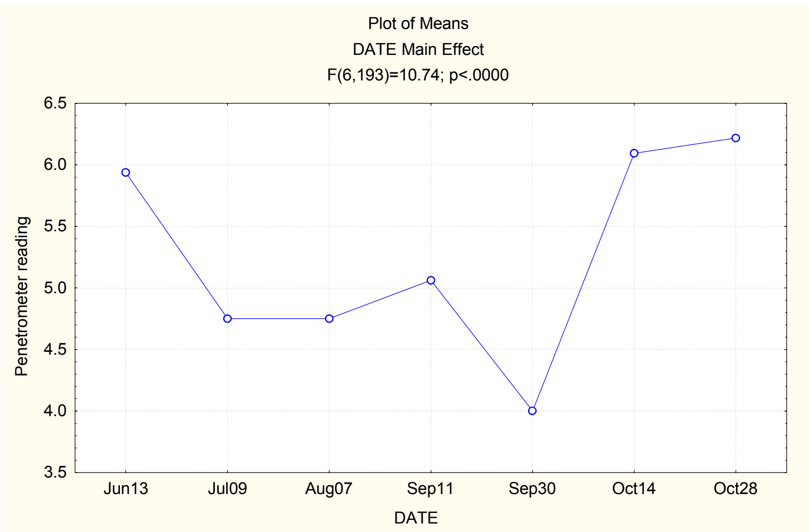


Figure 2.3 The difference of soil compaction between sites during the 2001 & 2003-growing season. 'Crop' indicates no marked roadways, 'road' indicates a marked roadway & 'tram' indicates a tramway.

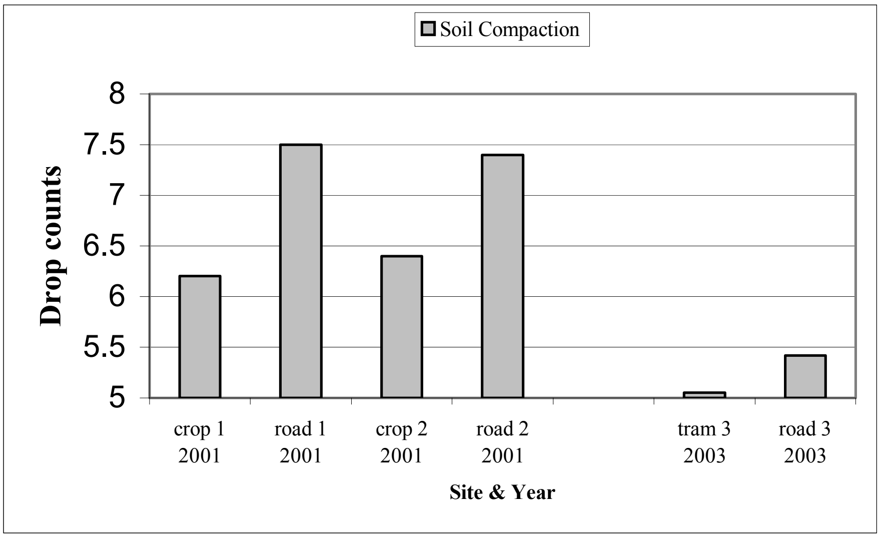


Table 2.1 Yield (kg) difference between pea vines growing in marked and unmarked tramways and within the commercial crop (2003 season).

Site Number	Unmarked Tramways 2001	Commercial crop 2001	Marked Tramways 2003	Commercial crop 2003
1	11.21	16.85	11.45	12.33
2	10.98	16.12	8.85	14.75
3	13.06	13.53	14.05	13.50
Total weight (kg)	35.25	46.5	34.35	40.58
Average weight (kg)	11.75	15.5	11.45	13.53
Tonne/ha	2.35	3.10	2.29	2.70

Table 2.2 Rainfall data for Mt Barker (millimetres)

Month	2001	2002	2003	Average
June	49.8	56.4	47.4	51.2
July	42.2	78.2	101.0	73.8
August	66.0	62.4	128.6	85.7
September	83.6	66.2	148.4	99.4
October	52.8	58.8	79.2	63.6
November	63.0	22.2	37.0	40.7

