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Yield Responses of Pale Legume Bug, *Lygus elisus* (Van Duzee) (Heteroptera: Miridae), on Spring Canola

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Abstract: The pale legume bug (PLB), *Lygus elisus* (Van Duzee), is one of the most important pests on canola plant in Colorado. A two-year study at early flower and pod stages of spring canola was conducted to evaluate plant yield responses for PLB in 2001-2002. Artificial infesting of number of PLB per head at early flower stages resulted in high yield losses than infestations at early pod stages in both years. In 2001, averaged yield losses for seven canola cultivars at early flower stages were 66, 63 and 72% and for five canola cultivars were 54, 66 and 63% with infested at 2, 8 and 16 PLB per head, respectively, compared to the non-infested control. However, such significant effects on yield following PLB infestation at early flowering were not repeated at both trials in 2002. In 2001, averaged yield losses for seven canola cultivars at early pod stages were 22, 34 and 50% with infested at 2, 8 and 16 PLB per head and for five canola cultivars was 49% with infested 16 PLB per head. In addition, significant yield losses at early pod stages occurred on cultivar 46A65 when infested at the highest level at second trials in 2002. The comparisons of 10% yield loss occurred with infestations of 3.1-5.6 PLB per head (avg. 3.7) at early flowering stage and 3.4-19.0 PLB per head (avg. 9.6) at early pod stage infestations in both years. In conclusion, the proposal of economic injury levels for infested different number of PLB might be changed between 3.1-5.6 PLB per head at early flower stages and 3.4-19.0 PLB per head at early pod stages.

Key words: Pale Legume Bug (PLB), *Lygus elisus* (Van Duzee) (Heteroptera: Miridae), artificial PLB infestation, plant yield responses, spring canola

INTRODUCTION

The genus *Lygus* Hahn (Hemiptera: Miridae) contain economical pests various variety of host plants (Schuh and Slater, 1995, Wheeler, 2001). Thirty four *Lygus* species are present in the USA and twenty-two of them have been recorded in Colorado (Kelton, 1975). Among the most economical *Lygus* species are the western tarnished plant bug, *Lygus hesperus* Knight, pale legume bug, *Lygus elisus* Van Duzee and tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois) in Colorado (Demirel *et al*., 2005). The Pale Legume Bug (PLB) is widely distributed at the Rocky Mountain regions of North America (Kelton, 1975). In 2002, 1745 *Lygus* species collected and reared to the adult stage indicated that PLB was recovered in highest numbers at 58.4% of the total in Colorado (Demirel *et al*., 2005). *Lygus* species feed primarily on buds, flowers, pods and seeds (Lamb, 1989) and their population reach peak during the flowering and the pod stages in canola (Timlick *et al*., 1993). Visible injuries to *B. napus* L. (canola, rape) and *B. campestris* L. (oilseed mustard) appear as surface

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lesions and cause buds and flowers to abscise and seeds to collapse. *Lygus* damage to buds and flowers usually results in a net reduction in the yield of canola seed (Butts and Lamb, 1990). In addition, on yield losses associated with various levels of *Lygus* was determined by sweep net sampling (Butts and Lamb, 1991). Plant growth stage was also a factor with greatest losses occurring with *Lygus* infestations present during the early pod stage (Butts and Lamb, 1991). Therefore, a proposing an economic threshold of 15 plant bugs per 10 sweeps in canola at the end of flowering or at the beginning of pod formation, based on crop prices and control cost from 1989 to 1992 (Wise and Lamb, 1998a).

The purpose of study was to evaluate plant yield responses of PLB to spring canola under the controlled infestation at early flower and pod stages. This can allow concurrent evaluations of PLB damage to different cultivars.

