Plant Bugs (Miridae) on Edible Beans

Cumulative report of research activities and results 2008 and 2009

to the

Manitoba Pulse Growers Association Inc.

Principal investigator

N. J. Holliday
Department of Entomology
University of Manitoba

Email: Neil_Holliday@UManitoba.CA

Report prepared by T. Nagalingam and N. J. Holliday

Summary

Four species of plant bugs are relatively abundant in southern Manitoba. In some years, plant bugs are of concern in dry edible beans and spraying of the crop against plant bugs occurs. However there is little information on the nature of injury of plant bugs to the crop, and the levels at which it is economically justified to control plant bugs. To address this issue this research project was planned with three objectives:

1. To assess the seasonal pattern and species composition of plant bugs in dry beans in Manitoba,
2. To examine in controlled conditions the effect of different stages of lygus bugs and of alfalfa plant bugs on different growth stages of dry edible beans, and
3. In field plots or field cages to develop general relationships between plant bug numbers and dry bean yield quantity and quality from which economic thresholds can be derived.

In summer 2008, initial field surveys were done to address objective 1. In September 2008, a Ph.D. student began work on the project, and the level of activity in the project increased considerably. This report provides information on methods used and results obtained to date.

Numbers of plant bugs in commercial fields of dry edible beans have been relatively low in the last two years, and this was particularly so in 2009. In 2009, soybean fields were also sampled and numbers of plant bugs were low in these fields too. In both years and crops, the dominant plant bug species present was *Lygus lineolaris*. Possibly because of low insect numbers, no relationship between plant bug numbers and dry bean injury (yield loss or quality reduction) in field samples was found in 2008; yield results for 2009 are not yet finalized.

A colony of *L. lineolaris* was established, and this has allowed considerable progress to be made on the characterization of injury caused by plant bug feeding. At the R1–R2 stage, feeding mostly causes abortion of reproductive structures. In the R4–R5 stage, injury prevents translocation to seeds, resulting in shrivelled seed. Feeding in the R6–R7 stage causes surface pitting of the seed, but little other injury. Feeding by fifth instar nymphs appears to be more detrimental to yield than feeding by adults plant bugs.

Two field cage studies were performed in 2009. A trial on navy beans at the R2–R3 stage produced a linear relationship between the weight of marketable seed and number of plant bugs in cages. Data from a second study on pinto beans at the R6 stage are still being processed.

Grading of yields from 2009 will begin shortly, at which time full analysis of 2009 research can be completed.

Introduction

Three species of lygus bugs are relatively abundant in southern Manitoba: *Lygus lineolaris*, *L. elisus*, and *L. borealis*. Of the three, *L. lineolaris* tends to be the most abundant. The species composition varies among plants, but in general, economic impact of the three species is considered to be rather similar, and it is normal to regard the three as equivalent when developing economic thresholds. All three species over-winter as adults in litter and crop residues, and in spring move into crops where they feed and lay eggs; they are able to feed and reproduce on a very wide range of weeds and crops. In some regions of the Prairies, some of the *Lygus* species have more than one generation. Movement into a crop tends to be synchronized with the appearance of reproductive buds or flowers, and nymphs subsequently develop on crops as they proceed through flowering and seed production. The proximity and condition of alfalfa is often important in the dynamics of plant bugs in a crop, as cutting of alfalfa for hay can cause dispersal to adjacent crops. However there is conflicting information about the role of alfalfa in the dynamics of lygus bugs in dry beans. In southern Manitoba, a large influence on the seasonal pattern of *L. lineolaris* is the development of a generation of nymphs on canola during its flowering and pod formation; the adults from these nymphs leave the canola at the time of its maturity and harvest; this dispersal may be responsible for the large numbers of adult lygus bugs that suddenly appear in late-maturing crops in late August and September.

Also present in southern Manitoba are several species of the genus *Adelphocoris*, of which the alfalfa plant bug, *A. lineolatus*, is the most abundant. Eggs of this species over -winter in alfalfa stems. During the summer there may be two generations in alfalfa in the southern prairies . It is generally believed that the effect of *A. lineolatus* on alfalfa is similar enough to *Lygus* spp. that for the purposes of economic threshold calculation, the two groups can be considered together. The effect of alfalfa plant bug on other crops has seldom been studied; the species is normally considered to be restricted to legumes such as alfalfa, sainfoin and sweet clover. Although it has been recorded in dry beans in Manitoba and has been controlled with insecticides, it is not clear whether it actually causes damage to dry beans.

Dry bean production is an important element of Manitoba's agricultural economy, and in export value of semi-processed crop products, ranks second to canola. Sporadically, plant bugs are observed during the growing season on the crop and spraying of dry beans against plant bugs occurs. In 2002, when spraying was quite widespread, both lygus bugs and alfalfa plant bugs were observed in the crop. However, in years when spraying occurred, regular sampling was not carried out to allow seasonal patterns of plant bug occurrence to be discerned. Information from dry bean processors indicates that problems with blemishes attributable to late season plant bug feeding are not uncommon. Losses due to seed blemishes of up to 20% have occurred in Canada. It is expected that this type of seed quality damage would result from late season feeding by the bugs. If dry beans respond in a similar way to other crops attacked by plant bugs, we would expect feeding from the time of flower bud appearance until near to pod maturation to result in abortion of buds, flowers or pods, so that loss of yield quantity could result. Currently, producers have no reliable thresholds to use as decision-making tools to determine appropriate responses to prevent economic loss. To develop such thresholds, it is first necessary to characterize the time when plant bugs feed on the crop, as this will affect the effect on yield. Then, detailed studies of the relationship of insect densities to yield quality and quantity can be undertaken to allow derivation of relationships between economic loss and insect numbers. These relationships will form the basis for the economic thresholds producers need to make optimal management decisions. Thus the overall objectives of the research project are:

1. To assess the seasonal pattern and species composition of plant bugs in dry beans in Manitoba.,
2. To examine in controlled conditions the effect of different stages of lygus bugs and of alfalfa plant bugs on different growth stages of dry edible beans, and
3. In field plots or field cages to develop general relationships between plant bug numbers and dry bean yield quantity and quality from which economic thresholds can be derived.