Discussion

Compaction of the soil plays a role in how a crop will grow. Heavy farm machinery along with their trailing implements that are driving over a crop at least four or five times during the season will have a direct effect upon the yield of the crop. Along with compaction, follows potential waterlogging that may lead to plant death and subsequently potential Ascochyta incidence. It has been observed that within the crop where waterlogging occurs, the incidence of Ascochyta is greater and if climatic conditions are suitable, a rapid spread of the fungus is possible throughout the crop. By utilising roadways where all vehicles must travel and where no vines are allowed to grow, should eliminate all potential outbreaks of the Ascochyta fungus due to compaction or crop injury.

Subsequent trials demonstrating the compaction of roadways and that of the areas within the crop did not show any significant difference between the sites. The reason for this anomaly may be due to the presence of crop trash remaining from the previous season. The crop trash was that of wheat stubble. This trash may have buffered the incidence of compaction in both the roadways, tramways and within the commercial crop. The stubble formed an even matt across the paddock surface that may have allowed any rainfall to soak into the ground rather than pooling on a bare and hard surface. The matt may also have the ability to absorb compaction of machinery due to the elasticity of the stubble. If this was possible, the soil would receive less compaction than if trash was not present. These theories require future research.

A secondary benefit of utilising roadways or tramways is a higher crop yield. Without any form of controlled vehicle access, crop yield is reduced by up to 25% in an area wherever a vehicle runs over the vines (Table 2.2). This is the minimum level of damage as the potential increased damage due to Ascochyta outbreaks could be far greater. The loss of cropping area due to any roadway or tramway may be of a concern to some farmers but should be placed into context. Regardless of the width required between roadways or the absence of any predetermined roadways, the cropping area lost will only equate to the area between wheels on the same axles. With the crop having a 25% reduction in yield in this area already, the economic return of utilising roadways or tramways could be justified if no Ascochyta occurs. If an outbreak of Ascochyta does occur, then roadways or tramways will also allow easy access to the area of the paddock without risking further infection due to the injury of more vines by having no permanent access routes.

Machinery movements are not the only means of soil compaction. The influence of weather with its wet and dry cycles will have an effect. Data obtained from the Bureau of Meteorology for the trial sites (Table 2.2), shows a direct comparison between rainfall and compaction. As rainfall increases, the soil becomes less compact. This is clearly evident in the month of September (Figure 2.1). With high rainfall the incidence of spreading fungal disease is increased, particularly if machinery is not kept to predetermined roadways where crop damage can be excluded. The linkage between rainfall and soil compaction is purely observational and requires further research.

Conclusion

Farm machinery causes compaction of the soil and also damages the crop resulting in potential yield losses of up to 25%. With losses potentially much greater due to the onset of Ascochyta, the implementation of permanent roadways is essential even with the loss of cropping area.

Data obtained from the Bureau of Meteorology for the trial sites shows a direct comparison between rainfall and compaction. As rainfall increases, the soil becomes less compact.

Crop trash may have a buffering potential against the incidence of compaction in both the roadways, tramways and within the commercial crop.

3. The effectiveness of fungicides in controlling Ascochyta

Introduction

Fungicides are presently the main preventative and reactive method of controlling Ascochyta in processing pea crops. Previous work by Tasmanian researchers (Pung *et al,* 1998), demonstrated that Bravo 720 (chlorothalonil 720g/L) was effective against Ascochyta. The aim of this trial was to compare the effectiveness of Bravo 720 to that of Phosject (phosohonic acid), Mancozeb (mancozeb 800g/kg) and a foliar fertiliser mix, Fertimix as a preventative measure against Ascochyta.

Materials & Method

Trial sites were located in commercial pea crops in the Kendenup District. Fungicides were applied with a hand sprayer. Two applications were applied two weeks apart commencing six weeks from sowing. The treatments were Bravo 720 applied at a rate of 1.8L/ha, Phosject at a rate of 5 ml/L and Mancozeb at a rate of 1.5g/L. Each treatment was applied with 200L of water/ha. All sites measured $20m^2$ with 3 replications per treatment. The control was left untreated. A foliar fertiliser mix (Fertimix - Mg, Fe, Mn, Cu, Zn, B & Mo at a rate of 2.4g/10ml) was also applied to determine whether plant measurements responded to an increase in nutrients. Measurements were taken at harvest to determine the incidence of Ascochyta. The measurements were:

1. total length of vine for 10 vines per treatment
2. total length of Ascochyta infection for each of the ten vines
3. total pea pod weights for the ten vines.

