Chapter Four

Influence of Adjacent crop on Arthropod Abundance and Movement.

Introduction

Refuge habitats

Refuge habitats or nursery crops are areas of vegetation within the agroecosystem that enable beneficial arthropods to increase in abundance. They can take the form of remnant bushland patches, riparian vegetation, abandoned or fallow fields, field edges, roadside verges, domestic parks or gardens, and planted crops. By definition refuge habitats are more attractive to beneficials than conventional crops because they provide the appropriate physical or biological resources in areas where they have been depleted (Wratten & Van Emden 1995). These resources may include over wintering sites, food, in the form of pollen and/or nectar, alternative prey for predators and hosts for parasitoids as well as a refuge from insecticide sprays. The practice of providing refuge habitats in the form of "companion plants" (e.g. flowers) in garden systems has been implemented for many years (Wratten *et al.* 1998). In broad acre cropping systems the use of refuge habitats is beginning to be exploited as part of integrated pest management (IPM) programs (Walker *et al.* 1996, Mensah & Khan 1997, Tuart 1999), despite our poor understanding of the mechanisms behind refuge habitats and arthropod movement.

Refuge habitats in IPM programs work on the premise that beneficials will move out of the refuge habitat into the target crop and stay there long enough to reduce pest numbers. We currently have a very limited understanding of if and how often beneficials move from one crop to another. We are capable of ranking crops in terms of their attractiveness or suitability for beneficials on empirical grounds, even if we are unsure of why they are so attractive. Walker *et al.* (1996) tested a number of crops (lucerne, maize, mungbeans, peanuts, potatoes, sorghum, pigeon pea and sunflower) as potential nursery crops for cotton beneficials in Queensland and New South Wales. They found that lucerne had the greatest diversity of beneficials, followed by sorghum. A similar result was found by Mensah (1999) who recorded consistently higher numbers of predatory Coleoptera and Hemiptera in lucerne than in comparison to alternative crops (cotton, sunflower, safflower, sorghum and tomato). Prasifka *et al.* (1999) investigated the use of sorghum as a source of insect predators for the control of cotton pests. Mark-recapture methods were used to measure predator movement between sorghum and cotton.

Even if we can show that a particular habitat harbors a greater abundance of predators how can this benefit the grower and/or contribute to IPM? Some hypotheses are:

Regional scale – long term (annual)

Refuge habitats increase the abundance of predators on a regional scale because of a combination of factors listed above. What percentage of a cropping area must be devoted to refuge habitats in order to encourage higher predator abundance that leads to a regional scale reduction in pest abundance is unknown.

Local scale – short term (seasonal)

If predators in refuge habitats are able to avoid insecticide sprays, they may leave these habitats and recolonise target crops when spraying has ceased. How the refuge habitats should be spatially located within the farming system and the proximity to target fields is unknown.

Farm scale – short term (within-seasons)

On a farm scale a refuge habitat adjacent to a target crop may reduce pest pressure in the target crop. The predators are thought to move out of the refuge to forage within the target field. Movement can be encouraged by manipulation of the refuge habitat.

All these hypotheses rely on two assumptions. Firstly, increasing the abundance of predators within a target crop will reduce pest damage to plants. This assumption is evaluated in other chapters of this thesis (see Chapter eight) and by many other authors (Johnson *et al.* 2000) so will be taken as given for the purpose of this chapter. Secondly, predators will move out of the refuge habitat into the target crop and stay there long enough to reduce pest numbers. We currently have a very limited understanding of how and why predators move from one crop to another. The dynamics of predator populations has been studied mainly within the target crop. How they function in other areas of the farming system is uncertain (Walker *et al.* 1996). Refuge habitats may have a negative effect by providing an area in which pest arthropods can escape insecticide sprays. Until we understand the mechanisms involved in refuge habitats the creation of large areas of refuge habitats within the farming system may have undesired consequences.

<u>Lucerne as a refuge crop</u>

An ideal refuge habitat would harbour high numbers of beneficials (that are effective against pests in the target crop), lower numbers of pests, be easily manipulated to ensure beneficial movement to the target crop and supply a profit to the grower. Lucerne (*Medicago sativa* L. or alfafa) has long been thought to be such a crop (Hossain *et al.* 2000a, 2001). Lucerne is a perennial forage crop used as feed for horses, dairy cows and other livestock. The crop is regularly harvested (every three to four weeks in summer) just before flowering and allowed to dry before being bailed. A planting can last from two to six years. One of the major benefits of lucerne is its ability to fix nitrogen and so improve soil quality. Lucerne is considered a key crop for salinity control in many areas of Australia, and more recently, lucerne varieties have been developed for ethanol and plastic production and for protecting groundwater quality (Comis 2002).

Bishop and Holtkamp (1982) first investigated the arthropod fauna of lucerne in Australia. Further studies have shown that lucerne crops generally supported large numbers of arthropods (Mensah 1999, Walker *et al.* 1996). Recently cotton growers have been encouraged to use lucerne as a refuge crop for cotton beneficials (Mensah & Harris 1995). This recommendation stems from a great deal of work by Mensah (1999, 2002a, b) using within-field strips of lucerne combined with food sprays to increase beneficial numbers within the cotton crop. The cotton crop was sprayed with the food spray (Envirofeast®) to encourage the movement of beneficials from the lucerne refuge into the adjacent cotton (Mensah 1997, 2002b). Within-field strips of lucerne were found to act as a trap crop for green mirids *Creontiades dilutus* (Stäl) (Mensah & Khan 1997). Very few studies have measured the movement of beneficials from lucerne to the adjacent target crop. Lockrey *et al*. (1994) vacuum sampled pests and beneficials within cotton at distances (two, 12 and 72m) from the lucerne strip. There was some indication that distance from lucerne had an effect on the spatial distribution of some arthropods, however this trend was not consistent nor could it be attributed to the cutting of lucerne. Mensah (1999) recorded similar results in cotton at distances (up to 300m) away from a lucerne strip. But again lucerne cutting was not tested. More promising results have been obtained in experiments that investigate the movement of arthropods from harvested lucerne strips into adjacent refuge strips of unharvested lucerne (Hossain *et al.* 2000a, 2001, 2002). Hossain *et al.* (2002) recorded directional movement of predators using barrier pitfall traps and malaise traps from one to three days after harvesting. In addition ‘sentinel’ cards baited with *Helicoverpa* spp. eggs showed that predation decreased with distance from the harvested plots and that habitat manipulation via lucerne harvesting could increase pest density and movement.

Here I investigate the importance of lucerne in terms of predator abundance and movement into an adjacent target field (soybean). Vacuum samples were used to determine what effect lucerne cutting has on arthropod abundance (pests and predators) in lucerne and adjacent soybean. The results were used to indirectly assess if lucerne cutting encourages movement of predators into soybean. The grid data on predator abundance and predation rate collected in chapter eight was used to investigate trends with distance from the soybean/lucerne interface directly after cutting.

4.A Lucerne cutting and arthropod movement

The questions addressed in this section are:

1. What is the effect of lucerne cutting on arthropod abundance within the lucerne?
2. What effect does lucerne cutting have on arthropod abundance in the adjacent soybean?
3. Does lucerne cutting encourage movement of predators into the soybean?

Materials and methods

During two seasons (2000/01 and 2001/02) arthropods were sampled in soybean fields that were adjacent to lucerne fields. In the first season two fields (Mendel, 3.2ha and Horti., 4.4ha) of soybean (Cawana variety) were planted in rows during the last week of December 2000. The adjacent lucerne (Mendel, Sceptere variety and Horti, Sequel/L69 variety) was planted two years prior. In the second season two fields (Gilbert A, 5.5ha and Gilbert C 8.8ha) of soybean (Warrigal variety) were planted in rows during the first week of December 2001. The adjacent lucerne (Hallmark/Sequel variety) was planted early in the same year. The soybean was inter-row cultivated to reduce weeds, irrigated when necessary and no insecticides were applied. The lucerne was cut and bailed usually every four weeks. The lucerne was directly adjacent to the soybean, except for Horti. where the lucerne and soybean crops were separated by a grassy road (see Chapter eight). Vacuum sample collections of arthropods were conducted over seven lucerne cuts, one in Mendel and two each in Horti, Gilbert A and C.

Vacuum sampling was conducted every two to three days in the lucerne and adjacent soybean. The vacuum sampler was a converted Echo PB2105 leaf blower with black pipe (diameter 12 cm) inserted over the exhaust fan into which a collection bag was attached by an elastic band. In the lucerne, $10m^2$ strips of crop were sampled at five, 10, 15, 20 and 30 metres from the crop interface (fig. 1). The nozzle of the vacuum sampler was moved slowly through the foliage in a swinging motion, covering a 1m swath. Each $10m^2$ area was vacuumed twice (up and back). In soybean 10m of row was sampled at the same distances from the crop interface, by slowly moving the vacuum nozzle through the foliage and up and down the plant stem. Each side of the row was sampled (up and back). A new transect position along the interface was used on each sampling date. Collection bags were removed from the nozzle while the vacuum was still running and sealed. Bags were kept chilled until they were returned to the laboratory and placed in a freezer overnight to kill the arthropods.

Due to the high number of samples collected throughout this experiment, each sample had to be sorted rapidly. Each collection bag was emptied onto a white tray and arthropods sorted into major predator and pest groups (table 1). No samples were examined under a microscope so small arthropods (e.g. microhymneoptera), and some immature stages were not recorded. Spiders were separated and identified to family with the aid of a microscope and stored in 80 percent ethanol.

<u>Data analysis</u>

The data were separated into four groups: predators in soybean, pests in soybean, predators in lucerne and pests in lucerne. Each group was graphed across the season for each field to get an idea of the temporal pattern in pest and predator abundance. Each cut was considered a sampling unit for the purpose of statistical analysis (n = 7). Three out of the four fields used had two cuts and the final field one cut during the sampling period. Technically most of the cuts are not independent because they come from the same field. However the results were highly not significant, therefore the conclusions drawn from the results would not have been affected. Soybean fields had row spacings of 75cm so the numbers were converted from numbers per 10 metre row to numbers per 10 square metres. The data on each group of arthropods for the sampling date just before cutting and the sampling date immediately after cutting were graphed across all cuts. Repeated-measures ANOVA was used to compare the mean of each arthropod group caught before and after cutting, at different cuts, and at different distances from the interface. The interaction between before and after samples and distance was tested. All analysis was performed in the statistical program S-Plus.

The observed number of arthropods in the soybean field after cutting was compared with expected values under different movement scenarios:

<u>Scenario 1.</u> All the arthropods missing from the lucerne after cutting moved into the target soybean field and spread evenly throughout that field. None died during cutting.