In summer 2008, initial field surveys were done to address objective 1. In September 2008, a Ph.D. student, Tharshinidevy Nagalingam, began work on the project, and the level of activity in the project increased considerably. This report provides information on methods used and results obtained to date.

Objective 1: Seasonal pattern and species composition

Methods

In the summer of 2008 and 2009, commercial fields of dry beans and soybeans were selected for regular sampling. Except when heavy rain made sampling impossible, fields were sampled at weekly intervals from the time of crop emergence until harvest of the crop. In each field, five sampling locations were established, one at about the mid-point of each side and 5 m from the field margin, and one near the centre of the field. At each of the five locations, a sample of 20 sweeps was taken with a sweep net on each sampling occasion; the direction of walk from the location marker during sweeping was alternated to reduce carryover effects of sampling from the past. When nymphs are detected in sweep net samples, five beat cloth samples were taken at each location, as nymphs are not efficiently sampled by sweeping. Samples were transported to the laboratory in a cooler and adult plant bugs identified to species, and nymphs to genus.

On each sampling occasion, the stage of bean plants, and recent activity in adjacent crops were recorded. Except where bean fields were swathed and harvested between sample intervals, or were direct combined, samples of 4 m^2 of swath were taken at each sampling location on the first visit following swathing. Fields where swath samples could not be taken were represented by a bulk sample provided by the producer. Samples were air-dried in cloth bags, and will be threshed to determine yield quantity, and the beans will be graded to assess quality.

In summer 2008, a total of 11 fields of dry beans were selected for regular sampling. Three fields were selected on the heavy soils of the Red River Valley. One field (sampled for most of the summer by MAFRI staff) was located near Carman. The remaining seven fields were in the area of Portage la Prairie. With one exception in the Red River Valley, all fields were quarter sections. Two of the fields in the Red River Valley were of pinto beans, all other fields were of navy beans. For each field, a record was made of crops in the adjacent fields. For each field, seasonal patterns of plant bug numbers were assessed in relation to bean growth stage, and the influence of adjacent crops assessed. Relationships of plant bug numbers to yield quantity and quality were investigated by statistical analysis.

In 2009, 13 commercial fields were selected for weekly sampling. There were seven fields in the Carman area (2 pinto beans, 2 navy bean fields and 3 soybean fields) and six fields in the Portage la Prairie area (2 pinto, 2 navy and 2 soybean). Yield data have been collected for these fields, but at this point, the beans have not been finally sorted or graded, and so no analysis has taken place.

Results

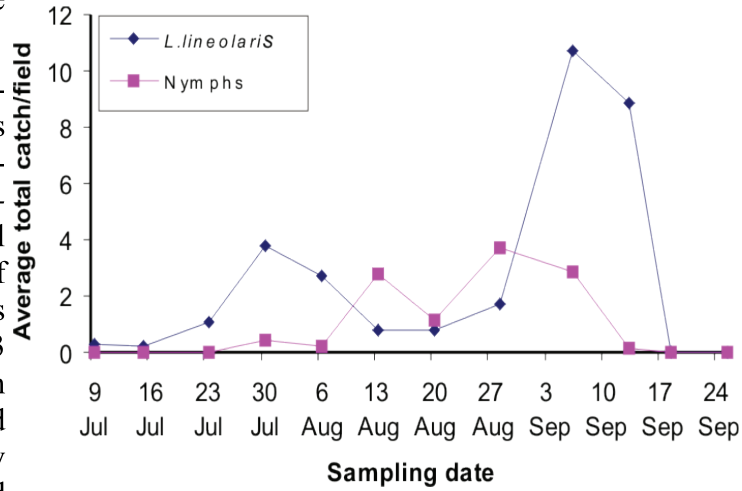
Results from 2008

Populations of plant bugs were generally low in 2008, with a total of 423 plant bugs collected. Adults of three species of *Lygus, L. lineolaris* (the tarnished plant bug), *L. elisus*, and *L. borealis*, were found, of which *L. lineolaris* adults constituted 86%. One species of *Adelphocoris*, *A. lineolatus*, representing 4% of adult plant bugs, was also collected.

Almost 29% of all plant bugs collected were nymphs, and nymphs occurred in all the fields sampled.