The raw data was statistically determined using ANOVA and means for each treatment.

Results

Length, number of nodes, disease length and percentage of disease plants were significantly affected by treatment (Figure 3.1, 3.2 & 3.3), while the number of pods and the weight of pods were not significantly affected by treatment (Table 3.1).

The greatest height occurred in the control treatment (53.3 cm), closely followed by Phosject (52.6 cm) and fertimix (52.1 cm). Plants treated with mancozeb grew the least (49.8 cm). This is similarly observed in the number of nodes. The incidence of disease is greatest in the Mancozeb treatment (77%). Only the Bravo treatment decreased the incidence of disease (66%).

Figure 3.1. Percentage of diseased plants per treatment.

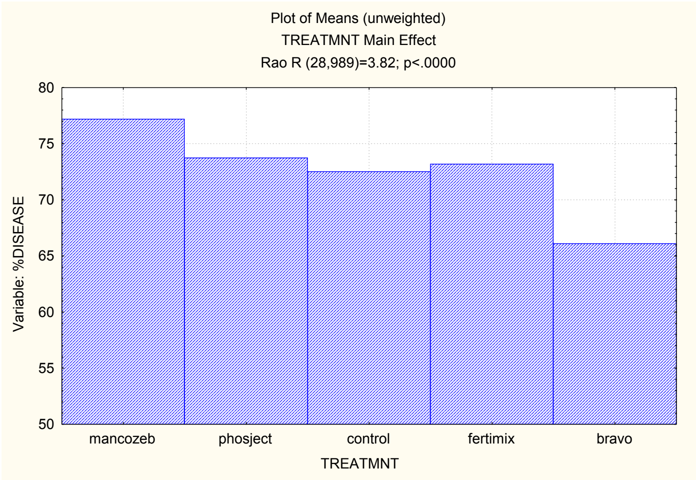


Figure 3.2. Height (cm) of plants per treatment.