MATERIALS AND METHODS

Plant Yield Response Trials in 2001

Two trials were conducted at the Colorado State University Horticulture Field Research Center (HFRC) in Fort Collins, Colorado. Two different plots at HFRC were established by seeding on 26 April, each plot consisted of 6 m long, two double-row beds with 76 cm row spacing. Experimental design was randomized complete split block design with 4 replications. In the first trial, seven spring canola (*Brassica napus* L.) cultivars were included: Hyola, Excel, Apollo, Helios, Alto, Defender and 46A65. A second trial had five cultivars: Hyola, Excel, Apollo, Defender and 46A65. Two trials were conducted at early flower and pod stages. The early flowering stage was comparable to Stage 4.2, when there are many flowers opened and lower pods are elongating. Early pod stage was comparable to stage 5.2, with the seeds in lower pods green. Before infestation in each plot, five canola heads were selected of approximately equal size. One of these served as a non-bagged control and four of them were bagged. Bags were placed over only one flowering and pod branch of the plants which will subsequently be termed head. The bags were of 12×20 cm polypropylene mesh (Applied Extrusion Technologies, Specialty Nets and Nonwovens, Middletown, Delaware) primarily used for confining heads during plant breeding. The bags were snuggly fastened to the stem with a twist-tie. Three infestation levels of PLB were introduced into the bagged heads -2, 8 and 16/head, one was retained as a bagged control. For evaluation of early flowering stage, these plants were bagged on 6 July and field-collected adult PLB introduced into the bags on 11 July. For evaluation of early pod stage, these plants were bagged on 25 July and field-collected adult PLB introduced into the bags on 26 July.

An application of carbaryl was used on 10 May to control western black flea beetles, *Phyllotreta pusilla* (Horn), at the seedling stage. Imidacloprid also was applied as a foliar before bagging on 30 June to control cabbage aphid, *Brevicoryne brassicae* (L.). No insecticides were used on plots after infestations. Plots were harvested on 24 August. Both infested and non-bagged heads were cut, with or without the bag intact and hung for drying. The pods were then crushed to release the seeds and separated from other debris by use of sieves. Data from each cultivar, growth stage and number of PLB/ head yield in all trials were analyzed using the Least Significant Difference (LSD) Multiple Comparison Test and Linear Regression ($p<0.05$) (SAS Institute Inc., 1990). In addition, significant differences of 0 PLB/ head yield versus non-bagged yield for each cultivar and growth stages in all trials were performed by t-test ($p<0.05$) (SAS Institute Inc., 1990).

Plant Yield Response Trials in 2002

Two trials were conducted at the Colorado State University Horticulture Research Center (HFRC) in Fort Collins, Colorado. Two different plots at HFRC were established by seeding on 3 April, each plot consisted of 6 m long, two double-row beds with 76 cm row spacing. The first trial contains six spring canola cultivars: Apollo, Hyola, Helios, Excel, IMC205 and 46A65. The second trial had four cultivars: Apollo, Hyola, Excel and 46A65. Plot design was similar to that of 2001. Pesticide use on the plots consisted of a pre-emergence application of trifluralin for weed control and an application of carbaryl on 10 May for control of western black flea beetle, *Phyllotreta pusilla* (Horn), at the seedling stage. Bagging of heads at the early flower stage was done on 23 June and field-collected adult PLB were introduced into bags on 25 June. For evaluations during the early pod stage, canola heads were covered with bags on 14 July and field-collected adult PLB introduced on 17 July. Bagging of heads and management of plots was similar to that of 2001. Both infested and non-bagged heads were harvested on 21 August, cutting with or without the bag intact and hung for drying. When dry, pods were crushed to release the seeds and seeds were separated from other debris by use of sieves. After this procedure, seed was further cleaned using Agriculex CB-1 (column blower) to sort out seed from plant debris. Data from in all trials were analyzed similar to those of 2001.

RESULTS AND DISCUSSION

Plant Yield Response Trials in 2001

Plant yield losses were significantly variable among cultivars at early flower and pod stages (Table 1). Significant plant yield losses occurred on most cultivars of early flower stages. Defender, Hyola and Alto cultivars sustained significant yield losses at 2 PLB per head during early flower in the first trial (Table 1). Helios and 46A65 showed significant yield losses at 8 PLB per head and Excel had significant yield losses with 16 PLB per head. In addition, Excel and Defender had significant yield losses at all infestation levels during early flower stages in the second trial (Table 1). On the other hand, yield losses were significantly lower during early pod stages. In the first trial, significant yield losses occurred on Alto with 2 PLB per head and Helios and 46A65 with 8, 16 PLB per head. In

