PEST MANAGEMENT

Population Dynamics and Damage Caused by the Leafminer *Liriomyza huidobrensis* Blanchard (Diptera: Agromyzidae), on Seven Potato Processing Varieties Grown in Temperate Environment

R López[1], D Carmona[1], A M Vincini[1], G Monterubbianesi[1], D Caldiz[2]

[1]*Zoología Agrícola, Unidad Integrada EEA Balcarce, INTA-Facultad de Ciencias Agrarias, Univ Nacional de Mar del Plata, CC 276. Ruta 226, km 73.5 B7620ZAA (Balcarce), Buenos Aires, Argentina; dcarmona@balcarce.inta.gov.ar*
[2]*Agronomy Area, McCain Argentina SA, Ruta 226, km 61.5, B7620EMA Balcarce, Buenos Aires, Argentina; dcaldiz@mccain.com.ar*

Edited by Jorge B Torres – UFRPE

Neotropical Entomology 39(1):108-114 (2010)

ABSTRACT - The leafminer *Liriomyza huidobrensis* Blanchard is considered a key pest for potatoes in Argentina. Population dynamics and leaf damage caused by the leafminer on seven selected potato processing varieties were assessed at Balcarce during the 2002 and 2003 growing seasons. Adult population dynamic was monitored using yellow sticky traps, while leaf damage (punctures and mines) was assessed using a damage index scale from low to severe. *Liriomyza huidobrensis* adults were present throughout the growing season and the population increased along crop development. The same was true for all varieties regarding larval damage, being low on early crop stages and severe late in the season. Varieties were grouped in two different categories according to damage scale index. Shepody, Kennebec, Frital and Innovator showed a higher damage index when compared with Santana, Ranger Russet and Russet Burbank, which exhibited a lower damage. Moreover, it could be assumed that damage was related to the foliage greenness, with light green colored varieties (Shepody, Kennebec, Frital and Innovator) being more attractive and affected by *L. huidobrensis*.

KEY WORDS: Yield, *Solanum tuberosum*, yellow sticky trap

Leafminers belonging to the genus *Liriomyza* are considered pests in many crops due to their damage to the leaves (Robert 1999). *Liriomyza* includes *ca*. 300 species distributed worldwide, with 23 of them being considered economically important (Parrella 1987, Kang *et al* 2009). The leafminer fly *Liriomyza huidobrensis* Blanchard, originally from the neotropics, was reported in Mexico, and Central and South America, but has rapidly disseminated to other countries in Europe, Africa and Asia (Mujica & Cisneros 2001, Larrain 2003). During the last 20 years, the leafminer fly has been considered a key pest in Peru, Bolivia, Brasil, Chile and Argentina. It is a polyphagous insect, affecting many host plants including horticultural crops and all associated weeds (Mujica & Cisneros 2001). Adult females damage the host mesophyll cells host due to ovipositor probing. After egg hatching, the eclosing larva also damage the leaf by mining the mesophyll and causing tissue death.

In Argentina *L. huidobrensis* has caused serious damage to beans, pea, celery, lettuce, pepper, spinach and tomato in the provinces of Jujuy, Córdoba, Entre Rios and Buenos Aires. Potatoes have been heavily damaged especially in the Southeast of Buenos Aires province, where 20-25,000 ha are annually grown (Caldiz 2006). In this region, *L. huidobrensis* was first detected during the 1980´s, damaging potatoes mainly during tuber bulking. It is highly likely that leafminer outbreaks since then were caused by an overuse of insecticides, which negatively impacted leafminer´s natural enemies (Vincini & Carmona 2006). Due to the associated damage and economical losses reported, the pest changed from being a potential to a key pest on potato (Vincini & Carmona 2006).

Despite the importance of leafminer in potato production, there is no local information available regarding its population dynamics and damage on potato varieties. Of special importance are the processing varieties, which occupy close to 50% of the growing area in the Southeast region. Additionally, there is evidence that temporal variations on population dynamics and damage level caused by *L. huidobrensis* are cultivar-dependent (Mujica & Cisneros 2001). Therefore, a survey on population dynamics and damage levels in different potato varieties was conducted in order to develop integrated pest management (IPM) practices based on threshold damage levels for different varieties.

Material and Methods

Site of study. Field trials were carried out at McCain experimental field located in Balcarce (37º 51 SL), province of Buenos Aires, Argentina, during the spring-summer season 2002/03. Based on previous soil analysis, 200 kg ha^{-1} NPK (32-23-0) were applied pre-planting; 250 kg ha^{-1} NPK (18-46-0) at planting, and 75, 60 and 15 kg ha^{-1} NPK (46-0-0) were also applied during crop growth.