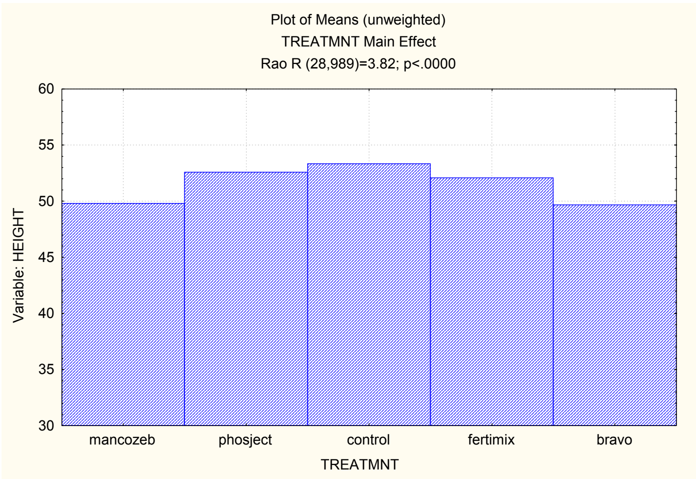


Figure 3.3. Number of nodes per treatment

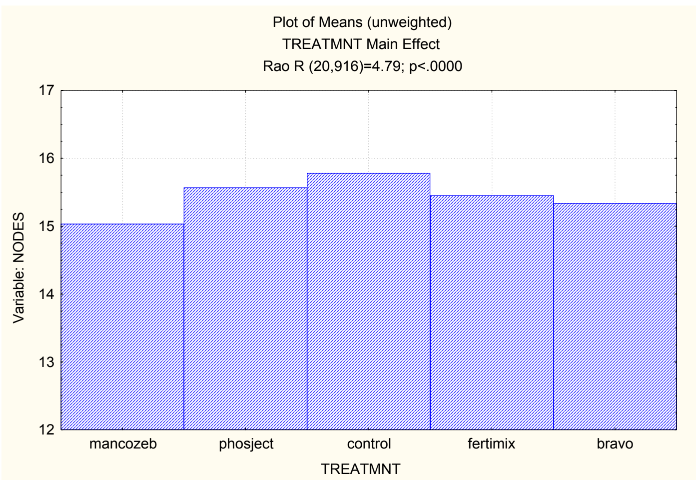


Table 3.1. The effect of treatment means on pea vines

Treatment	Stem Length (cm)	Disease Length (cm)	N^{o} of Nodes	Diseased Plants (%)	N^{o} of Pods	Pod Weight (g)
Bravo 720	49.7	10.03	15.33	66.10	4.70	16.50
Fertimix	52.1	11.17	15.45	73.17	4.85	16.28
Mancozeb	49.8	11.57	15.03	77.19	4.52	15.20
Phosject	52.6	11.45	15.57	73.73	5.18	19.38
Control	53.3	11.35	15.78	72.51	4.88	17.25

Discussion

Bravo was the only treatment to have a significant effect on reducing the incidence of Ascochyta (Table 3.1). Bravo not only limited the effect of the Ascochyta on affected vines, but also demonstrated that it prevented the fungus from infecting other vines in the treatment areas. These results support the view of Tasmanian researchers that Bravo 720 was effective against Ascochyta.

All treatments had a detrimental effect on the length of the pea vine including the foliar fertiliser treatment (Figure 3.2). This indicates that the length of plants were not affected by the presence of Ascochyta, as all vines except some of those treated with Bravo 720 showed some degree of infection of Ascochyta.

The Fertimix treatment displayed no advantage in aiding plant growth or overall plant health in regards to protecting the plant against Ascochyta infection (Table 3.1).

Phosphonic acid that is used widely in the horticultural industry against a wide range of fungi had no beneficial effects against Ascochyta. As a cheap and effective control against some fungi, it was thought that it could protect or sustain the plant from a mild infection of the Ascochyta infection (Table 3.1).

The application rate of Mancozeb may not be suitable for processing peas as shown by the stunted growth of the plants (Figure 3.2). With the shortest plants and those with the least number of nodes, this treatment at the recorded rate is not recommended for use in processing pea crops. The chemistry of Mancozeb showed the least control of all the treatments applied.

Bravo 720 was applied to crops over the next two seasons with limited results. The primary reason for this could have been the lack of climatic conditions that were conducive to the spread of Ascochyta. All crops showed similar levels of infection as occurred in this trial.

Conclusion

Preventative treatments for the control of Ascochyta are limited. Bravo 720 remains the sole preventative measure against the Ascochyta fungus. How this treatment works when conditions are more conducive to the spread of Ascochyta is unknown.

4. Sap composition of pea vines

Aims

With little data available for the nutrient composition of processing pea vine crops over their growing season, a number of sap tests were performed for future reference as well as to identify if there were any nutrient deficiencies. If any deficiencies were detected, then a possible link to the incidence of Ascochyta may arise.

Materials & Method

Ten vines per site from twelve sites were collected at random and bagged. The collector wore disposable gloves and all samples were collected prior to 12 noon. The samples were sent express post to a laboratory for sap analysis. The twelve sites were located throughout the Kendenup District and did not discriminate between health, vigour or appearance of the crop. Some of the sites did include outbreaks of Ascochyta. Collection dates were 82, 103 and 133 days from sowing (Table 4.1).

Results

The site of each sample was not significant in affecting the sap composition. The factor of time did affect sap analysis for P, K, Ca, Mg and Mn. In all cases nutrient concentration started high, dropped at the second sample date and then increased for the last sample date (Table 4.1).

Table 4.1 Mean vine sap composition (ppm) at 82, 103 and 133 days from sowing.