Table 1: Yield (g./head) of canola cultivars baggedand infested with different numbers of Pale Legume Bug (PLB) during the early flower stage and the early pod stageat HFRC 2001

			No. PLB/Head[y]								
Trials	Cultivars	Growth stage[z]	0	2	8	16	Slope	Intercepts	df	f-value	p<0.05
1	Hyola	EF	2.12a	0.60b	0.72b	0.54b	-0.06677	1.706	3,12	5.060	0.017
1	Helios	EF	3.47a	1.17ab	0.86b	0.73b	-0.12669	2.015	3,12	2.579	0.010
1	Excel	EF	1.50a	0.73ab	0.90ab	0.59b	-0.03919	1.819	3,12	1.276	0.032
1	Defender	EF	1.01a	0.17bc	0.33b	0.10c	-0.03806	1.484	3,12	37.136	0.0001
1	Apollo	EF	0.85a	0.35b	0.13b	0.37b	-0.02201	2.097	3,12	2.875	0.080
1	Alto	EF	1.45a	0.46b	0.67b	0.36b	-0.04559	1.352	3,12	7.630	0.004
1	46A65	EF	1.19a	0.86ab	0.40b	0.57ab	-0.03609	2.185	3,12	1.077	0.039
1	Hyola	EP	4.97ab	6.27a	4.76ab	3.36b	-0.13854	2.007	3,12	1.399	0.291
1	Helios	EP	7.45a	4.87ab	3.44b	4.42b	-0.14928	1.670	3,12	2.423	0.012
1	Excel	EP	5.88a	3.63ab	5.52ab	2.78b	-0.12790	1.001	3,12	2.662	0.095
1	Defender	EP	7.30a	5.02ab	5.77ab	3.93b	-0.15515	0.927	3,12	1.845	0.193
1	Apollo	EP	5.34a	4.43ab	2.41ab	1.51b	-0.23645	1.728	3,12	3.215	0.062
1	Alto	EP	7.24a	4.21b	3.33b	3.23b	-0.19552	0.693	3,12	12.616	0.001
1	46A65	EP	5.72a	5.69a	3.58b	2.86b	-0.19540	1.002	3,12	8.113	0.003
2	Hyola	EF	3.16a	1.71b	1.49b	1.61b	-0.06932	2.184	3,12	0.607	0.623
2	Excel	EF	4.15a	1.65b	1.23b	1.10b	-0.14246	1.452	3,12	10.425	0.001
2	Defender	EF	2.81a	1.03b	1.02b	1.09b	-0.07075	1.616	3,12	4.666	0.022
2	Apollo	EF	5.16a	2.14b	1.78b	1.62b	-0.16199	2.091	3,12	1.333	0.311
2	46A65	EF	1.70a	1.37ab	0.33b	0.89ab	-0.05335	2.237	3,12	2.338	0.125
2	Hyola	EP	6.10a	6.53a	5.42a	4.47a	-0.11940	1.377	3,12	1.373	0.298
2	Excel	EP	7.33a	8.31a	6.88ab	4.02b	-0.23577	1.261	3,12	3.249	0.060
2	Defender	EP	6.13a	5.76a	5.30a	2.05b	-0.24740	0.941	3,12	5.480	0.013
2	Apollo	EP	5.60a	4.78ab	5.29a	2.59b	-0.16370	1.462	3,12	1.437	0.281
2	46A65	EP	5.85a	4.16ab	4.45ab	2.73b	-0.15597	1.975	3,12	2.041	0.162

[z]Early flower stage (EF) and early pod stage (EP). [y]Means followed by the same letter in a row do not differs significantly (p<0.05, LSD, Regressions Analysis)

addition, the second trial, significant yield losses on early pod stages on Defender resulted in 16 PLB per head (Table 1). Averaged yield losses for seven cultivar at early flower stages were 66, 63 and 72% and 54, 66 and 63% at five cultivars with infested at 2, 8 and 16 PLB per head, respectively, compared to the non-infested control at early flower stages in 2001 (Table 1 and 4). In addition, averaged yield losses for seven cultivars at early pod stages were 22, 34 and 50% the heads infested at 2, 8 and 16 PLB per head and 49% for five cultivars with 16 PLB per head (Table 4).