As *L. lineolaris* was the dominant species of *Lygus*, only its seasonal pattern is easy to discern (Fig. 1). Adult *L. lineolaris* were present in very small numbers at the beginning of sampling. Numbers of adults began to rise in the week of 23 July, which corresponded with the beginning of flower bud formation or bloom in many fields. Adult catches declined by the week of 13 August, and in that same week *Lygus* nymphs were present in samples from 30 July to 13 September, nymphs were most frequently collected from 13 August to 6 September. This pattern is consistent with expectations: adults come into the fields to feed when reproductive bud tissue first becomes available and lay eggs in the stems of the plant on which they are feeding. These hatch approximately two weeks after laying, and nymphs develop on the crop over a 3–4 week period before moulting to adults. The late season peak of adults in Fig. 1 is much higher than one might expect based upon the catches of nymphs in earlier weeks in the same fields. This late season peak of adult *L. lineolaris* is a common phenomenon in crops that remain green late in the season in Manitoba. There is considerable circumstantial evidence that the main reason for this peak is the migration of adults that are displaced from harvested crops, particularly canola.

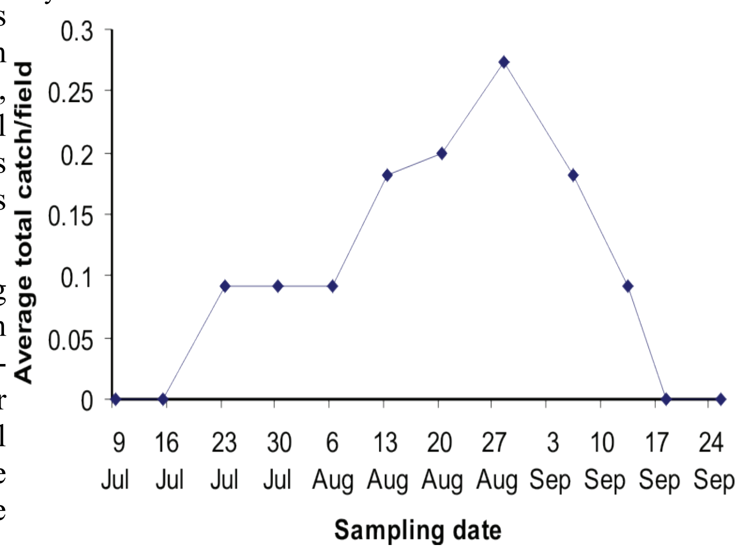
Fig. 1. Seasonal pattern of *Lygus lineolaris* adults and *Lygus* spp. nymphs obtained by averaging catches from 11 regularly sampled fields of dry beans in summer 2008



The seasonal pattern of adult *Adelphocoris lineolatus* showed a single peak in late August and early September (Fig. 2). This species overwinters as eggs in the stems of perennial legumes, primarily alfalfa, and so arrival of adults in dry beans occurs after nymphal development has occurred elsewhere.

Detailed records of plant bug numbers in relation to bean growth stage and events in surrounding crops are available for most fields. MAFRI personnel did not collect such data for the field at Carman, and data are

Fig. 2. Seasonal pattern of *Adelphocoris lineolatus* adults obtained by averaging catches from 11 regularly sampled fields of dry beans in summer 2008.



incomplete for one field in the Red River Valley. Plant bug numbers were higher in the Red River Valley than elsewhere, and peaked at 55 and 26 per field collection in the two pinto bean fields and at 16 in the navy bean field. In the pinto bean fields, highest numbers of plant bugs occurred in late August or early September (Fig. 3), and if they were causing injury at this time, it would likely result in seed blemishes. In the Carman and Portage la Prairie areas, where all sampled fields were of navy beans, the highest observed numbers of plant bugs were 19 and 12 per field collection respectively, and these peaks occurred in early September. A field from the Portage area provides an example of the general patterns observed in 2008 (Figs. 4). There was initial influx of adults when the crop was in the flowering and pod-formation stage. Nymphs were evident throughout much of Au-

Fig. 3. Catches of plant bugs in a pinto bean field in the Red River Valley in summer 2008, showing bean growth stage.

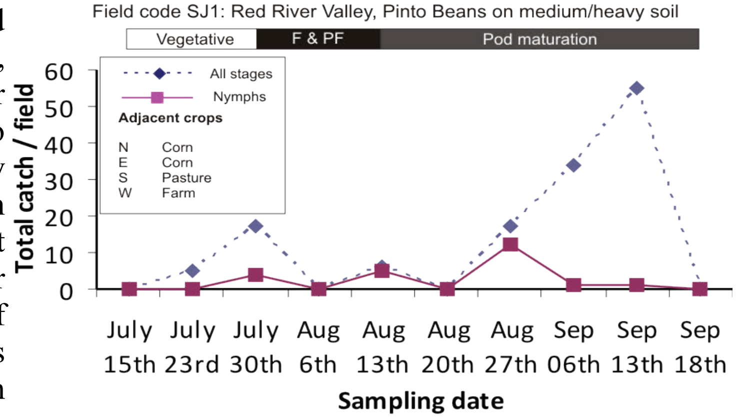


Fig. 4. Catches of plant bugs in a navy bean field in the Portage la Prairie area in summer 2008, showing bean growth stage and harvest events in adjacent crops.

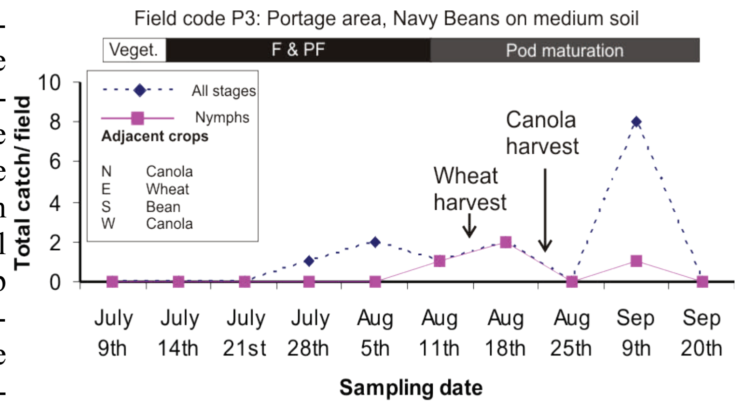


Table 1. Total catch of plant bugs, seed yield and insect damage for each of 11 dry bean fields sampled in summer 2008.