Nutrient Conc. (ppm)	NO 3	P	K	Ca	Mg	Zn	B	S	Cu	Fe	Mn
5 Sept (82 days)	141	122	3440	958	350	11.59	1.91	516	0.82	2.88	3.55
26 Sept (103 days)	140	86	3053	641	302	9.21	2.21	369	1.29	3.32	1.32
25 Oct (133 days)	170	141	4219	1324	733	9.52	7.50	361	1.88	3.28	3.63

Discussion

Reasons for sap composition not being affected by site are unknown. Possible reasons for this event could be that all crops are supplied with sufficient nutrients for their growth. If all nutrients were available for sufficient growth, then no limitations would occur across the sampled sites. As all processing pea crops are used in rotations with other crops, the residual nutrients from previous crops as well any fertilisers applied at sowing, may be providing excess nutrients at the time of sampling.

The reason for the trend of nutrients to be affected by time must assume to be caused by factors outside of the farmer's control, as no application of nutrients post sowing is common to all sampled sites. The reason why the nutrients P, K, Ca, Mg and Mn are affected by time is also not known. A possible factor related to this event is that of the onset of the pea crop commencing to flower and subsequently developing pods rather than vegetative growth. With this switch of growth from vegetative to reproductive, a difference of the sap contents of the whole plant may occur. The onset of changes in climatic conditions may act as a trigger for this event.

Conclusion

The lack of a significant relationship between sap composition and sample site demonstrates that there is no clear link between pea vine sap levels and the incidence of Ascochyta in the pea vine samples.

5. Aerial Photography

Aims

Aerial photographs were taken of a commercial pea crop to identify areas within the crops that were not performing at an optimum level and therefore susceptible to an outbreak of Ascochyta. Ascochyta is brought on by stress factors and it is hoped that by identifying these areas, preventative measures could be taken to lessen the impact of any outbreaks.

With this system of photography, four different lenses take each image:

1. True colour image – a natural image of the surveyed area

2. False colour infrared image – is sensitive to the amount of healthy plant cells. Areas that appear dark pink in these images indicate vegetation with a higher plant cell density per pixel.

3. Plant cell density (PCD) image – a measure of near infrared reflectance. Variations in near infrared reflectance can be directly attributed to the quantity of plant leaves per pixel and the density of healthy plant cells in those leaves.

4. Vigour Index image – displays the level of photosynthetic activity that is an indication of a plants health. The resultant image shows an individual plant's vigour relative to all the other plants included in the ratio.

Materials & Method

An aerial photograph was taken at the post flowering stage of the pea crop. Four lenses were used to take the photograph. The crop selected to photograph was identified with use of co-ordinates as supplied by the landholder. The site was selected, as it was relatively easy to identify and was considered to be a uniform crop in its growth appearance.

Results

The plant cell density image demonstrates that the crop was far from uniform. It also showed that less than 50% of the crop was at a maximum density (Figure 5.1). The true image showed the machinery paths (Figure 5.2). The false image demonstrated that approximately 20% of the crop contained an optimum density of healthy plant cells in their leaves and the remainder of the crop contained a much lower density (Figure 5.3). The vigour image showed that up to 50% of the crop is unhealthy (Figure 5.4).