<u>Scenario 2.</u> 50 percent of the arthropods missing from the lucerne after cutting moved into the target soybean field and spread evenly throughout that field. The remaining 50 percent went elsewhere or died due to cutting.

Scenario 3. 25 percent of the arthropods missing from the lucerne after cutting moved into the target soybean field and spread evenly throughout that field. The remaining 75 percent went elsewhere or died due to cutting.

The mean number of arthropods per square metre was calculated from the five vacuum samples in lucerne and soybean. The difference (either positive or negative) between the numbers before and after cutting was calculated. In the lucerne field the difference per square metre was multiplied by the lucerne field area to give the total numbers of arthropods missing after cutting. Expected numbers per square metre within the soybean was calculated for three movement scenarios. Expected values were compared to the observed difference in arthropod numbers recorded in the soybean field. This analysis assumes that vacuum sampling catches the same proportion of total arthropods in both crop types and crop growth stages.

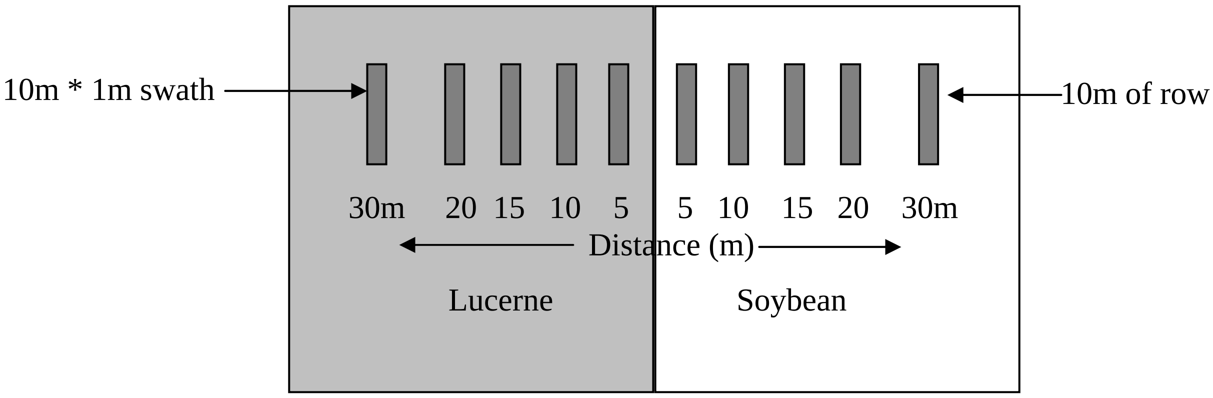


Figure 1. Schematic diagram of vacuum sampling regime in soybean and adjacent lucerne field (2000/01 and 2001/02 seasons). The sampling regime moved to a different position along the interface after each sample. The soybean samples were converted into numbers per 10 square metres based on a 75cm row spacing.

Table 1. Major groups used for sorting vacuum sample catches from lucerne and soybean fields. All other arthropods collected were not counted (wasps, small pests etc.). Identifications and common names are based on Wood *et al.* (2000).

Pests Taxa	Common name	Life stages recorded[1]	**Predators** Taxa	Common name	Life stages recorded[1]
Helicoverpa spp.		All stages	Hymenoptera - Formicidae	Ants	A
Spodoptera litura	Cluster caterpillar	L	Coccinellidae	Various ladybeetles	A, LI
Aproaerema simplexella	Soybean moth	L	*Oechalia schellembergii*	Spiny shield bug	A, LI
Lamprosema. Abstitalis	Legume webspinner	L	*Cermatulus nasalis*	Glossy shield bug	A, LI
Merophyas divulsana	Lucerne leafroller	L	*Taylorilygus pallidulus*	Brocken-backed bug	A
Zizina labradus	Blue-grass butterfly	A, L	*Tytthus chinensis*	Predatory crop mirid	A
Thysanoplusia orichalcea	Soybean looper	L	*Campylomma liebknechti*	Apple dimpling bug	A, LI
Mocis alterna		L	*Nabis kinbergii*	Damsel bug	A, LI
Lepidoptera	Other loopers	L	Hemiptera	Other predatory bugs	A, LI
Lepidoptera	Other	A, L	Neuroptera	Lacewings	A, LI
Monolepta australis	Redshouldered leaf beetle	A	Araneae	Spiders	A, LI
Zygrita diva & *Corrhenes stigmatica*	Lucerne crownborers	A			
Coleoptera	Weevils	A			
Hemiptera – Miridae	Pest mirids	A, LI			
Nezara viridula	Green vegetable bug	A, LI			
Piezodorus hybneri	Banded shield bug	A, LI			
Riptortus serripes, Melanacanthus scutellaris	Brown bean bugs	A, LI			
Hemiptera	Leafhoppers	A			
Hemiptera - Aphidae	Aphids	A, LI [2]			
Hemiptera	Other pest bugs	A, LI			

[1] L: larvae, A: adults, LI: late instars

[2] Estimated in lots of 10 up to 500 per samples

Results

If cutting encourages movement of arthropods we would expect to see an increase in abundance within the soybean directly adjacent to the lucerne with a decrease in abundance as you move away from the interface. The data collected here was combined for all seven cuts to produce an average pest or predator abundance for the sampling date before and directly after cutting (fig. 2). The abundance of lucerne predators was reduced significantly straight after cutting at all distances from the interface (before: mean 17.5 ± standard error 1.5, after: 4.2 ± 0.5, $F_{1,30}$ = 96.89, P < 0.01). Predators in soybean did not show any significant change in mean abundance before or after cutting of the adjacent lucerne (before: 10.7 ± 0.8, after: 11.0 ± 1.1, $F_{1,30}$ = 0.16, P = 0.69). Cutting of lucerne significantly reduced pest numbers in lucerne (before: 84.5 ± 11.9, after: 18.9 ± 3.6, $F_{1,30}$ = 47.49, P < 0.01) but had little effect on pest abundance in adjacent soybean (before: 24.7 ± 4.1, after: 26.5 ± 4.9, $F_{1,30}$ = 0.29, P = 0.29). For all arthropod groups there was a significant difference between cuts (lucerne predators $F_{6,24}$ = 21.15, P < 0.01, lucerne pests $F_{6,24}$ = 200.39, P < 0.01, soybean predators $F_{6,24}$ = 8.79, P < 0.01, soybean pests $F_{6,24}$ = 63.65, P < 0.01) and no significant difference with distance from the soybean/lucerne interface (lucerne predators $F_{4,24}$ = 1.47, P = 0.24, lucerne pests $F_{4,24}$ = 0.19, P = 0.94, soybean predators $F_{4,24}$ = 1.05, P = 0.40, soybean pests $F_{4,24}$ = 1.52, P = 0.23).

The temporal pattern in pest and predator abundance was very different for each field sampled. In Mendel lucerne predators showed a decrease in abundance after cutting and gradually increased as the lucerne grew back (fig. 3). A similar trend was observed for lucerne pests. Soybean predators fluctuated regardless of the cutting of the lucerne. In Horti the pattern of pest and predator abundance in the soybean mirrored what was occurring in the lucerne (fig. 4). This is the only field in which the lucerne and the soybean were separated by a grassy road, this may have influenced the observed temporal patterns. In the following season the numbers of pests in Gilbert A and C were considerably higher than the previous season (fig. 5 and 6). Predators and pests in soybean fluctuated independently of the cutting of adjacent lucerne in both fields. In both fields, cutting of lucerne did reduce pest and predator numbers in lucerne.

The observed difference in arthropod numbers in the soybean after cutting rarely matched any of the three movement scenarios investigated (table 2). After the first cut in Gilbert A the second expected scenario (half the lucerne arthropods spread evenly over the adjacent soybean field) almost matched the observed difference in pest numbers in soybean (observed difference = 1.1, expected from scenario 2 = 1.2, within 10% of observed). In Gilbert C (cut 1) the expected values from scenario 2 were within 20 percent of the observed numbers in soybean (observed difference = 2.4, expected from scenario 2 = 2.7). In all cuts the second expected scenario produced values closest to the observed values. Mendel (cut 2) had the greatest increase in predators (4.3 per metre squared) in the soybean after the adjacent lucerne was cut. Gilbert C (cut 2) had the greatest increase in pests (16.5 per metre squared) in the soybean after the adjacent lucerene was cut. This increase coincided with a large decrease in the numbers of pests (166.2 per metre squared) and predators (20.4 per metre squared) within the lucerne field after cutting. Fields Horti (cut 1 and 2), Gilbert A (cut 2 pests) were not analysed because the arthropod decreased within the soybean after the adjacent lucerne had been cut.