Planting was performed in plots of four rows and 5 m length with a 4-row planter on 20th October 2002 in a completely randomized block design with four replications of the following potato processing cultivars: Frital INTA, Kennebec, Shepody and Santana (double purpose) and Innovator, Ranger Russet and Russet Burbank (suitable for processing into French fries). Seed pieces (45 g) were treated with Vitavax (Carboxim+Thiram) + Persist (Mancozeb 42%) in doses of 0.6 kg and 0.5 l ton^{-1} of seed, respectively. The trial was irrigated with a Valley forward advance sprinkler system based on soil moisture assessed by Watermark sensors.

Pests and diseases were managed as normally done in the area. Insecticides were applied 12 times during crop growth based on calendar application. Ten applications were done to control insects affecting the foliage and *L. huidobrensis* adults and two were especifically targeted to control the leafminer larvae (Table 1).

Adult population dynamics. Yellow sticky traps (20 x 20 cm) were designed based on Chávez & Raman (1987) and used for leafminer adults monitoring from 26th December 2002 to 26th March 2003 on a weekly basis. A total of eight traps were distributed in the site of study at 20 m from the edge of the experimental plots. Data for adult dynamics is jointly presented for all tested varieties. Trap catch was idenfied at the Agricultural Zoology Research and Service Laboratory, Integrated Unit EEA INTA-FCA, UNMdP. Adult counts of *L. huidobrensis* was conducted using a yellow plastic square of similar size of the sticky traps, divided in 12 observation fields of 6.25 x 6.66 cm, and the insects were counted in each field. All insects were separated using an entomological pin and were set in a petri dish 80% ethanol to remove the excess of the sticky material. The identification *L. huidobrensis* was carried out under a binocular microscope Olympus with the aid of a taxonomic key (Weintraub 2001).

Table 1 Insecticide application schedule. Balcarce, 2002-2003

Dates	DAP	i.a.	Dose (l/ha)
8 Oct. 2002		Chlorpiriphos	1.44
10 Dec. 2002	38	Deltametrin	0.015
14 Dec. 2002	42	Metamidophos	0.48
27 Dec. 2002	55	Imidacloprid	0.05
3 Jan. 2003	62	Lambda-cyhalotrin	0.0125
10 Jan. 2003	69	Cartap	0.25
	69	Endosulphan	0.3
17 Jan. 2003	76	Lambda-cyhalotrin	0.0125
23 Jan. 2003	82	B-ciflutrin	0.0075
1 Feb. 2003	91	B-ciflutrin	0.0075
4 Feb. 2003	95	Lambda-cyhalotrin	0.0125
13 Feb. 2003	104	Cartap	0.25[1]
	104	B-ciflutrin	0.0075
20 Feb. 2003	111	Clorpiriphos	0.48
25 Feb. 2003	116	Clorpiriphos	0.384
	116	Metamidophos	0.48
1 Mar. 2003	120	Clorpiriphos	0.384
4 Mar. 2003	123	Metamidophos	0.48

[1]kg/ha

Damage. Damage was evaluated from 26th December 2002 to 4th March 2003, dividing the crop canopy into three layers: lower (0-20 cm), intermediate (20-40 cm) and upper (> 40 cm). For each variety and replication, five leaflets were randomly collected (Valladares *et al* 1996, Cambareri 2004). Leaf damage was ranked as "mines" or "punctures". A damage index was established based on the percentage of the leaf area damaged (Fig 1), as follows: very low (0-20%), low (20-40%), moderate (40-60%), high (60-80%) and severe (80-100 %). Leaflets were observed on an illuminated viewfinder (60 x 50 x 20 cm high), with a glass surface and 6x 15 W OSRAM bulbs.

Data analyses. For each variety, damage was described as the mean average damage between the three crop layers. Damage was categorized as the percentage of leaf area affected by "punctures" and "mines" in each crop layer and is described in relation to sampling date and crop development status. Differences on damage scale between varieties were assessed by using the Kruskal–Wallis test at each sampling date. Once differences were detected, those with similar damage indices were grouped. Then, the association between varieties and damage was determined by using Pearson´s and Spearman´s correlation coefficients. Analyses were performed using computing R environment (R Development Core Team, 2004).