Table 2: Yield (g./head) of canola cultivars baggedand infested with different numbers of Pale Legume Bug (PLB) during the early flower stage and the early pod stageat HFRC in 2002

			No. PLB/Head[y]								
Trials	Cultivars	Growth stage[z]	0	2	8	16	Slope	Intercepts	df	f-value	p<0.05
1	46A65	EF	1.20a	2.02a	1.36a	0.47a	-0.06684	2.265	3,12	1.132	0.375
1	Apollo	EF	1.40a	0.99a	0.86a	0.48a	-0.04956	2.649	3,12	0.574	0.643
1	Excel	EF	1.00a	0.92a	0.64a	0.90a	-0.00717	2.614	3,12	0.072	0.974
1	Helios	EF	4.35a	3.95a	2.04a	1.25a	-0.20028	2.800	3,12	1.920	0.180
1	Hyola	EF	1.57a	2.15a	0.75a	0.59a	-0.08465	2.551	3,12	0.673	0.585
1	IMC205	EF	0.31a	2.12a	1.52a	1.73a	0.04619	2.154	3,12	1.141	0.372
1	46A65	EP	4.53a	3.34a	5.03a	4.06a	0.01019	2.324	3,12	0.785	0.525
1	Apollo	EP	2.81a	2.51a	2.75a	2.35a	-0.02055	2.505	3,12	0.109	0.953
1	Excel	EP	5.27a	6.03a	4.00a	4.43a	-0.08576	2.839	3,12	0.717	0.561
1	Helios	EP	8.12a	7.92a	7.74a	7.95a	-0.00835	2.885	3,12	0.024	0.995
1	Hyola	EP	3.96a	4.19a	2.29a	3.60a	-0.04483	2.986	3,12	0.623	0.614
1	IMC205	EP	2.85a	3.45a	3.85a	3.05a	0.00459	1.931	3,12	0.254	0.857
2	46A65	EF	5.05a	4.05a	5.73a	3.77a	-0.04268	2.156	3,12	0.740	0.548
2	Apollo	EF	3.16a	2.77a	1.57a	1.74a	-0.09120	2.930	3,12	0.876	0.480
2	Excel	EF	5.73a	5.20ab	2.26b	2.91ab	-0.19136	3.288	3,12	2.866	0.081
2	Hyola	EF	5.26a	6.91a	5.64a	5.65a	-0.02068	2.336	3,12	0.151	0.927
2	46A65	EP	10.41a	8.12ab	9.09a	5.32b	-0.25792	2.668	3,12	3.853	0.038
2	Apollo	EP	4.36a	4.38a	5.06a	3.81a	-0.02759	2.272	3,12	0.126	0.943
2	Excel	EP	6.75a	8.96a	8.22a	7.69a	0.00752	1.298	3,12	0.642	0.602
2	Hyola	EP	7.13a	5.53a	6.66a	7.18a	0.04467	3.160	3,12	0.516	0.679

[z]Early flower stage (EF) and Early pod stage (EP). [y]Means followed by the same letter in a row do not differ significantly (p<0.05, LSD, Regressions Analysis)

Table 3: Yield (g./head) of canola cultivars bagged and infested with different numbers of Pale Legume Bug (PLB) during the early flower stage and the early pod stage in 2001-2002