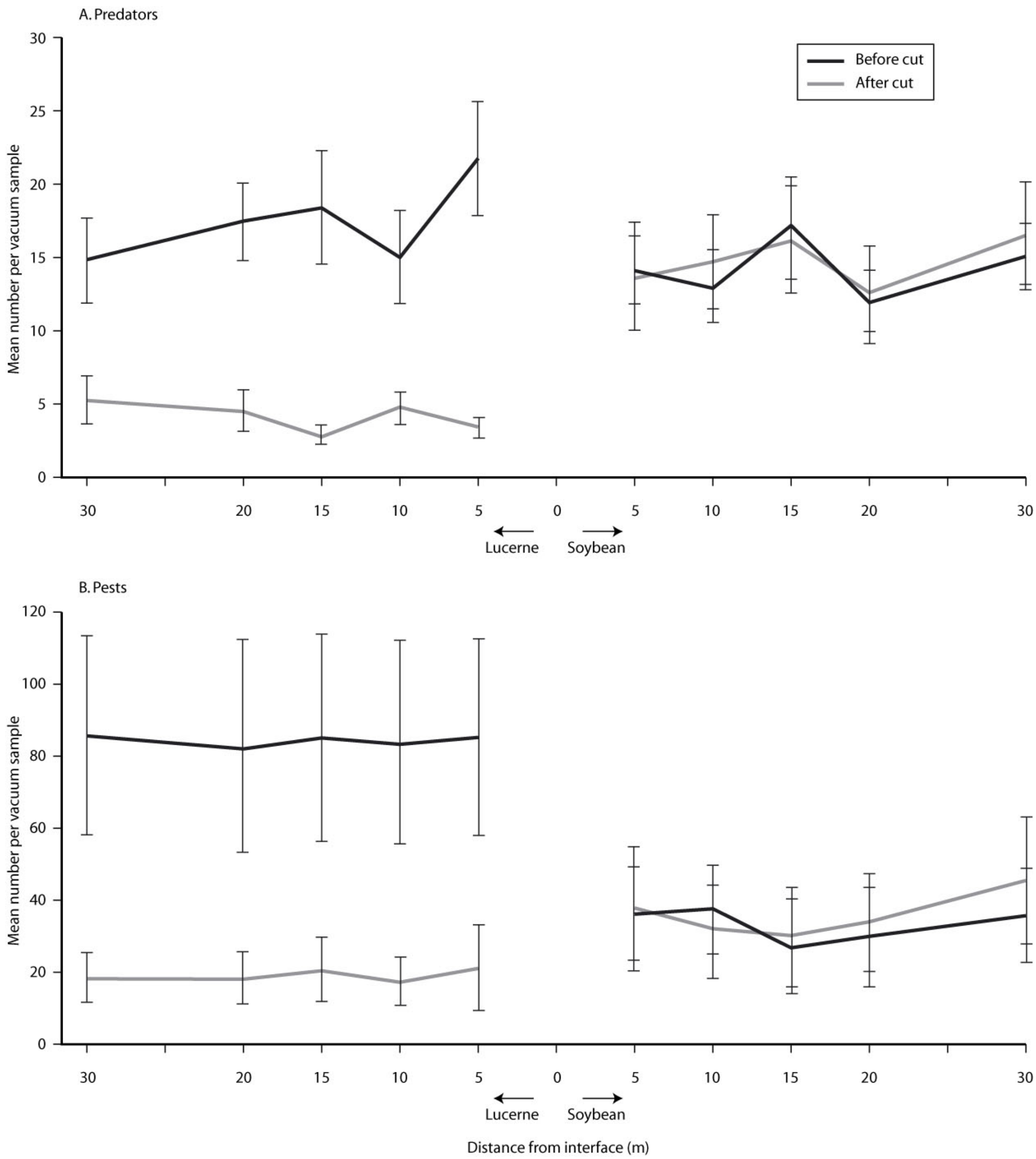
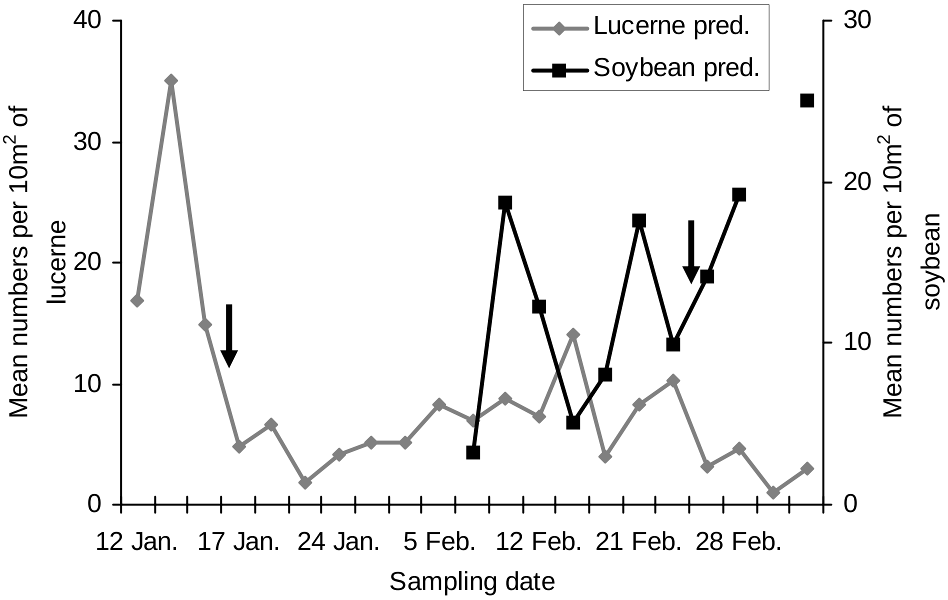


Figure 2. Vacuum samples of arthropods at distances from the lucerne/soybean interface. Arthropods were grouped into Predators in lucerne and soybean (**A**) and Pests in lucerne and soybean (**B**). One vacuum sample was collected immediately before the lucerne was cut and the second immediately after cutting. The bars represent standard error.

A. Predators Mendel



B. Pests Mendel

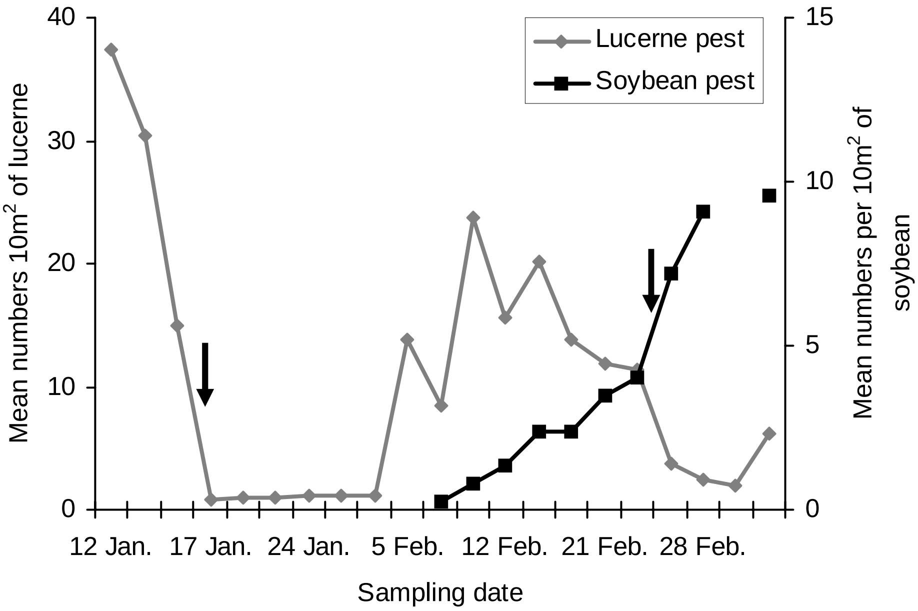
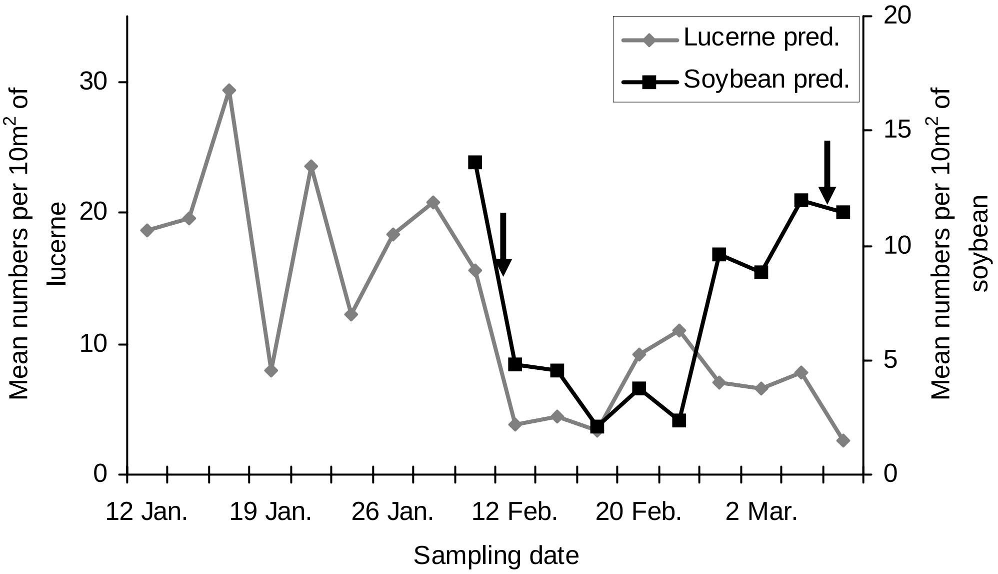


Figure 3. Vacuum samples of **A.** predators and **B.** pests from soybean and adjacent lucerne fields. Mendel field summer 2000/01. Each sampling point is an average of five 10 metre vacuum samples at 5, 10, 15, 20 and 30m from the interface. Arrows indicate when the lucerne was cut. No standard error bars are shown to simplify the graph.

A. Predators Horti



B. Pests Horti

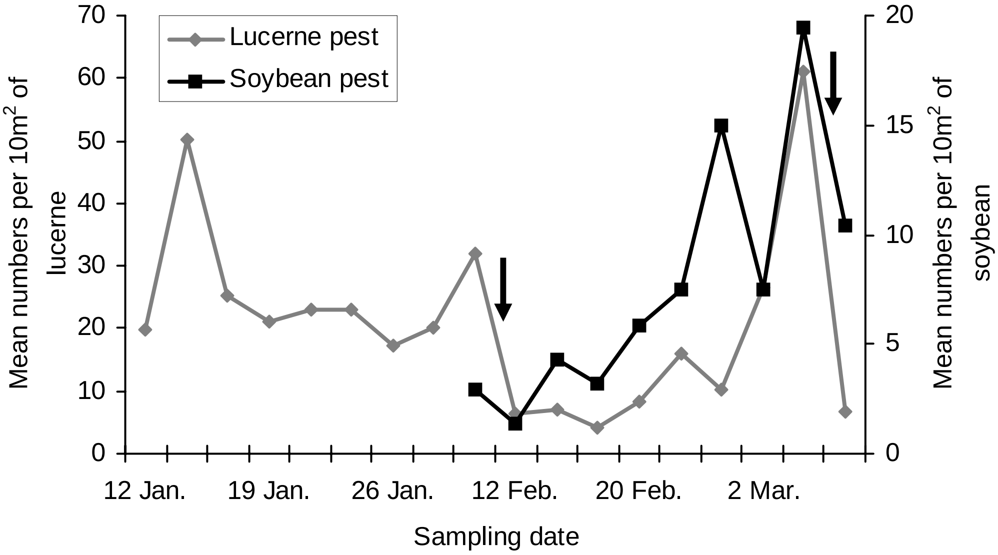
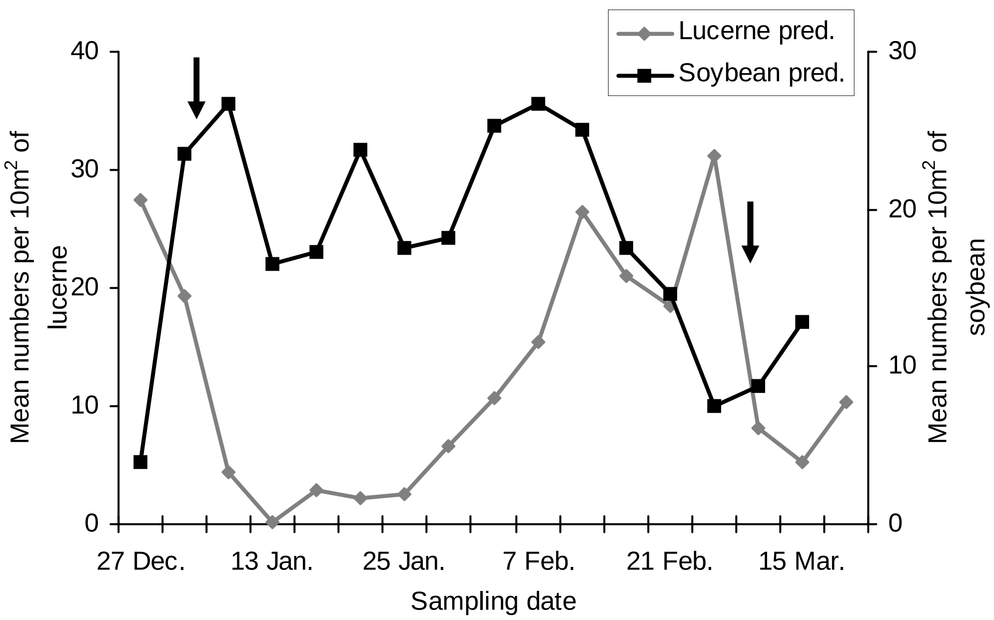


Figure 4. Vacuum samples of **A.** predators and **B.** prests from soybean and adjacent lucerne fields. Horti field summer 2000/01. Each sampling point is an average of five 10 metre vacuum samples at 5, 10, 15, 20 and 30m from the interface. Arrows indicate when lucerne was cut. No standard error bars are shown to simplify the graph.