Results and Discussion

Adult population dynamics. Specimens of *L. huidobrensis* were captured throughout the sampling period from 54 DAP onwards. The highest population density was recorded during the period from the 2nd-3rd week of January (806 specimens $trap^{-1}$ $week^{-1}$) to the 3rd week of February (3947 speciemns $trap^{-1}$ $week^{-1}$). Within this period, population density steadily increased from the 4th week of January, which coincided with the flowering period. Our data showed a clear association between *L. huidobrensis* seasonal population dynamics and crop development. Population densities slowly increased during early crop growing stages, but had a stead increased from flowering onwards. Several authors found that inmigrant adults initiate infestations in small potato plants (Chavez 1985, Mujica *et al* 2000, Mujica & Cisneros 2001), and as the plant developed, the number of adults increased about one week before flowering and decreased during the initiation of plant senescence (Vincini & Carmona 2006).

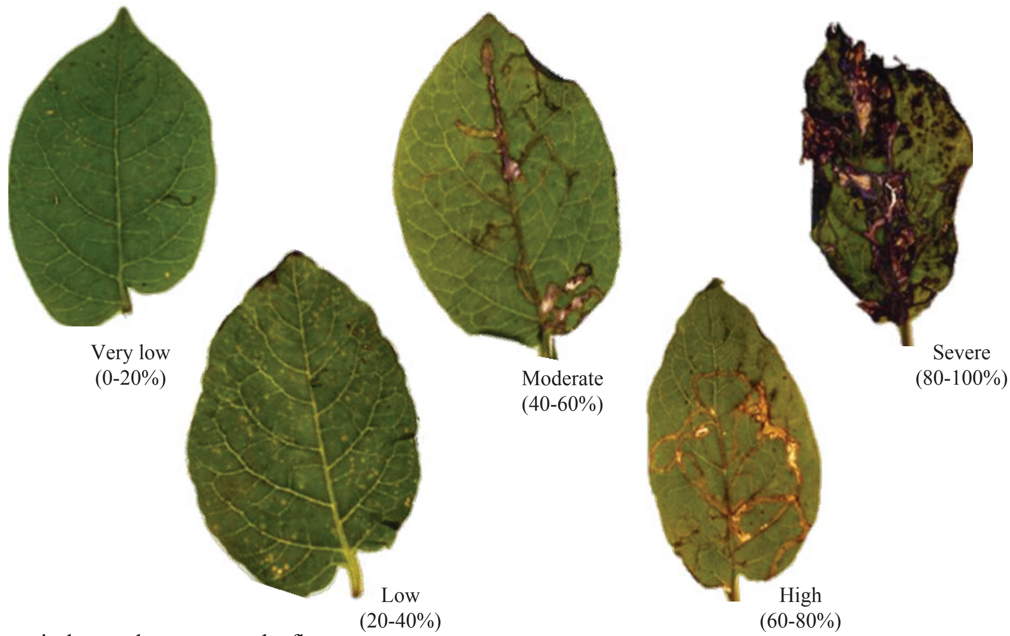

Fig 1 Damage index scale on potato leaflet.

Damage. Increased as the crop developed for all varieties (Fig 2), and for all three canopy layers tested (Figs 3, 4). The highest damage was recorded in the lower layer early in the season and by mid-crop development, mainly due to oviposition punctures caused by colonizing females. In all varieties, the damage pattern was initially low, and increased with crop development. As the crop produced more leaves, there are more opportunities for adults to land and for larvae to develop; as a consequence the population increased. Mujica & Cisneros (1997) observed a higher damage index in the lower crop layer and a lower damage in the intermediate and upper crop layers during early crop development. This damage pattern could be related to an egg extrusion phenomenon related to leaf aging. Egg extrusion is a hypersensitive reaction that comprehends hypertrophic cell growth leading to egg ejection and consequent exposure to the environment and natural enemies. Extrusion is high in young leaves and low in old ones. Nearly 90% of the eggs inserted in actively growing leaves do not reach the embryonic stage nor hatch due to this phenomonon. However, when eggs are laid in a mature leaf, the extrusion is virtually inexistent and once the eggs are hatched, the