Crop	Total plant bugs/ in field in the season	Seed yield ($g/4\ m^2$)	No. of insect damaged seeds / 250 ml
Navy beans	16	1642	16
	17	1342	24
	14	1655	17
	16	1398	35
	22	1032	22
	9	1332	16
	28	1443	13
	33	2117	9
	47	2582	0
Pinto beans	134	1939	0
	52	1687	0

gust. The adults collected in early September, were too numerous to have come only from the maturation of nymphs in the field. The adults were likely migrants from canola in the area

Table 1 shows the plant bug catches, seed yield and results of commercial seed grading for each field sampled in 2008. There was no evidence of a negative effect of insect numbers on yield quantity or quality. For navy beans, correlation analysis of numbers of insects and yield at individual sampling points showed a significant positive relationship between the total weight and the total number of insects (r = 0.38 n = 37 p = 0.02). Such a relationship implies there was more yield in fields with more plant bugs. There was no significant relationship between plant bug numbers and yield weight for pinto beans. Neither for navy beans nor pinto beans was there a significant relationship of insect numbers and number of seeds graded as insect-injured.

Results from 2009

The 2009 growing season was even cooler and crop development was even later than in 2008. Sampling of fields began later because crop emergence was delayed. Weather prevented sampling in some fields in some weeks. In navy beans, a total of 98 plant bugs were collected; of the 94 adults, 80% were tarnished plant bugs, *Lygus lineolaris*, 12% were *L. borealis*, and 9% were *Adelphocoris* spp. In navy beans, 4 nymphs, all of the genus *Lygus*, were collected; the first nymphs were not collected until 10 September. For much of the growing season the number of plant bugs in navy beans was very small (Fig. 5), but in early September there was a large increase in the population, coinciding approximately with canola harvest.

Species composition in pinto beans was very similar to that in navy beans: of the 84

Fig. 5. Numbers of plant bugs collected in 100 sweeps per field per week in navy bean fields in Portage la Prairie (total of two fields) and Carman (one field).

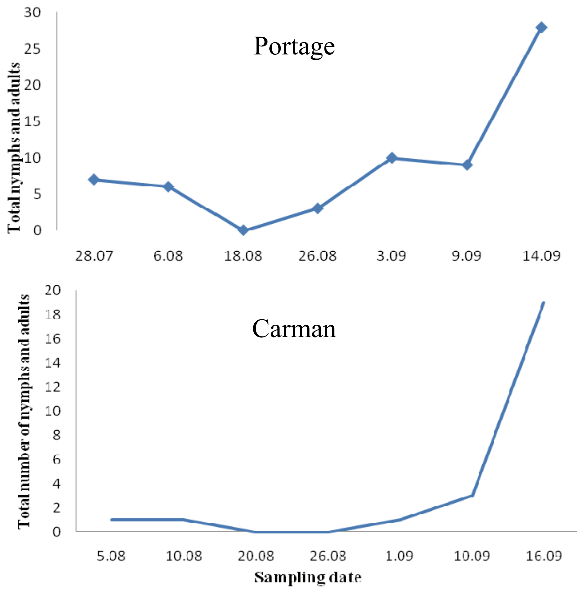
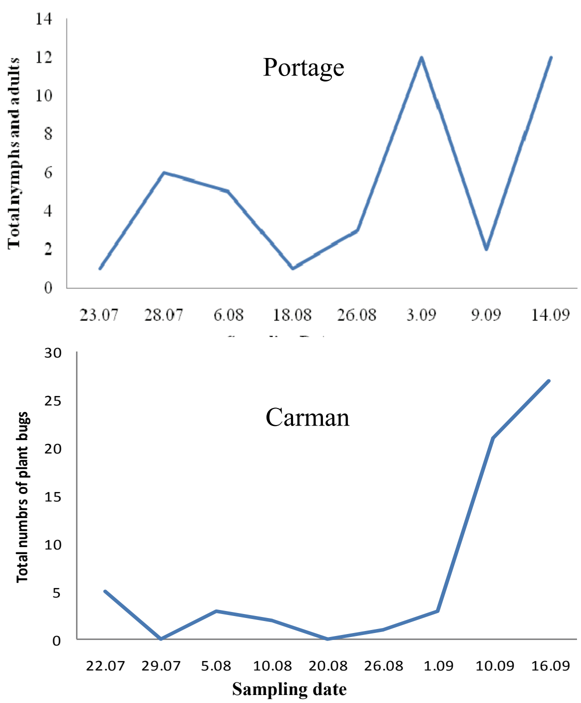


Fig. 6. Numbers of plant bugs collected in 100 sweeps per field per week in pinto bean fields in Portage la Prairie and in Carman (totals of two fields in each location).