A. Predators Gilbert A



B. Pests Gilbert A

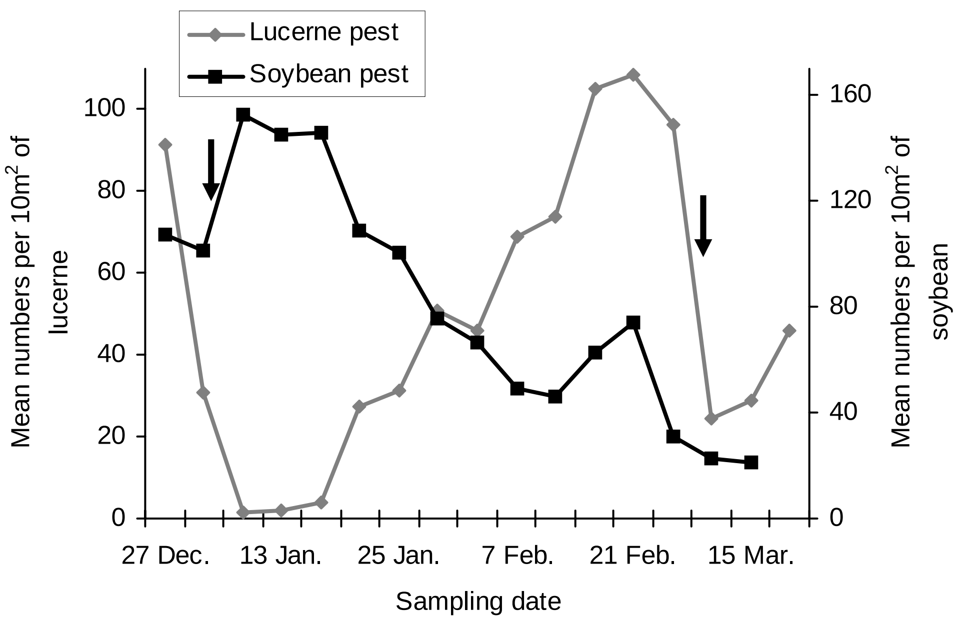
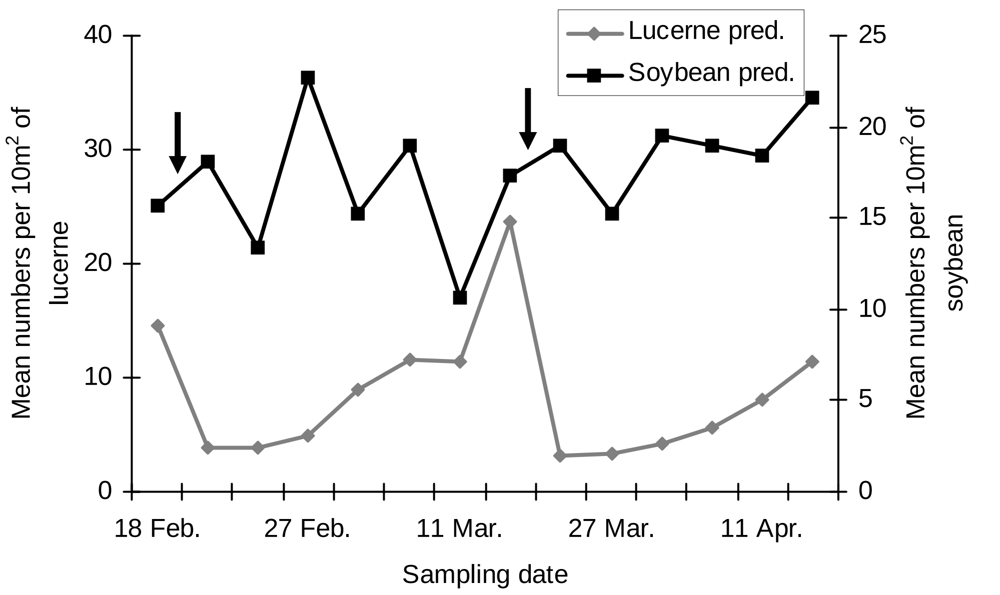


Figure 5. Vacuum samples of **A.** predators and **B.** pests from soybean and adjacent lucerne fields. Gilbert A field summer 2001/02. Each sampling point is an average of five 10 metre vacuum samples at 5, 10, 15, 20 and 30m from the interface. Arrows indicate when lucerne was cut. No standard error bars are shown to simplify the graph.

A. Predators Gilbert C



B. Pests Gilbert C

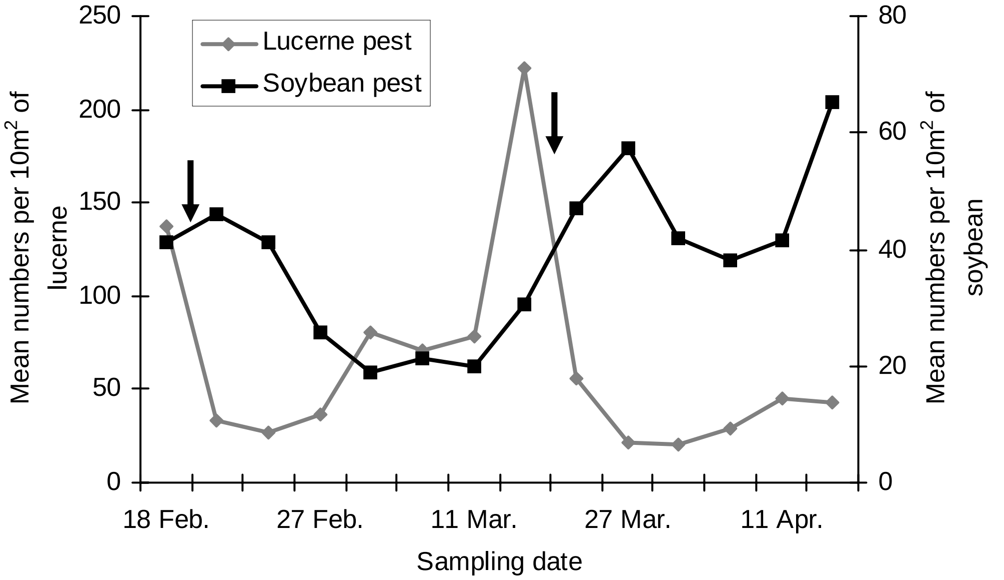


Figure 6. Vacuum samples of **A.** predators and **B.** pests from soybean and adjacent lucerne fields. GilbertC field summer 2001/02. Each sampling point is an average of five 10 metre vacuum samples at 5, 10, 15, 20 and 30m from the interface. Arrows indicate when lucerne was cut. No standard error bars are shown to simplify the graph.

Table 2. Comparison of observed changes in arthropod numbers in soybean and lucerne after cutting of lucerne with three expected movement scenarios. All abundance measures are means of five vacuum samples of $10m^2$ in lucerne and soybean.

Field	Cut	Arthropod group	Observed difference[1] (no./m^2)	Expected based on: Scenario 1. (no./m^2)	Scenario 2. (no./m^2)	Scenario 3. (no./m^2)
Gilbert A	1	Pests	1.12	2.34	1.17[$]	0.58
Gilbert A	1	Predators	0.26	1.2	0.6	0.30[#]
Gilbert A	2	Pests	-0.83	NA	NA	NA
Gilbert A	2	Predators	0.14	1.84	0.92	0.46
Gilbert C	1	Pests	4.79	52	26	13.00
Gilbert C	1	Predators	2.4	5.4	2.7[#]	1.35
Gilbert C	2	Pests	16.49	83.1	41.55	20.78
Gilbert C	2	Predators	1.6	10.2	5.1	2.55
Mendel	2	Pests	3.19	11.4	5.7	2.85[$]
Mendel	2	Predators	4.26	10.5	5.25	2.63

[1] Difference = After cut count - Before cut count
Scenario 1. All lucerne arthropods spread evenly over adjacent soybean field
Scenario 2. 50% of lucerne arthropods spread evenly over adjacent soybean field
Scenario 3. 25% of lucerne arthropods spread evenly over adjacent soybean field
[$] Indicates expected values are within 10% of the observed value
[#] Indicates expected values are within 20% of the observed value

Discussion

If there was movement of arthropods (pests or predators) from lucerne to adjacent soybean field in response to cutting we would expect to see more arthropods in the soybean directly after cutting and maybe even some relation to distance from interface. This was not observed (fig. 2). The cutting of lucerne did effectively reduce numbers of pests and predators in the lucerne field. A corresponding increase in abundance in adjacent soybean was not observed for pests or predators.

The average number of pests and predators did increase in the soybean after cutting of the adjacent lucerne in some cases (pests: four out of seven cuts, predators: five out of seven cuts, table 2). This increase was often much smaller than what would be expected if all the arthropods missing from the lucerne were to move into the adjacent soybean and spread evenly throughout (scenario 1, table 2). Some of the arthropods missing from lucerne may have moved into other surrounding fields and fields further away. The expected value, if half the missing arthropods were to move into adjacent soybean field, was closer to the observed value in most cases (scenario 2, table 2). This analysis involved comparing numbers of arthropods missing from cut lucerne to numbers of arthropods found in adjacent soybean and relies on the assumption that the vacuum sampler is equally efficient in both crop types. Hossain *et al.* (1999) found that the efficiency of vacuum sampling differed between tall and short lucerne. In this study no attempt was made to standardise arthropod collection data between the two crop types and this may bias the expected values obtained.