Figure 5.1. Plant Cell Density Image

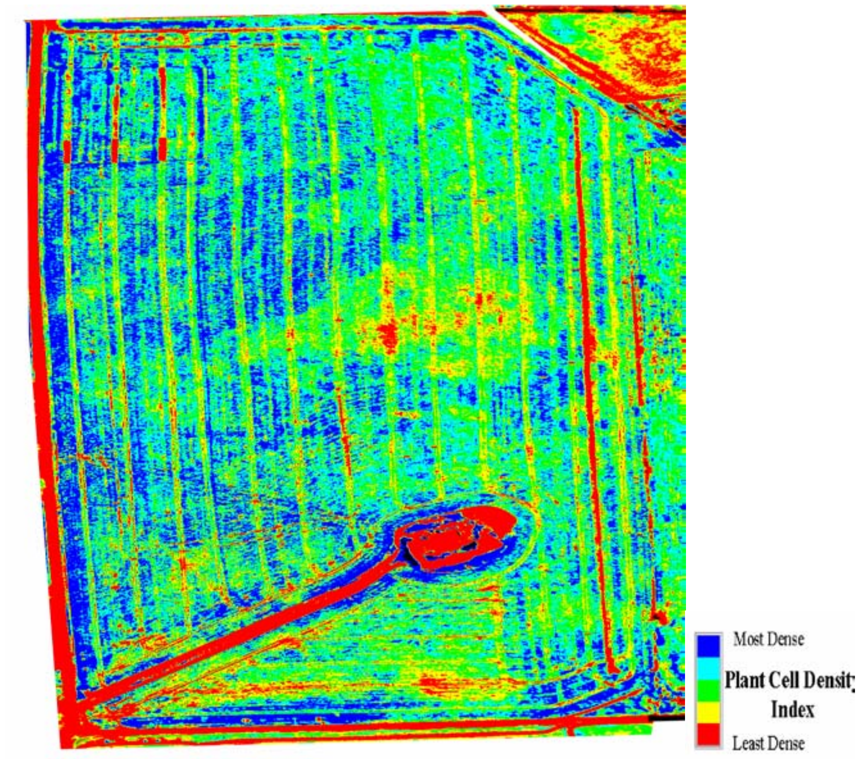


Figure 5.2. True Image

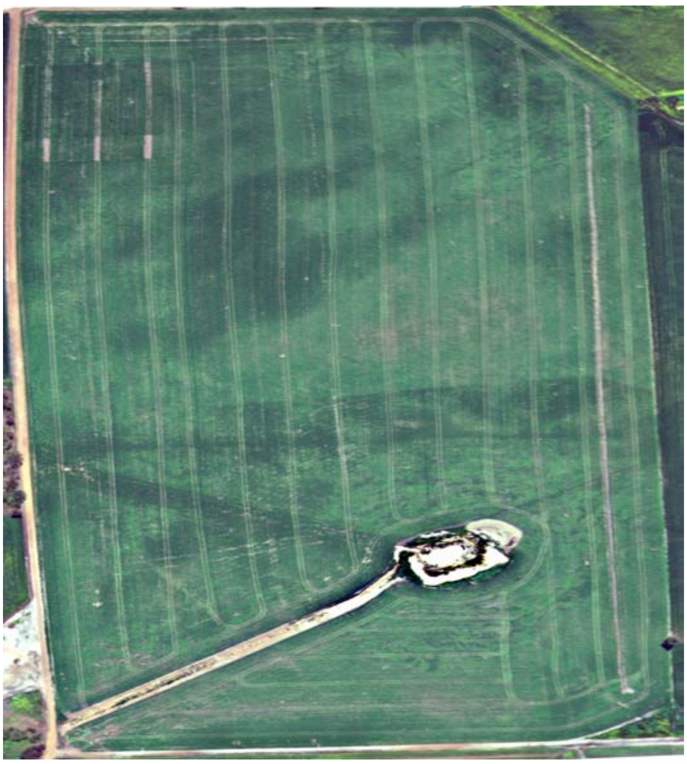


Figure 5.3. False Image

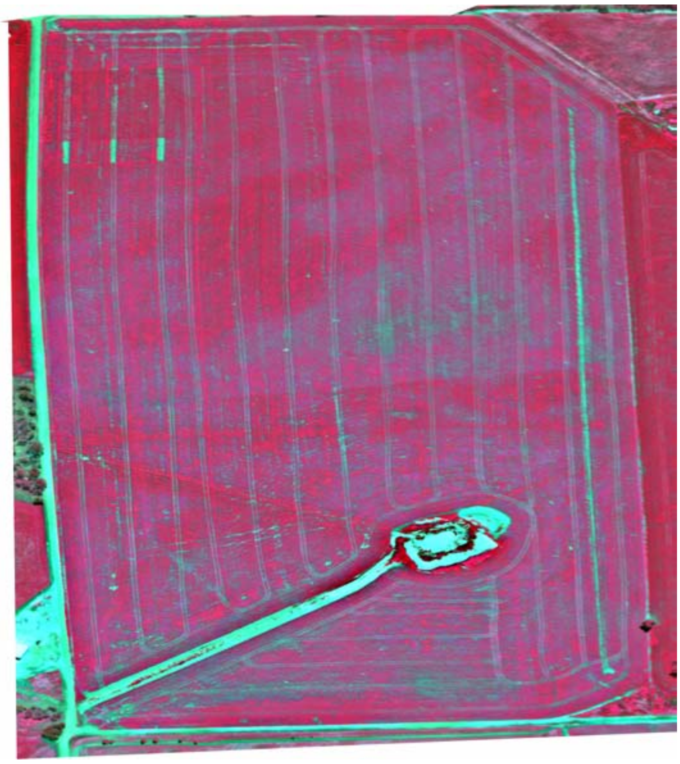
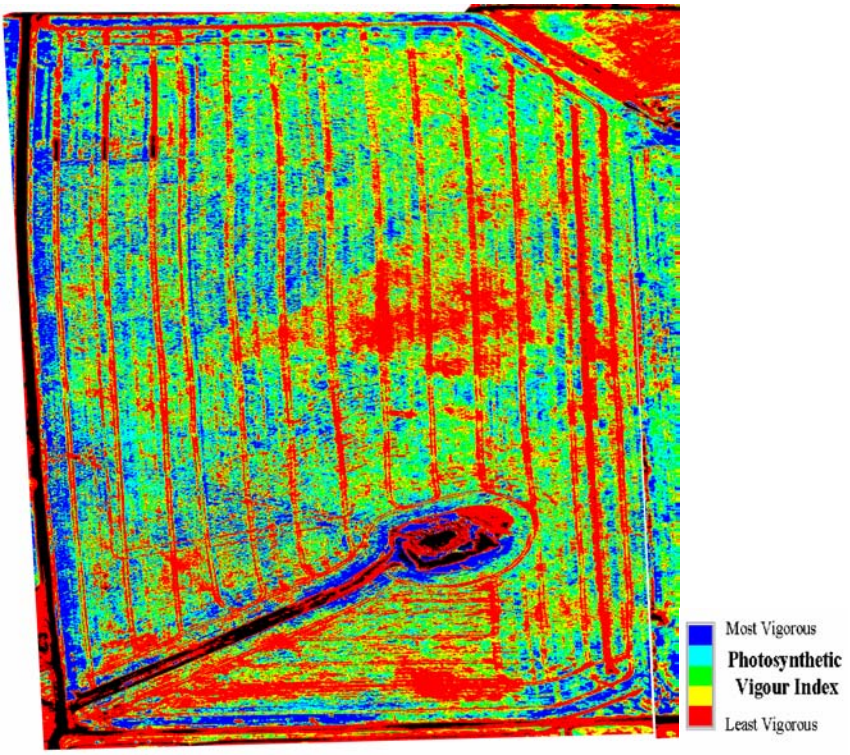


Figure 5.4. Vigour Image



Discussion

From these photographs, the pea crop in question was far from uniform and far from healthy for a large percentage of the crop.

The true image (Figure 5.2) shows a crop that has been repeatedly driven over as indicated by the clearly evident wheel tracks. In this crop, a self-propelled boom spray was the main vehicle that caused the wheel tracks. Machinery has crushed and damaged a large percentage of the vines within these roadways as evident by the outlines in both the vigour (Figure 5.4) and plant cell density image (Figure 5.1). Both of these images show the lowest category for photosynthetic activity cell density that supports the view of vine damage. With this degree of damage, the potential incidence of Ascochyta is high

The false image (Figure 5.3) clearly demonstrates that the crop contains only a small proportion of optimum density healthy plant cells. The reason for this low level is not clear but may be due to moisture stress, changes in soil type or disease. As no irrigation is applied to these crops, the image may represent those soil types that are able to hold more moisture or moisture over a longer period of time. Visual identification did not support this view although it cannot be ruled out completely. Ascochyta was present in these areas but was not of a higher incidence than other areas in the paddock. Soil type was the most likely explanation for the variation within the image. Visual observation showed a soil that comprised predominantly of small laterite fragments. In some of these areas, the pea seed had not germinated or may not have been seeded due to a blockage in the seed delivery tubes. The reason for non-germination of seed may be due to the seed not being properly covered by the rocky soil fragments compared to other areas of the paddock that had a lower ratio of rock fragments.