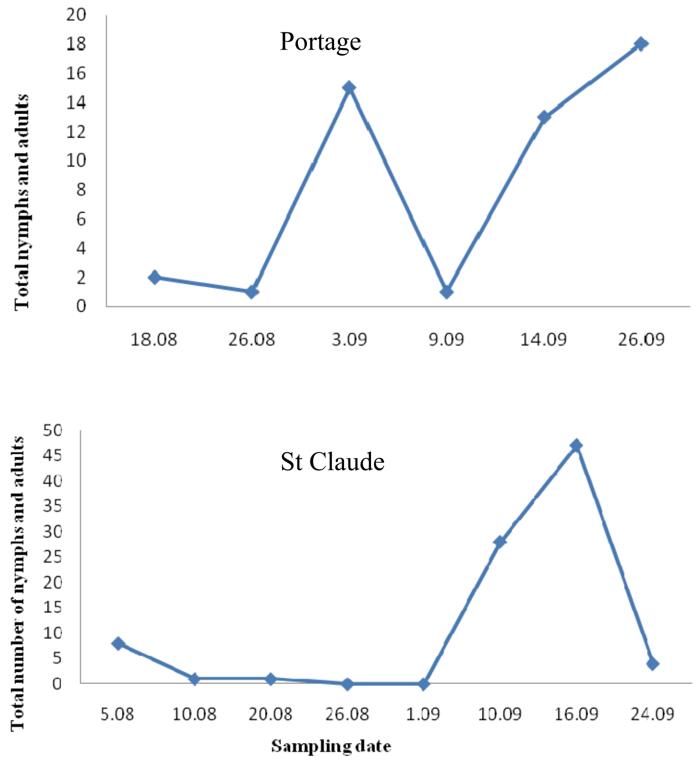


adults collected, 77% were *L. lineolaris*, 8% were *L. borealis*, 1% were *L. elisus*, and 13% were *Adelphocoris* spp. A total of 10 nymphs were collected and these were all *Lygus* spp. collected on or after 10 September. As with navy beans, the number of plant bugs was highest in pinto beans in September.

From the five soybean fields sampled a total of 174 adult plant bugs were collected of which 86% were *L. lineolaris*, 5% were *L. borealis*, 0.6% were *L. elisus*, and 9% were *Adelphocoris* spp. In soybeans 3 *Lygus* nymphs and 2 *Adelphocoris* nymphs were collected on or after 10 September.

From each of the sampled fields, pods were hand-harvested from a 4 m^2 area of swath. These pods have recently been threshed, and are currently being cleaned in preparation for weighing and grading.

Fig. 6. Numbers of plant bugs in 100 sweeps per field per week in soybean fields at Portage la Prairie (total of two fields) and St Claude (one field)



Objective 2: To examine in controlled conditions the effect of different stages of lygus bugs and of alfalfa plant bugs on different growth stages of dry edible beans

Methods

Detailed studies of the effects of plant bugs on dry beans are greatly facilitated if there is a reliable supply of insects of stages required for experimental work. We have been successful in establishing a colony of *L. lineolaris*. This is a remarkable achievement for Ms Nagalingam, the student involved, as few laboratories in the world have been able to maintain successful thriving *L. lineolaris* colonies. The source material for colony were *L. lineolaris* collected in September 2008 from alfalfa and soybean fields in Manitoba. A similar technique was attempted for the rearing of the alfalfa plant bug, *A. lineolatus*, using material collected in August 2009. However, this attempt was not successful, perhaps because the adults collected in August were already in reproductive diapause.

Rearing methodology for *L. lineolaris*

The colony is maintained in incubators at 21ºC temperature, 90% RH and a photoperiod of 16:8 h L:D. Green beans were used as an adult food and for egg laying. First and second instar *L. lineolaris* were reared on cut pieces of broccoli and third to fifth instars are reared on green beans. The plant materials used in culturing were surface sterilized by soaking for 15 minutes in Chlorox® solution (5ml / 1.5 litres of water), then rinsed thoroughly in running water and air dried.

Adults were reared in "bug tub cricket cages" with 20–25 insects in each cage, and 4–5 sterilized green beans per cage. The adults were kept on beans for a period of 4–5 days and then the beans replaced. Beans removed from the cages were inspected microscopically for eggs. Newly emerged adults have a pre-oviposition period of 7–10 days (Bariola, 1969) and they start laying eggs thereafter. The peak egg laying period was from the second to fourth week after the emergence. Eggs are mostly laid on the top edge of the beans. Beans with eggs were reared in 14 cm diameter Petri dishes, with three pods per dish. The egg incubation period was 5–7 days.

Nymphs started to emerge from the beans 9–11 days after removal from the adult cages. After the commencement of emergence of nymphs, a small piece of broccoli was added to the egg cages as food. Emerged nymphs with broccoli pieces were then transferred to 9 cm diameter Petri dishes for nymph rearing. Dishes were inspected frequently, and mouldy or dried broccoli pieces were remove. When the nymphs were in their early third instar they were transferred to rearing cages containing green beans. Each rearing cage contained about 20–25 nymphs of same age, and 4–5 green beans were added to each cage as food. Newly-moulted adults were transferred daily to the adult cages.

Nature of injury and damage caused by *L. lineolaris* on navy beans

This experiment was designed to examine the relative injuriousness of different stages of lygus bugs (fifth instar and adults) to different growth stages of navy beans (cv. Envoy), and to assess the nature of the resulting injury. For 5 days, either adults or fifth instar nymphs of *L. lineolaris* were confined in a sleeve cage to a single inflorescence or reproductive structure of a plant, under controlled conditions (23ºC, 60% RH and 16:8 h L:D) in plant growth rooms.