Not all of arthropods missing from lucerne after cutting would have been able to move into the adjacent fields. Some arthropods missing from lucerne may have been killed during the cutting process. This seems unlikely for the flying arthropods that are able to disperse very quickly when disturbed. It is not uncommon to observe Coccinellidae adults flying away before the lucerne slasher has cut an area of crop. Further evidence that few arthropods are killed by the action of the slasher comes from Hossain *et al.* (2000b) who found that the proportion mortality attributed to the cutting of lucerne was 0.16 for *C. transversalis*, 0.07 for *O. schellembergii* and zero for *D. bellulus*. Howell and Pienkowski (1971) found that abundance of Linyphiidae, Thomisidae and Salticidae changed after lucerne cutting and this was due to movement out of the field as well as the ability of spiders to hide in cracks in the soil but not mortality. The vacuum sampling protocol used would have only detected gross movements of plant-dwelling arthropods from one defined area to another. No conclusions can be drawn about cursorial movement from the vacuum sampling results. Furthermore, samples were only collected during the daytime and some nocturnally active predators may have been missed (Green 1999). Abundance sampling can only provide an indirect indication of predator movement through observed changes in abundance patterns.

My results are similar to those of Stoltz and McNeal (1982) who found no difference in insect numbers at 10, 50 and 100 metres into adjacent bean fields when lucerne was cut. In fields of hay lucerne adjacent to seed lucerne in Alberta, insect movement from the cut hay fields was detected for only a few species and it was only obvious directly adjacent to the cut hay (Schaber *et al.* 1990). Mensah (1999) found that predator numbers recorded in cotton at distances away from a lucerne strip were not significantly different from each other. Some predators (predatory bugs and spiders) did show spatial patterns in relation to distance from lucerne however these results were not related to lucerne cutting. Perhaps mark-recapture experiments (see Prasifka *et al.* 1999) that include the addition of a food spray in combination with lucerne cutting may produce clearer evidence of arthropod movement. It is apparent that cutting of lucerne is followed by an expected decrease in plant-dwelling pests and predators within the lucerne crop. No corresponding increase in abundance in pests or predators was observed in adjacent soybean. This suggests that cutting of lucerne alone does not result in movement of predators into the adjacent target crop as has been suggested. However the presence of lucerne fields within a cropping area may have some impact on regional predator populations and so still be useful for IPM programs, although this has yet to be critically tested.

4.B Trends with distance from the adjacent lucerne

The grid data collected in Chapter eight was used to answer the following questions:

1. Are there any patterns in abundance of predatory arthropods with distance from the lucerne/soybean interface?
2. Are there any patterns in predation of *H. armigera* eggs and pest damage to plants with distance from the lucerne/soybean interface?

Materials and Methods

Over two seasons (2000/01 and 2001/02) data on arthropod abundance, plant damage and egg predation was collected in a grid sampling scheme. The data was collected as part of an intensive sampling scheme investigating within field spatial patterns (see Chapter eight). The sampling grid consisted of a minimum of 42 points and was positioned across the lucerne/soybean interface. Traps were arranged in a six by seven point grid with 20m between each sampling point. The first row of six traps was located in the lucerne at 10m from the interface (referred to as -10m in the graphs) and the next rows were placed in the adjacent soybean at 10, 30, 50, 70, 90, and 110m away from the interface. In six of the eight sampling grids the final row of traps was a minimum of 20m from the edge of the soybean field. Gilbert A was shorter in length than the other fields and so the sampling grid was extended to the edge of the soybean field. An extra row of sampling points was located at 130m and a row in the weedy edge of the field (approximately 150m).

At each point on the grid a pitfall trap collected ground-dwelling arthropods and a vacuum sample (25cm of soybean row or 25cm^2 area of lucerne) collected foliage-dwelling arthropods. An egg card with 20 *H. armigera* eggs was attached to a plant at each grid point and left exposed for 18 hours as a measure of predation. Leaf area loss and pod damage estimates were collected at each grid point. A more complete description of methods used to collect arthropods and other parameters at each of these sampling points is given in Chapter eight. In total eight grids were sampled from four fields (table 3). The arthropod collections in Gilbert C grid 3 were not sorted so only a limited data set was available for analysis. All sampling took place at the same time in the lucerne growth cycle, just after cutting.

<u>Data analysis</u>

The data in chapter eight was analysed using statistical techniques that show spatial patterns in counts that have both X and Y reference points. In this section I investigate simpler patterns that are influenced only by the samples distance from the lucerne/soybean interface

(Y location). The data was treated as a transect that runs perpendicular to the interface. A correlation matrix was calculated for each sampling grid in the program S-Plus. Those parameters which displayed large correlation coefficients (greater than 0.50 or less than negative 0.50) with Y were investigated further using scatter plots and robust linear regression.

Bar graphs were used to present non-linear patterns. The mean of the six samples collected at each distance along the transect (the Y values) was calculated for a few of the more interesting parameters.

Results

Linear correlations

The parameters that were correlated with distance from lucerne were different for each sampling grid (table 3). In Horti grid 1 Dermaptera caught in pitfall traps showed a positive correlation with distance for lucerne (fig. 7). In Mendel grid 1 spiders caught in pitfall traps showed a negative correlation with distance from lucerne ($P < 0.01$). Linear regression showed that only 14 percent of variation in spider abundance was explained by distance from lucerne, however this relationship was significant. In Mendel grid 2 leaf area loss and vacuum sampled predators were positively correlated with distance from lucerne. In Gilbert A grid 1 spiders collected in pitfall traps and Lycosidae showed a negative correlation with distance from lucerne. Linear regression did not show a significant relationship for both predatory groups and their R^2 values were low (PT Araneae $R^2 = 0.05$, $P = 0.11$, PT Lycosidae $R^2 = 0.18$, $P = 0.06$). The scatter plot suggests that the simple correlation coefficient was strongly influenced by the high numbers collected in lucerne (fig. 8). In the soybean field itself there is little variation with distance from lucerne. Predators and pests collected in vacuum samples showed a strong positive correlation with distance from lucerne. This relationship was significant (V Predators $R^2 = 0.31$, $P < 0.01$, V Pests $R^2 = 0.31$, $P < 0.01$). In Gilbert A grid 2 pest arthropods collected in vacuum samples and weed density were correlated with distance from lucerne. In Gilbert C grid 1 and 2 spiders collected in pitfall traps were negatively correlated with distance from lucerne. This pattern was primarily due to high numbers recorded in the lucerne field and 10m into the soybean field (fig. 9). In Gilbert C grid 1 plant height was not strongly correlated with distance from lucerne however in grid 2 there was a strong positive correlation. Examination of the scatter plots shows that the weak correlation in grid 1 is a result of higher than expected plant height at 10m from the interface (fig. 10). By the second grid this difference is less apparent and the soybean plant height is fairly constant throughout the field (fig. 10). The strong positive correlation is an artefact of lucerne plant height that is naturally much shorter than that of soybean.

Non-linear patterns

Some of the more interesting parameters measured did not show a simple linear pattern with distance from the lucerne/soybean interface. *H. armigera* egg predation on cards in Horti grid 1 was high in lucerne and decreased from 10 to 50m away from the interface then increased towards the back of the field (fig. 11). In Mendel grid 1 egg predation was also lowest at 50 to 110m away from the interface (fig. 11). In Gilbert A grid 1 and 2 there was an increase in egg predation in lucerne and at 130m from the interface, close to the weedy edge (fig. 12). In Gilbert C field there appeared to be no common pattern amongst sampling grids (fig. 12). The overall average egg predation varied greatly between fields and between grids within a field. In Gilbert C the mean egg predation per card was 30 to 40 percent but in Gilbert A it was 39 to 59 percent. In Mendel mean egg predation per card was 16 to 38 percent and 45 percent in Horti (results discussed in detail in Chapter eight).

Leaf area loss due to the action of herbivorous pest arthropods was very low throughout both seasons (on average < 10%). The pattern in leaf area loss was very variable between sampling grids (only Mendel has been graphed fig. 13). Mendel grid 1 showed the clearest pattern with higher leaf area loss immediately adjacent to lucerne, which decreased with increasing distance from the interface (fig. 13). Mendel grid 1 was the only grid which showed a strong positive linear correlation between leaf area loss and distance from lucerne (table 3).

Predator abundance in vacuum samples and pitfall traps showed no consistent trends with distance from lucerne (only Horti and Gilbert A have been graphed fig. 14). In Horti grid 1 predator abundance in pitfall traps was lowest in lucerne and increased gradually until 50m away from the interface (fig. 14). In Mendel grid 1 predator abundance was similar in the lucerne and soybean fields. In Gilbert A grids 1 and 2 the greatest predator abundance was recorded in traps near the weedy field edge (fig. 14). This increase was primarily due to high numbers of ants being caught in these traps. In Gilbert C grid 2 a peak in abundance was observed at 70m from the interface. A single trap that collected large numbers of ants heavily influenced this mean value.

Generally numbers of plant-dwelling predators (and other arthropods) caught in vacuum samples increased as the plants matured. In Horti grid 1 there was a peak in abundance of predators caught in vacuum samples at 10m from the interface (fig. 15). This increase was again primarily due to higher than average numbers of ants collected. Similar explanation can be given for the peaks at 70m and 90m from the interface. In Mendel there was a consistent trend in grid 1 and 2 with increasing predator abundance with distance from lucerne (Fig. 15). No plant-dwelling predatory groups were collected in high numbers in lucerne. A few ants were occasionally collected but all other predators did not remain in the cut lucerne. In Gilbert A grid 1 the greatest numbers of predators were caught at 110m from the interface (fig. 16). By grid 2 the numbers of predators caught throughout the soybean field were similar. In Gilbert C patterns in abundance were variable (fig. 16) with the highest abundance recorded at 10m from lucerne in grid 1 and at 50m from lucerne in grid 2.

Table 3. Correlation coefficients for various parameters against distance from the lucerne/soybean interface (Y-value). In total eight sampling grids were collected from four fields across two seasons. Coefficients greater than 0.50 or less than –0.50 are shown in bold.