			Early flower stage[y]		Early pod stage[y]	
Trials[z]	Year	Cultivars	0 PLB	Non-bagged	0 PLB	Non-bagged
1	2001	Hyola	2.12a	2.08a	4.97a	5.16a
1	2001	Helios	3.47a	4.64a	7.45a	5.13a
1	2001	Excel	1.50a	2.80a	5.88a	1.77b
1	2001	Defender	1.01b	2.00a	7.30a	4.60a
1	2001	Apollo	0.85a	1.60a	5.34a	3.74a
1	2001	Alto	1.45a	2.63a	7.24a	2.89b
1	2001	46A65	1.19a	0.99a	5.72a	5.20a
2	2001	Hyola	3.16a	4.13a	6.10a	7.39a
2	2001	Excel	4.15a	5.95a	7.33a	7.52a
2	2001	Defender	2.81a	4.34a	6.13a	4.14a
2	2001	Apollo	5.16a	4.35a	5.60a	3.27a
2	2001	46A65	1.70b	3.51a	5.85a	5.80a
1	2002	46A65	1.19a	1.69a	4.53a	2.22b
1	2002	Apollo	1.40a	2.27a	2.81a	1.96b
1	2002	Excel	1.00a	2.72a	5.27a	2.77a
1	2002	Helios	4.35a	2.02a	8.12a	0.96b
1	2002	Hyola	1.57a	1.79a	3.96a	2.95a
1	2002	IMC205	0.31b	3.66a	2.85a	2.37a
2	2002	46A65	5.05a	6.23a	10.41a	6.60a
2	2002	Apollo	3.16a	3.53a	4.36a	4.34a
2	2002	Excel	5.73a	3.85a	6.75a	5.86a
2	2002	Hyola	5.26a	6.07a	7.13a	6.65a

[z]All trials were conducted at HFRC in 2001-2002. [y]At each growth stage, means followed by the same letter in a row do not differ significantly (p<0.05, t-test)

Table 4: Yield (g./head) of canola cultivars baggedand infested with different numbers of Pale Legume Bug (PLB) during the early flower stage and the early pod stage at the HFRC in 2001-2002

			Combined PLB/Head[y]								
Trials	Years	Growth stages[z]	0	2	8	16	Average slope	Intercepts	df	f-value	p<0.05
1	2001	EF	1.66a	0.56b	0.62b	0.47b	-0.05349	2.098	3,108	12.262	0.0001
1	2001	EP	6.27a	4.87b	4.11b	3.16c	-0.17118	1.434	3,108	13.965	0.0001
2	2001	EF	3.40a	1.58b	1.17b	1.27b	-0.09957	2.098	3,76	7.840	0.0001
2	2001	EP	6.20a	5.91a	5.47a	3.17b	-0.18445	1.382	3,76	10.028	0.0001
1	2002	EF	1.64ab	2.02a	1.19b	0.91b	-0.06039	2.513	3,92	2.248	0.088
1	2002	EP	4.59a	4.60a	4.28a	4.24a	-0.02412	2.630	3,92	0.139	0.936
2	2002	EF	4.80a	4.73a	3.80a	3.51a	-0.08648	2.630	3,60	0.921	0.436
2	2002	EP	7.16a	6.75a	7.26a	6.00a	-0.05833	2.387	3,60	0.653	0.584

[z]Early flower stage (EF) and Early pod stage (EP). [y]Means followed by the same letter in a row do not differ significantly (p<0.05, LSD, Regressions Analysis)

Table 5: Summary of yield loss relationship between Pale Legume Bug (PLB) and canola seed weight at HFRC in 2001-2002

Trials	Year	Growth stage[z]	Yield (g)/0PLB/head	Average slope	PLB to produce 10% yield loss[y]
1	2001	EF	1.66	-0.05349	3.1
1	2001	EP	6.27	-0.17118	3.7
2	2001	EF	3.40	-0.09957	3.4
2	2001	EP	6.20	-0.18445	3.4
1	2002	EF	1.64	-0.06039	2.6
1	2002	EP	4.59	-0.02412	19.0
2	2002	EF	4.80	-0.08648	5.6
2	2002	EP	7.16	-0.05833	12.3

[z]Early flower stage (EF) and Early pod stage (EP). [y]Number of PLB estimated to cause 10% yield losscalculated by (Y/10)/(-S), where Y = yield (g) and S is the lope of yield loss (g) per PLB/canola head

Plant Yield Response Trials in 2002

Plant yield losses varied among cultivars during early flower and pod stage (Table 2). However, such dramatic effects on yield following PLB infestation at early flower stages were not repeated at both of the six and four cultivars. Significant plant yield losses for four cultivars at early pod stages occurred on 46A65 when infested with 16 PLB per head (Table 2). In addition, averaged plant yield losses were significantly higher at early flower stages of six and four cultivars than were early pod stages (Table 4). However, averaged plant yield losses did not occur statically significant with all infestation levels in both early flower and pod stages of six and four canola cultivars.