The growth stages used were R1 (reproductive stage dominated by buds and subsequent flowering), R2 (mid to full flowering stage dominated by flowers and subsequent pods), R4–R5 (early pod set, seed initiation) and R6–R7 (mid seed fill stage). One insect (adult or nymph) was confined per sleeve cage in the R1, R2 and R4–R5 stages. The R4–R5 experiment was repeated using three insects per sleeve cage, and five insects were confined per a sleeve cage for the R6–R7.

For each experiment, two sets of plants were grown. One set was used to assess characterize microscopically the feeding injury after five days of feeding. The other set was grown to harvest and the yield data for the inflorescence were assessed to determine the damage caused by feeding. In each of the two sets, there were three treatments, each replicated six times. Treatments were control (no insects), fifth instar nymphs and adults.

The effect of different stages of lygus bugs on different growth stages of beans

Laboratory experiments using whole plants will be conducted to determine relative injuriousness of different stages of *L. lineolaris* to different growth stages of dry beans. So far, one such experiment has been performed. In it, R6–R7 stage potted bean plants were caged using a net cloth cage (30 threads/ cm) and insects were introduced in cages. Control plants were caged without insects. Insects were allowed to feed for a 5 day period and then were removed from the cages. The initial number of pods on each plant was counted before the insect introduction to the cages. After insect removal, the plants were grown to maturity and the effects of insect treatments on yield quality and quantity were assessed. There were five treatments, each replicated five times. Treatments were:

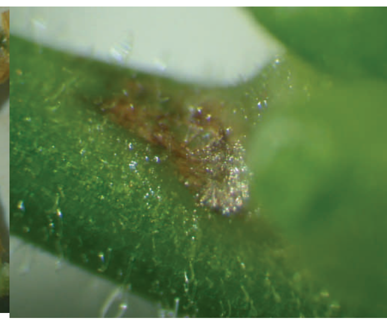
Treatment 1: Control with no insect
Treatment 2: Fifteen fifth instar nymphs
Treatment 3: Fifteen adults
Treatment 4: Thirty fifth instar nymphs
Treatment 5: Thirty adults

Results

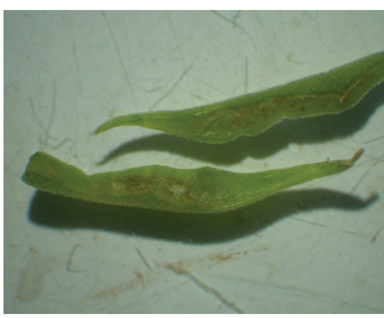
Nature of injury and damage caused by *L. lineolaris* on navy beans

Fig. 7. Navy beans in R1 and R2 growth stages injured by *L. lineolaris* (photo credit: T. Nagalingam)


Aborted pods with brownish spots


Brown, split region on the node

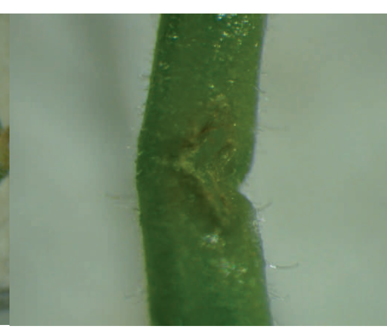

Feeding injury on pod tip


Longitudinal section of an aborted pod


Pin head spot


Split bean surface


Inflorescence stem break over the lesion


Split region on inflorescence stem


Internal discolouration and feeding gallery in pods

Visual and microscopic observations of feeding injury are summarized below for all the stages tested.

R1 and R2 stage (Fig. 7)

In these stages, there were scattered feeding spots (brownish lesions) on the inflorescence stems, particularly near nodes. The tip of the small pods (R2 stage) and bigger pods, appeared burned. Stylet penetration marks were visible on R2 stage pods. The flower stems, small pods and other tender regions were split due to feeding and subsequent growth of the plant tissue. Pin point spots were found on pods at the R2 stage. Young pods and flowers turned yellow and aborted from the inflorescence, with the break occurring in the pedicel region. Longitudinal dissection of injured pods at the R2 stage showed clear internal galleries penetrating the length of the pods.

R4–R5 stage (Fig. 8)

Fig. 8. Navy beans in the R4–5 growth stage injured by *L. lineolaris* (photo credit: T. Nagalingam)