	Horti grid 1	Mendel grid 1	Mendel grid 2	Gilbert A grid 1	Gilbert A grid 2	Gilbert C grid 1	Gilbert C grid 2	Gilbert C grid 3
V Predators	-0.02	0.32	**0.53**	**0.59**	0.04	-0.02	0.33	NA
V Pests	-0.09	0.08	0.28	**0.57**	**-0.75**	-0.07	-0.20	NA
PT Predators	0.31	0.17	-0.08	0.23	0.25	-0.42	-0.05	NA
PT Dermaptera	**0.65**	-0.38	-0.18	-0.09	0.00	-0.37	-0.09	NA
PT Carabidae	0.32	-0.03	0.30	-0.30	0.11	**-0.59**	0.17	NA
PT Araneae	0.13	**-0.59**	-0.31	**-0.58**	-0.04	**-0.62**	**-0.60**	NA
PT Lycosidae	NA	-0.45	-0.15	**-0.64**	-0.23	-0.48	**-0.67**	NA
PT Pests	0.35	-0.08	0.11	0.06	0.19	-0.39	0.28	NA
% Egg predation	-0.09	-0.44	-0.20	-0.09	-0.16	-0.31	0.12	-0.21
% Leaf area loss	-0.37	-0.25	**0.58**	0.39	0.36	0.30	-0.10	0.35
Weed density	NA	NA	NA	0.29	**0.62**	-0.25	0.24	0.38
Plant height	NA	NA	NA	**0.59**	0.15	-0.35	**0.57**	-0.11

V: Vacuum samples, PT: Pitfall traps, NA: indicates parameter not analysed

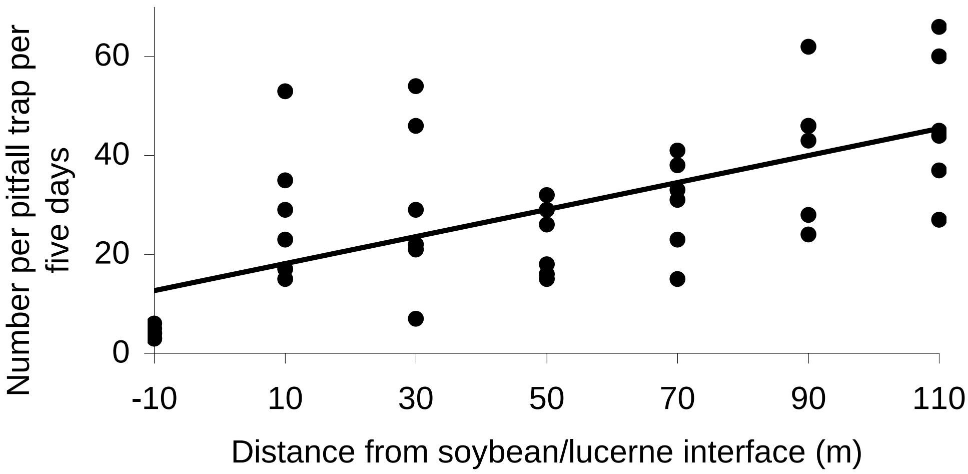


Figure 7. The pattern in Dermaptera caught in pitfall traps at distances from the lucerne/soybean inerface in Horti field grid 1. At each Y point six pitfall traps were placed out at 20m from each other.

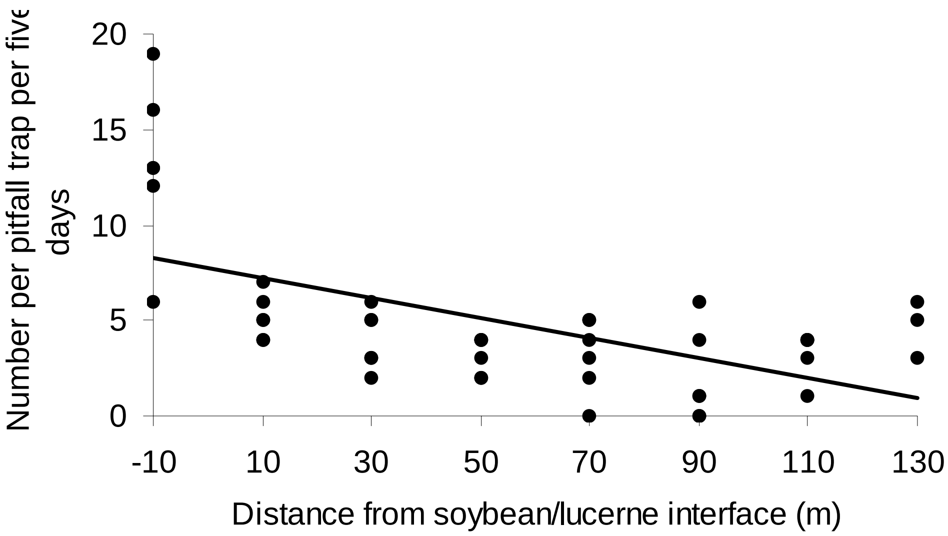


Figure 8. The pattern in Araneae caught in pitfall traps at distances from the lucerne/soybean inerface in Gilbert A grid 1. At each Y point six pitfall traps were placed out at 20m from each other.

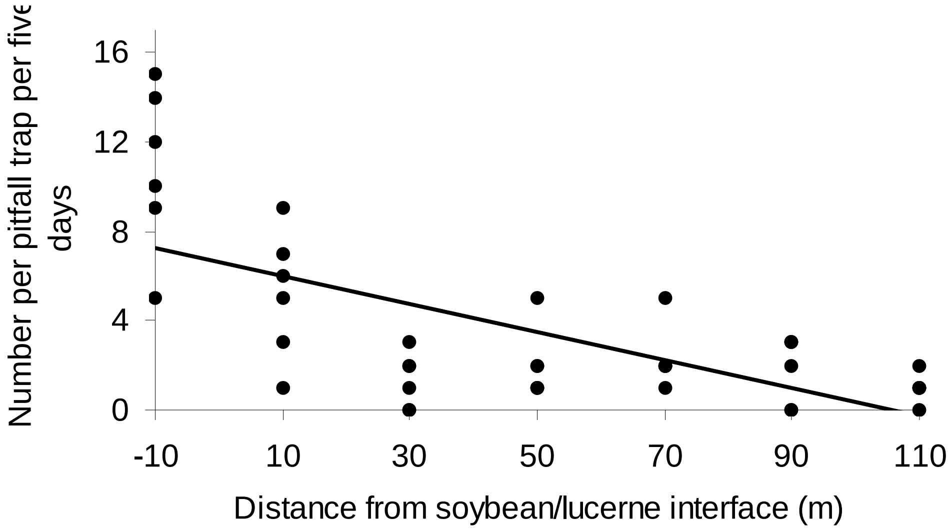
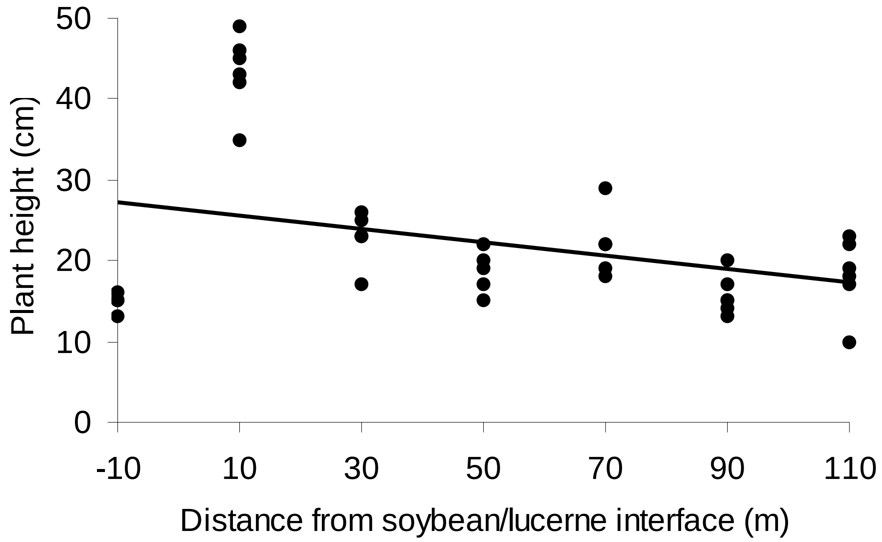


Figure 9. The pattern in Lycosidae caught in pitfall traps at distances from the lucerne/soybean inerface in Gilbert C grid 2 (r = -0.67). At each Y point six pitfall traps were placed out at 20m from each other.

A. Gilbert C grid 1 *r* = -0.35



B. Gilbert C grid 2 *r* = 0.57

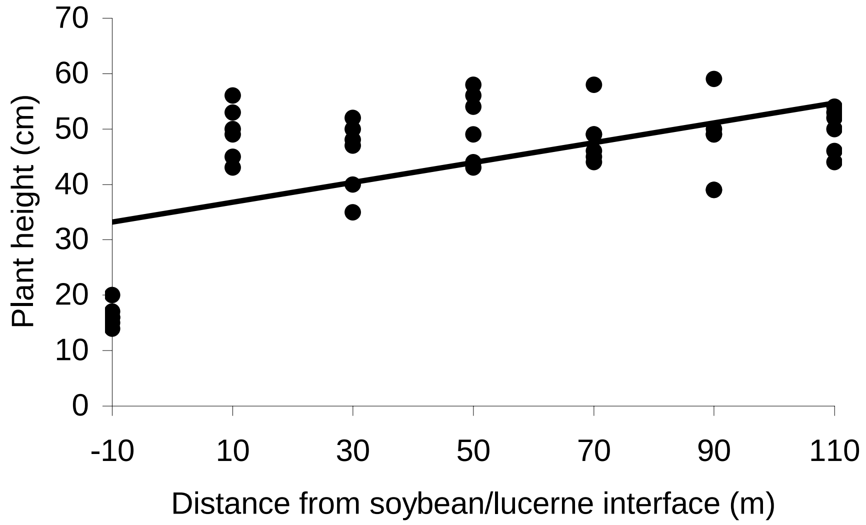
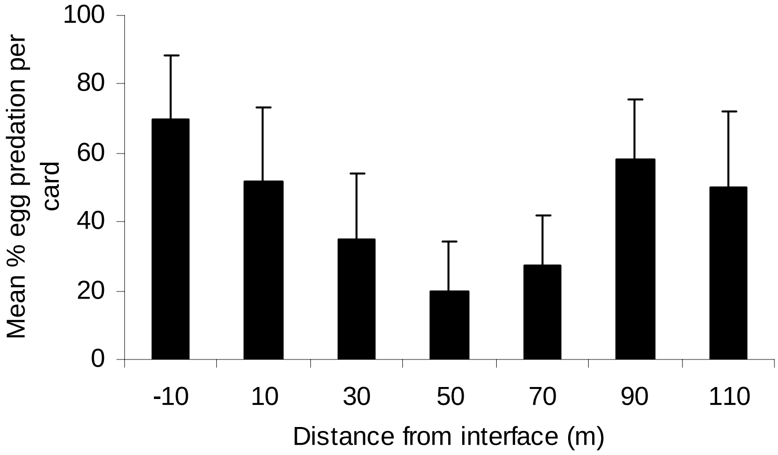


Figure 10. Pattern in plant height at distances from the lucerne/soybean interface in **A.** Gilbert C grid 1 and **B.** grid 2. At each Y point six samples of plant height were collected at 20m from each other.