A low plant cell density (Figure 5.1) of up to 50% in this crop demonstrates two possibilities. The first could be that the seeding process is not uniform and the second could be that the plants have died since sowing or have not germinated. As no obvious patterns can be determined from the image we can safely say that the sowing method was relatively uniform. The latter theory is therefore more feasible. With some plants either dying or failing to germinate, the number of plants per known area is diminished and therefore there will be a lower number of leaves and subsequently a lower density of cells in that known area. The cause for this characteristic is most likely the same as for the false image (Figure 5.3).

Less than 50% of the crop is not healthy as indicated by the vigour image (Figure 5.4). This demonstrates that the crop is stressed in some way that is limiting its potential growth. If a proportion of the plants in the image are indeed healthy, a problem clearly exists.

Conclusion

The soil type, moisture availability and disease have all been mentioned as possible causes of the observed characteristic. Quite possibly, there are combinations of factors involved and not just one limiting factor to explain these images and the economic impacts to the farmers and ultimately the processing pea industry. More detailed research is required to discover the causes of the images presented.

General Discussion

Command and Frontier Optima as a combination pre-emergent herbicide provides an opportunity for the pea industry to overcome one of its greatest disease hurdles. This chemistry allows a pea crop to be free of broadleaf weeds at the time of crop emergence with protection throughout a large part of its life cycle. With the control of double gee *(Emex australis*), fumitory (*Fumaria muralis)*, capeweed (*Arctotheca calendula*) and wild radish (*Raphanus raphanitrum*) achieved with a single spray application, the only other herbicide spray required is for grass species.

The advantages of using only one pre-emergent and one post emergent herbicide compared to up to three or four post emergent herbicides provides a substantial economic saving. Not only are fewer chemicals used but also less damage to cropping area is achieved. With the crop spared from being crushed by spray equipment, the vines have a lower chance of being infected with the Ascochyta that is widespread in the area. With a lower chance of infection due to less injury, fewer fungicide applications are needed that in turn save the crop from further machinery damage.

These two chemicals allow the circle of vine damage followed by fungicide application followed by vine damage, to be broken resulting in a potential higher yield with lower chemical costs. At present, Serve-Ag Research has submitted both these chemicals to the NRA for registration.

As Command and Frontier Optima do not control ryegrass (*Lolium perenne*) at an economic level, the build up of ryegrass resistance in the future will need to be observed. With broadleaf weeds no longer a major issue, the persistence of ryegrass must be managed and one group of chemistry avoided for its control in all crops where it is a problem.

With crop losses of up to 25% from machinery alone, the use of this new chemistry is essential for the industry's survival. However, the use of new chemistry is not the only solution in reducing the risk of Ascochyta. Weather conditions and site suitability will place crops at higher risk even with the use of preventative fungicides such as Bravo 720. Bravo 720 may reduce the incidence of Ascochyta but with its application, damage to the vines will occur allowing further entry for fungal diseases. Without a range of fungicides to control Ascochyta, the use of permanent roadways and tramways must be implemented to enable Ascochyta control.

With permanent roadways and tramways, farm machinery can cover the entire crop without any damage occurring to the vines. The onset of winter weather and its effects on soil compaction will no longer impede farm machinery that requires access to the paddock for agronomic applications. With this practice implemented, the vine yield should reach its optimum with reduced economic costs.

Pea crops grown in trash from a different crop in the previous season show reduced levels of compaction from farm machinery and climate. The use of trash has added benefits as well as the effect of absorbing some of the machinery weight. The trash can also act as mulch, preventing the escape of moisture through evaporation. With less stress experienced by moisture loss the vines should demonstrate an increased state of health. Nutrition levels within the vines did not show any clear link between pea vine sap levels and the incidence of Ascochyta.

The use of aerial photography and the their images is a tool that requires further development. Ideally, the image is required prior to sowing the pea crop and then again during the growth of the crop prior to crop flowering. With images obtained prior to sowing, the best areas for cropping could be identified and areas susceptible to Ascochyta could be avoided. The planning of roadways could also be achieved to minimise the loss of cropping area. Images obtained at an early stage of the crops life may identify problem areas that could be rectified, resulting in a higher crop yield.

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