Feeding spots on suture region


Discolouration of pod surface

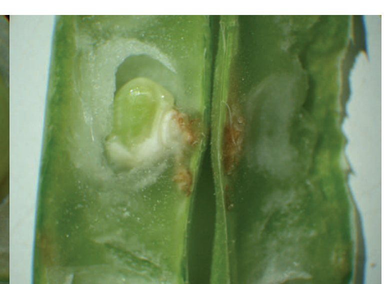

Brown stippled areas on nodal area


Brown stippled area on inflorescence stem and on peduncle


Burnt appearance of pod tip


Feeding injury on placenta and funiculus of a pod


Extended damage to pericarp


Damage on funiculus and placenta

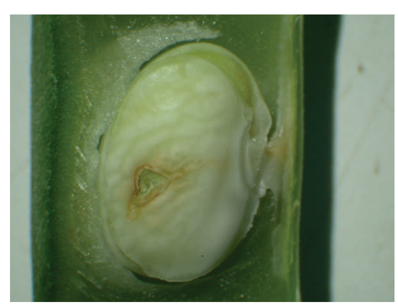
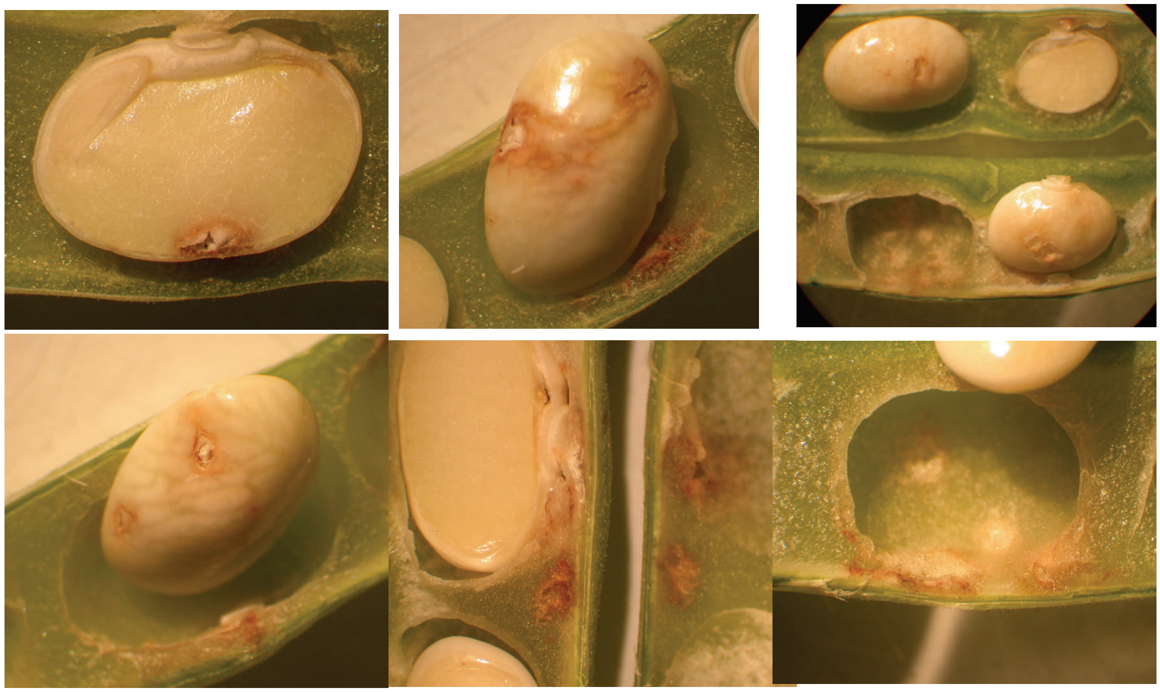

Pitted seed surface

Fig. 9. Navy beans in the R6–R7 growth stage injured by *L. lineolaris* (photo credit: T. Nagalingam)



In this stage, symptoms were more prominent with the three lygus bug treatment than the one lygus bug treatment. Injured pods on R4–R5 stage exhibited brown to yellow discoloration and brown to black feeding spots. On dissection, discoloured feeding lesions were seen inside the pods; the lesions were mostly associated with funiculus and testa region adjoining the axis of the seed. At this stage, pitting of the surface of seeds was also evident but its incidence was low.

R6–R7 stage (Figure 9)

At this stage, the seed surface pitting was the major injury observed.

Effect on yield

Several yield parameters were measured during the study. Table 2 shows the weight of marketable (unblemished, unshrivelled) seed produced by the inflorescence on which *L. lineolaris* nymphs or adults were confined. In the R1 and R2 stages there were signifi-

Table 2. Weight of mean ± SE marketable seed yield (g) from caged inflorescences exposed to feeding by *L. lineolaris* for 5 days.

Treatment	R1 with 1 Lygus	R2 with 1 Lygus	R4-R5 with 1 Lygus	R4-R5 with 3 lygus
Control	2.732 ± 0.268	1.543 ± 0.270	2.981 ± 0.639	2.018± 0.630
Nymph	1.227 ± 0.278	0.734± 0.274	2.150 ± 0.721	0.186 ± 0.110
Adult	2.169 ± 0.549	2.045 ± 0.419	1.950 ± 0.551	0.881 ± 0.359

cant effects on marketable seed weight of the feeding ($p = 0.045$ and $p = 0.039$ respectively), and feeding by fifth instar nymphs tended to reduce seed weight by more than feeding by adults. When one bug (adult or nymph) was confined to an inflorescence at the R4–5 stage, there was no significant effect of feeding on yield, however when three bugs were confined to an R4–5 inflorescence, weight of marketable seed from the inflorescence was again affected by bug feeding, with a greater effect of nymphs than adults. Yield data for the R6–R7 stage are not yet available.

Yield loss from feeding at the R1 and R2 stages was mostly attributable to abortion of floral parts and young pods. Yield loss in the R4–5 growth stage was largely associated with shrivelled seed. A considerable amount of the feeding at this stage took place at the funiculus, placenta or other locations where injury could affect translocation of photosynthates to the developing seed. Such a blockage of translocation of food and water would be expected to result in failure to fill the seed, resulting in shrivelling.

The effect of different stages of lygus bugs on different growth stages of dry edible beans

To date this experiment was done only on the R6–7 stage. Harvest of the plant was obtained and pods are currently being dried. Data will be analyzed once they become available. The experiments for the other growth stages will be continued during winter 2009–10.