A. Horti grid 1



B. Mendel grid 1 and 2

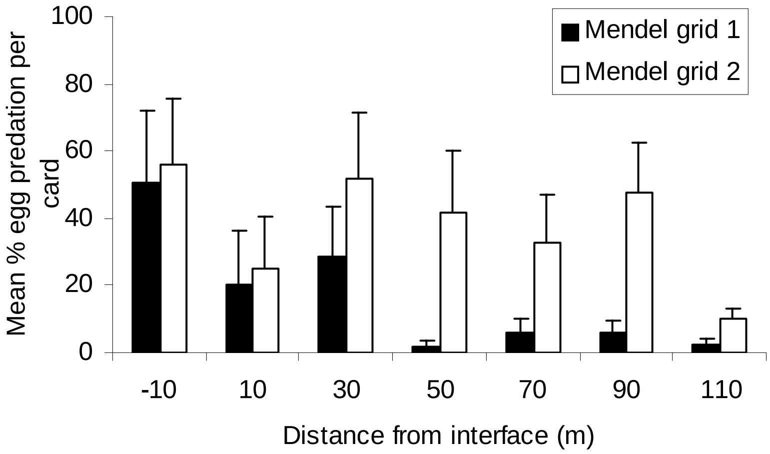
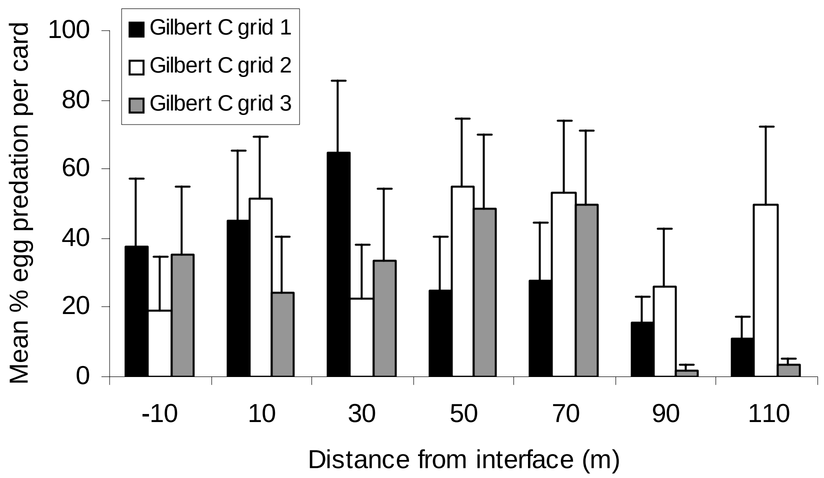


Figure 11. Patterns in *H. armigera* egg predation on cards with distance from the lucerne/soybean interface in **A.** Horti field grid 1 and **B.** Mendel field grid 1 and 2. The –10 value indicates the samples were collected in the lucerne field at 10m away from the interface; all other samples were in the soybean field. There were six replicates at each distance and the bars indicate standard error.

A. Gilbert C grid 1, 2 and 3



B. Gilbert A grid 1. and 2.

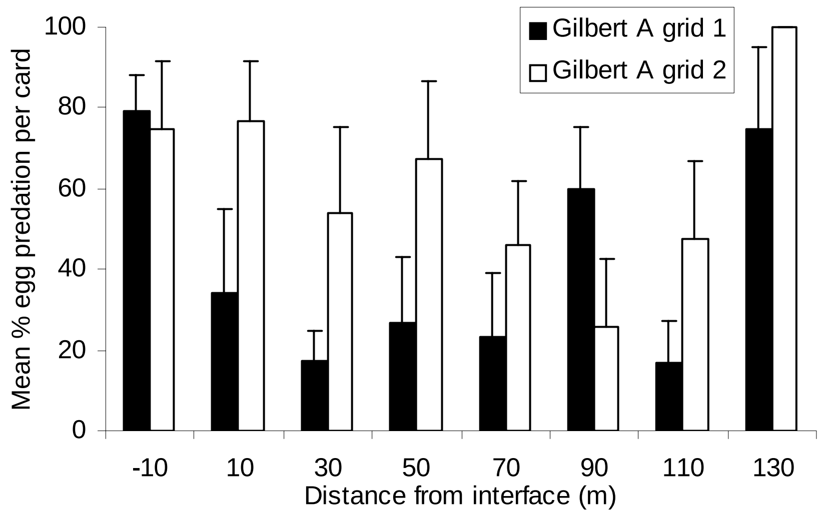


Figure 12. Patterns in *H. armigera* egg predation on cards with distance from the lucerne/soybean interface in **A.** Gilbert C field grid 1, 2 and 3 and **B.** Gilbert A field grid 1 and 2. The –10 value indicates the samples were collected in the lucerne field at 10m away from the interface; all other samples were in the soybean field. There were six replicates at each distance and the bars indicate standard error.

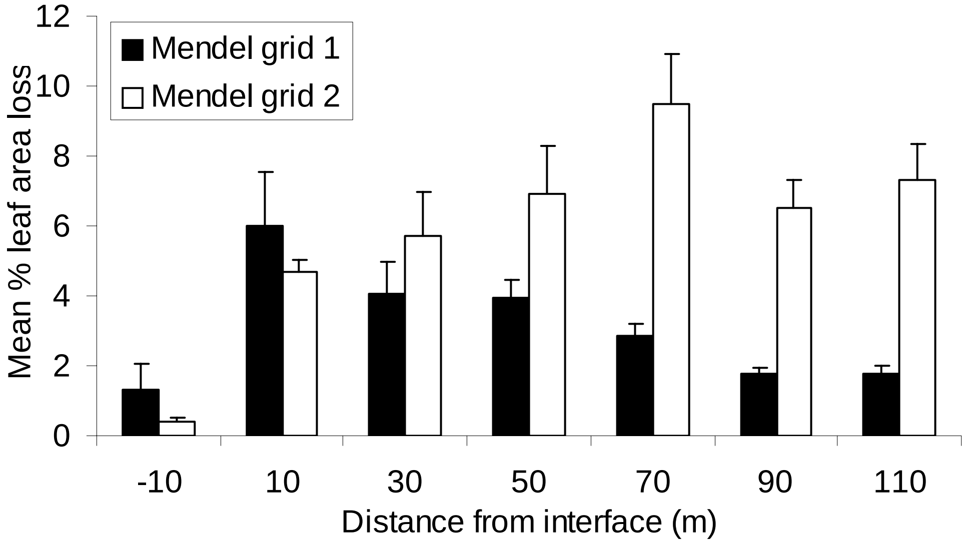
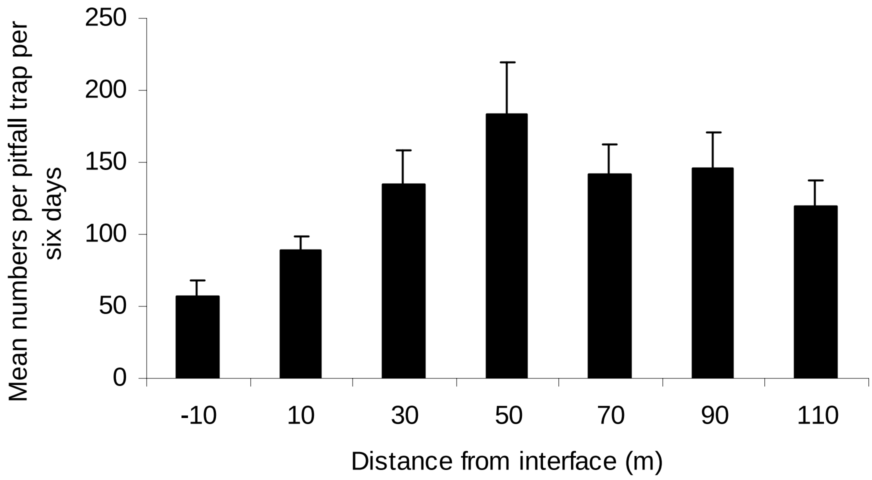


Figure 13. Patterns in leaf area loss with distance from the lucerne/soybean interface in Mendel grid 1 and 2. The –10 value indicates the samples were collected in the lucerne field at 10m away from the interface; all other samples were in the soybean field. There were six replicates at each distance and the bars indicate standard error.

A. Horti grid 1



B. Gilbert A grid 1 and 2

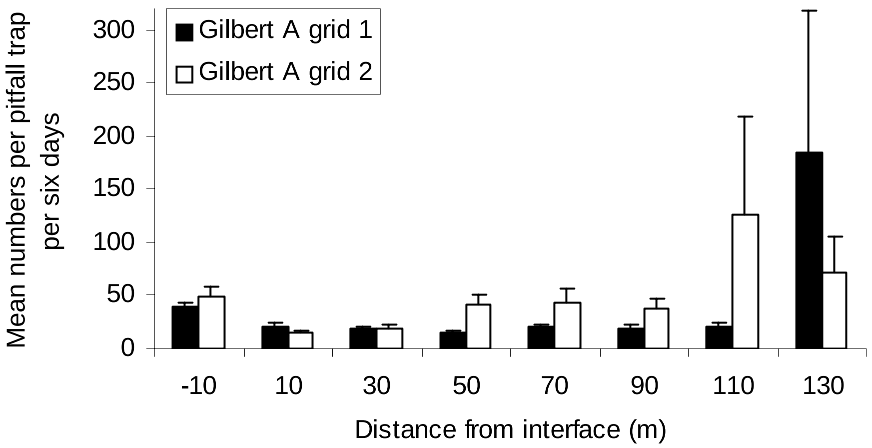
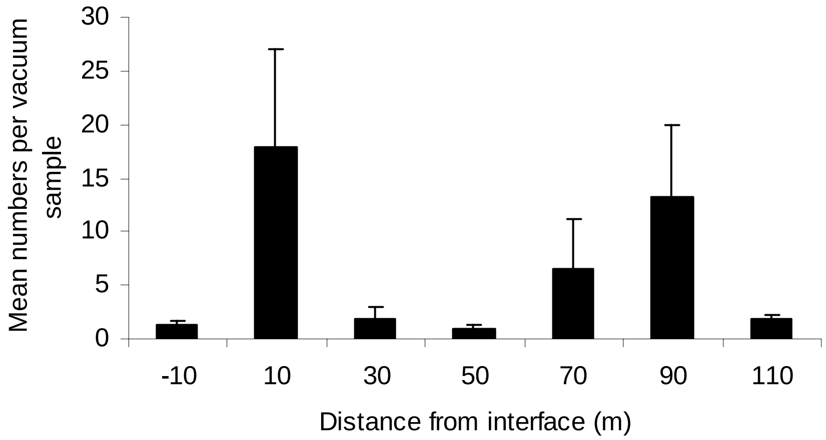


Figure 14. Patterns in predator abundance in pitfall traps with distance from the lucerne/soybean interface in **A.** Horti field grid 1 and **B.** Gilbert A grid 1 and 2. The –10 value indicates the samples were collected in the lucerne field at 10m away from the interface; all other samples were in the soybean field. There were six replicates at each distance and the bars indicate standard error.