Artifacts associated with the study technique of bagged heads may be a factor in the responses observed from PLB infestation. Variability of Inter-plot was very high in these studies, which can obscure significant differences. Bagging can interfere with pollination, although spring canola is largely self-pollinated. However, comparison of the non-bagged heads with bagged heads where 0 PLB were introduced (Table 3) suggests that there was little effect on yield from bagging.

Plant yields losses varied greatly among these reported trials making it difficult to compare the effects of different PLB infestations on yield. To develop such comparison of calculations were made of the number of PLB required to produce 10% yield loss. This was done by use of the slope of the yield loss (in grams)/PLB in the formula (Y/10)/(-S), where Y = average yield of non-infested check and S is the slope. In all four trials where there was a negative relationship of yield with increasing PLB infestation a determination of numbers of FCB per head required to cause 10% yield loss could be established (Table 5). The studies indicated that yield losses were significantly higher at early flower stages than early pod stages in both years. Plant yield losses also varied among cultivars for each trial. In comparisons of 10% yield losses occurred with infestations of 3.1-5.6 PLB per head (avg. 3.7) with early flower stage infestations and 3.4-19.0 PLB per head (avg. 9.6) at early pod stage infestations (Table 5). Therefore, the proposal economic injury levels might be 3.1-5.6 PLB per head for early flower stages and 3.4-19.0 PLB per head for early pod stages of canola cultivars.

Central to optimally managing insects with an Integrated Pest Management approach is determining the damage potential of different pest populations. These are commonly presented as Economic Thresholds (ET), described as the pest population density at which a tactic should be initiated in order to stop the pest density from reaching the Economic Injury Level (EIL) (Norris *et al*., 2003; Pedigo *et al*., 1986). Economic thresholds have been proposed for *Lygus* in canola. Evaluations were done by sweep net sampling method from different researchers. For example, in the report by Butts and Lamb (1991) highest loss from a mixed population of *Lygus* occurred at densities of 52 *Lygus* bugs/10 sweeps at the early pod stages. A proposed an economic threshold of 15 *Lygus*/10 sweeps in canola at the end of flowering or at the beginning of pod formation (Wise and Lamb, 1998a,b). These previous efforts at establishing economic thresholds for *Lygus* on canola used sweep net sampling of field populations. A condition with the artificial infestation of bagged heads of this study is not strictly comparable. However, low populations (2 PLB/head) of PLB were able to significantly reduce yields in some cultivars at early flowering in the 2001 trials. This suggests that relatively low numbers of PLB at this growth stage can similarly affect canola yields as do mixed *Lygus* species infestations used in earlier studies. In incidence of collapsed seeds increased by 1.5% for each *Lygus* bug per sweep (Turnock *et al*., 1995). However, the effect of increasing PLB number per head did not decrease yields in a strictly linear fashion. A total weight of seed produced per pod was negatively related to the percentage of seeds blasted by *Lygus* (Butts and Lamb, 1990). When *Lygus* blasted 10% of the seeds, the loss in weight of seed produced per pod was about 11%, showing that pods had little or no ability to compensate the weight of seeds for the loss of seeds. Such direct correlation of increasing *L. elisus* and yield loss was not consistently observed. Instead of there often appeared to be a plateau of yield loss at higher PLB densities. During this study eight canola cultivars were included in at least one trial. All of them, with the exception of IMC205, which was included only in 2002, showed significant yield loss from PLB infestation in at least one trial. This suggests that there is likely little resistance to *Lygus* injury among canola cultivars.

In conclusion, yield reductions for eight cultivars were higher infestations at early flower stages than infestations at early pod stages in both years. In addition, the current studies also showed that comparisons of 10% yield loss occurred with infestations of 3.1-5.6 PLB per head (avg. 3.7) with early flowering stage infestations and 3.4-19.0 PLB per head (avg. 9.6) at early pod stage infestations. Therefore, proposal of economic injury levels for PLB might be variable between 3.1-5.6 PLB per head for early flower stages and 3.4-19.0 PLB per head for early pod stages.

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