Objective 3: In field plots or field cages to develop general relationships between plant bug numbers and dry bean yield quantity and quality from which economic thresholds can be derived

Methods

Initially, it had been planned to conduct field plot experiments to achieve this objective, In field plot experiments, numbers of free-living plant bugs would be manipulated using insecticides or by adding insects from surrounding areas. The advantage of such an approach is that results can be seen to be applicable to operational field conditions. However, in 2009, the numbers of plant bugs in the field at the appropriate time of year was very small, and so field plot studies were not feasible. Consequently, two field cage studies were performed instead.

In both field cage studies, lygus bugs were introduced into the cages, containing dry edible beans growing in the field. The source of these insects was either our laboratory colony of *L. lineolaris*, or field-collected *Lygus* spp., predominantly *L. lineolaris*. Different densities of nymphs and adults of lygus bugs were introduced to 1 m^2 cages, 1.2 m in height. In each experiment, treatments were replicated six times in a randomized complete block design. All the cages were kept closed from the time of insect introduction until plants reached harvest maturity and seed quality and quantity of the treatments were assessed on harvest.

Navy bean study

This study was carried out in a navy bean field at the University of Manitoba Fort Garry campus. Treatments were: control (no insects), 30 lygus bug adults and 60 lygus bug adults. In this experiment plants were caged when they were in R2–3 stage of growth, and the insects immediately introduced. Two rows of plants were caged inside the cages. with an average of about 15 plants per cage.

Pinto bean study

This study was carried out in part of a commercial pinto bean field near Portage la Prairie. The treatments were, control (no insects), 30 adults of *L. lineolaris* and 30 *L. lineolaris* nymphs composed of equal numbers of fourth and fifth instars. Plants were caged when they were in the R6 stage of growth. 6–7 plants were kept inside each of the cage.

Results

Navy bean study

There was a significant effect ($F = 5.2$, d.f. = 2,10, $P < 0.05$) of lygus bug treatment on the weight of marketable seed/m^2 in the cage study (Table 3) and a strong negative linear relationship between the number of adult lygus bugs and the weight of marketable seed ($F = 9.9$, d.f. = 1,10, $P = 0.01$). Marketable seed yield in cages was reduced by about 0.25 g/m2 for each adult lygus bug present. The weight of shrivelled seeds was not significantly affected by treatment ($F = 1.1$, d.f. = 2,10, $P = 0.3$).

The experiment was carried out in the R2–R3 stage, a stage that is dominated by flowers and small pods. According to our laboratory studies, the dominant effect of lygus feeding at this stage is the abortion of small pods and flowers. Thus the reduction in marketable seed weight is probably caused by the abortion of reproductive parts. Absence of effects on shrivelled seed weight would be expected based on our laboratory studies at this stage.

Pinto bean study

This study was carried out successfully, but sample processing and analysis of results are not yet complete.

Discussion

In both years the dominant plant bug in field surveys of dry edible beans and soybeans has been *L. lineolaris*, which is the most abundant species present in many crops in southern Manitoba (Mostafa 2008). Numbers of plant bugs in dry edible beans have been relatively low in the last two years, and this was particularly so in 2009. The absence of a relationship between plant bug numbers and injury in field samples in 2008 is probably attributable to the low numbers, but it is also possible that injury from other sources is being misdiagnosed.

Table 3. Effect on yield of exposing navy beans at the R2–R3 stage to lygus bugs in field cages.

Treatment	Marketable seed yield (g/m^2)	Shrivelled seed weight (g/m^2)
Control (no insects)	95.1 ± 9.6	0.10 ± 0.04
30 lygus bugs	86.8 ± 6.8	0.22 ± 0.06
60 lygus bugs	68.7 ± 9.2	0.21 ± 0.07

Considerable progress has been made on the characterization of injury caused by lygus bug feeding. This was possible because of the establishment of a colony of *L. lineolaris*. Injury largely took the form of abortion of reproductive structures if it occurred at the R1–R2 stage. In the R4–R5 stage, injury was mostly to tissues responsible for translocation of photosynthates to seeds, and this was associated with shrivelled seed. Feeding in the R6–R7 stage caused surface pitting of the seed, but little other injury was observed. From studies of injury to R1, R2 and R4–R5 stages, there appears to be greater loss of yield when fifth instar nymphs feed than when adults feed. This is consistent with findings in our laboratory that nymphs are more injurious than adults to buckwheat (Mostafa 2008).

Because of the low numbers of plant bugs in the field in 2009, it was not possible to perform manipulations of plant bugs in open field plots as had been intended. Instead, field cage studies were performed. Although data are still being analysed for one of these trials, the first trial to be completed was consistent with our laboratory finding that lygus bug feeding at the R2–R3 stage results in abortion of reproductive structures. The linear relationship observed between amount of marketable yield and number of plant bugs observed in this one cage study is encouraging, as it may mean that the yield response, and estimation of economic injury levels will be relatively simple. However, it should be recognized that this is the result of a single trial. Further studies are required to establish a robust relationship that can be used to derive an economic injury level and threshold on which producers can rely.

References

Bariola, L. A. 1969. The biology of the tarnished plant bug, *Lygus lineolaris* (Beauvois), and its nature of damage and control on cotton. Ph.D. Thesis. Texas A &M University. 102 pp.

Mostafa, A. M. 2008. Plant bugs (Hemiptera: Miridae) on buckwheat and seed alfalfa crops in Manitoba: dynamics, yield implications and management. Ph.D. Thesis, University of Manitoba, Canada. 211 pp.