A. Horti grid 1



B. Mendel grid 1 and 2

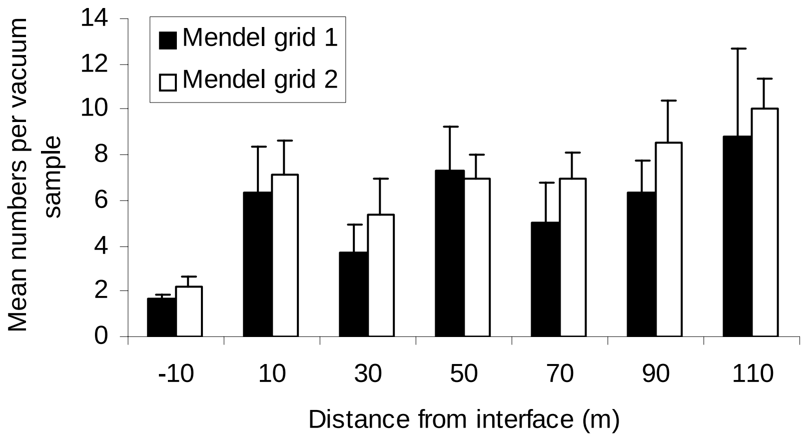
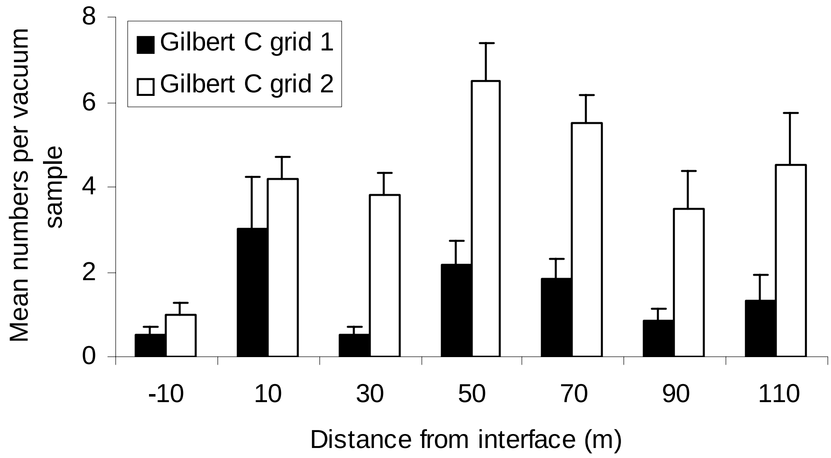


Figure 15. Patterns in predator abundance in vacuum samples with distance from the lucerne/soybean interface in **A.** Horti grid 1 and **B.** Mendel grid 1 and 2. The –10 value indicates the samples were collected in the lucerne field at 10m away from the interface; all other samples were in the soybean field. There were six replicates at each distance and the bars indicate standard error.

A. Gilbert C grid 1 and 2



B. Gilbert A grid 1 and 2

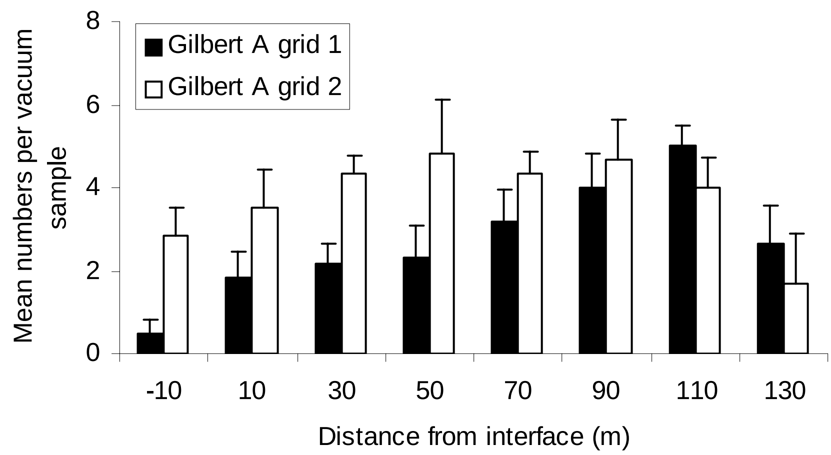


Figure 16. Patterns in predator abundance in vacuum samples with distance from the lucerne/soybean interface in **A.** Gilbert C grids1 and 2 and **B.** Gilbert A grid 1 and 2. The –10 value indicates the samples were collected in the lucerne field at 10m away from the interface; all other samples were in the soybean field. There were six replicates at each distance and the bars indicate standard error.

Discussion

All of the data from the sampling grids was collected at one point in the cycle of lucerne plant growth, immediately after cutting. At this point in time you would expect the crop to be very unattractive for plant-dwelling arthropods and be an ideal time to detect movement into adjacent crop. If such behaviour occurred you would expect to observe a greater abundance of arthropods directly adjacent to lucerne that then decreases with distance from the interface. Similar trends should be seen in measures of arthropod activity such as plant damage and predation rate. Leaf area loss in Mendel grid 1. is one of few parameters which displayed this expected pattern of linear decrease with distance from lucerne (fig. 13). To detect linear relationships between the parameters measured and distance from lucerne correlation coefficients were calculated (table 3). Strong positive and negative linear correlations existed for a few parameters in each grid, but the relationships were not consistent. Further analysis using linear regression showed that not all strongly correlated factors responded significantly to the Y location. Often this was due to the fact that the parameter measured was higher in the lucerne but displayed no gradient, or a minor gradient once in the soybean (for example fig. 8).

For those parameters that showed a strong correlation with distance from lucerne we cannot conclude, from these results, that proximity to lucerne was the cause of the observed pattern. Firstly, there may be an underlying factor, which was not measured, that also displays a similar pattern with distance from lucerne and has a greater impact on the observed parameter. Secondly, distance from an interface may have a significant effect on the parameter measured regardless of what crop type is adjacent to soybean. Only soybean adjacent to lucerne was examined here but soybean adjacent to sorghum or sweet corn may give similar results.

Consistent non-linear patterns were not detected in the data. Distance from lucerne had some influence on egg predation rate in Gilbert A fields, but so too did the weedy field edge at the other side of the field (fig. 12). Distance from the weedy field edge had an influence on the abundance of predators in pitfall traps (fig. 14). Their presence in pitfall traps indicates that they are capable of foraging large distances (at least 20m) into the field from the uncultivated field edge. Distance from lucerne (and the weedy field edge in Gilbert A) generally had little effect on predators collected from vacuum samples. Abundance of predators appears to be effected more by plant characteristics in the immediate sampling area. This is particularly true for Gilbert C field in which the soybean was planted at different times. Heavy rains prevented the entire field being sown after approximately 20m of crop had been planted adjacent to lucerne. The remaining field was sown a week later after the first rows had emerged. This is supported by the predator abundance in the vacuum samples, which peaked at 10m from the interface in the first grid. By the second sampling grid the differences in plant height were less apparent (fig. 10 and 16).

Comparing data collected from two crop types using the same measurement technique can be difficult due to differences in collection efficiency in each crop. For example, the technique used to estimate leaf area loss was designed for use in soybean fields. Using the same technique in lucerne, which has a very different leaf size and shape, may produce inappropriate results. Sampling techniques such as pitfall traps should have similar catch efficiency in lucerne and soybean fields, however vacuum sample catches may not because they are influenced by plant characteristics (Hossain *et al.* 1999). Standardisation of sampling techniques across crop types was not attempted here but is recommended for future work.

No clear and consistent patterns were detected in the abundance of predatory arthropods with distance from the lucerne/soybean interface. The same conclusion can be drawn for patterns in predation of *H. armigera* eggs and pest damage to plants with distance from interface. The interface (with lucerne and with other field edges) did have some influence on some parameters measured however many other factors appear to be involved with determining predator abundance and activity. These conclusions support those of the previous section (and Chapter three), which found that cutting of lucerne alone does not guarantee movement of predators into the adjacent target crop. These results clearly show that some parameters fluctuate greatly within a field whilst others are homogeneous throughout.

Chapter Summary

- Vacuum samples were used to determine what effect lucerne cutting has on arthropod abundance (pests and predators) in lucerne and adjacent soybean. In lucerne, a $10m^2$ strip of crop were sampled at 5, 10, 15, 20 and 30m from the crop interface and in soybean 10m of row was sampled at the same distances.
- The abundance of lucerne predators was reduced immediately after cutting at all distances from the interface. Predator abundance in soybean did not show any change. Cutting of lucerne significantly reduced pest numbers within the lucerne but had little effect on pest abundance in the adjacent soybean.
- For all arthropod groups there was a difference in the numbers of pests and predators caught between each cut (n = 7 cuts in total) but little difference was found in arthropod abundance with distance from the soybean/lucerne interface.
- The temporal pattern in pest and predator abundance was very different for each field sampled. In most fields arthropod abundance in soybean fluctuated regardless of the cutting of the lucerne.
- Grid data on predator abundance and predation rate collected in chapter eight was used to investigate trends with distance from the soybean/lucerne interface directly after cutting.
- Strong positive and negative linear correlations existed for a few parameters in each grid, but the parameters were not consistent. Leaf area loss in Mendel grid 1 displayed the expected pattern of linear decrease with distance from lucerne.
- No clear and consistent patterns were detected in the abundance of predatory arthropods, predation of *H. armigera* eggs, and pest with distance from the interface. Some of the parameters measured fluctuated greatly within a field whilst others are homogeneous throughout.
- The cutting of lucerne alone does not guarantee movement of predators into the adjacent target crop. However the presence of lucerne fields within a cropping area may have some impact on regional predator populations.

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