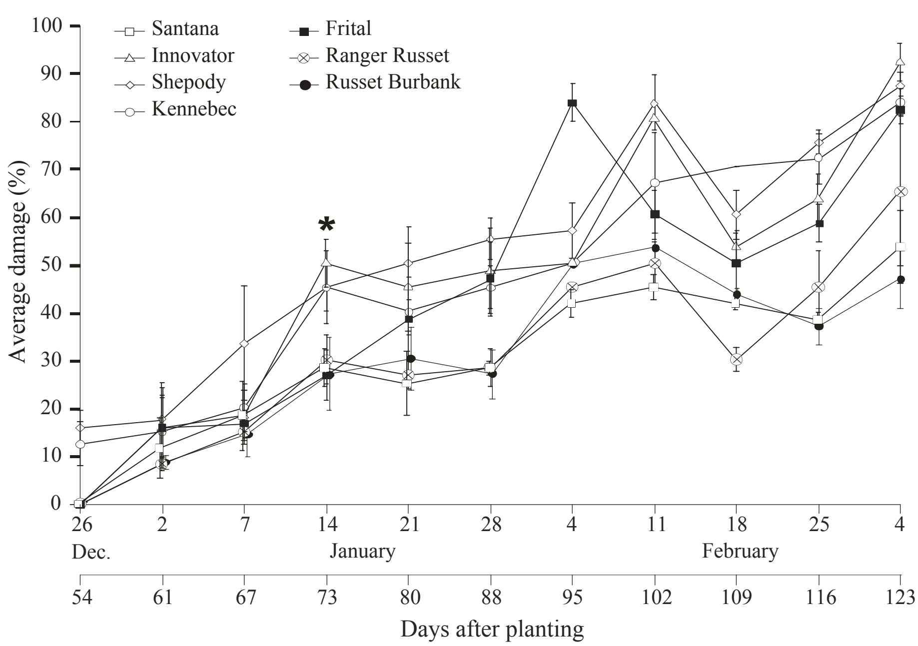

Fig 2 Damage progression on seven potato varieties. Balcarce, Buenos Aires province. 2002-2003.

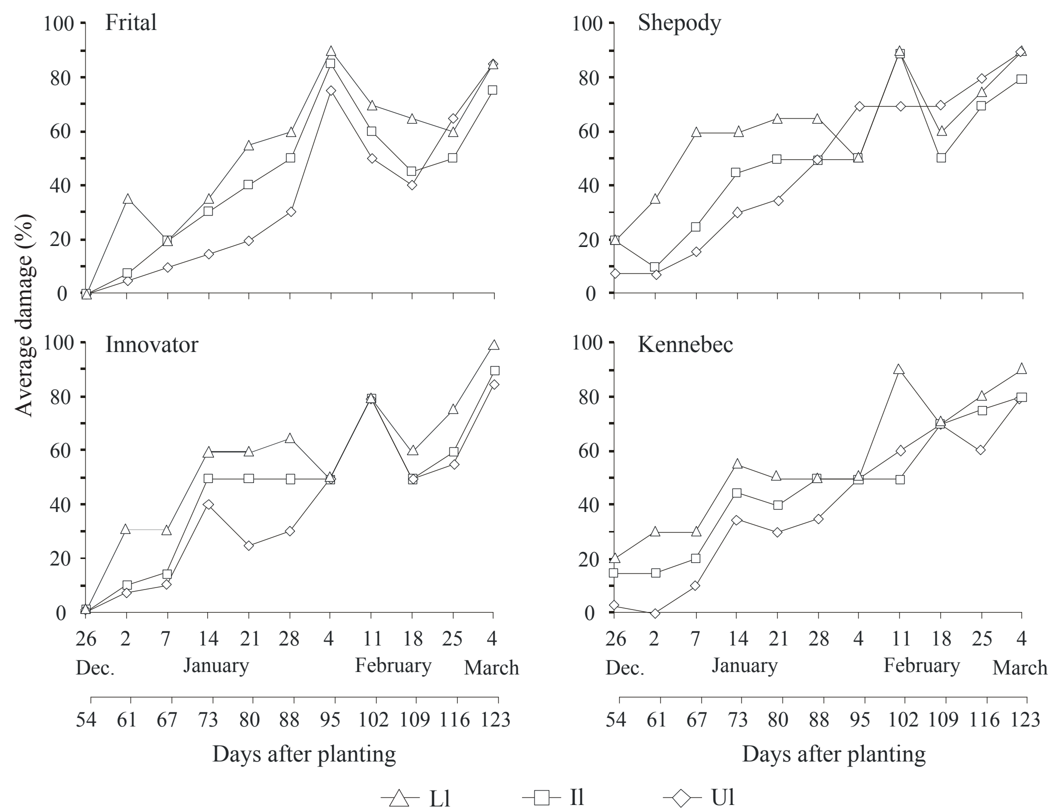

Fig 3 Damage progression on the most damaged varieties. Balcarce, Buenos Aires province. 2002-2003. (Ll: lower layer, Il: intermediate layer and Ul: upper layer).

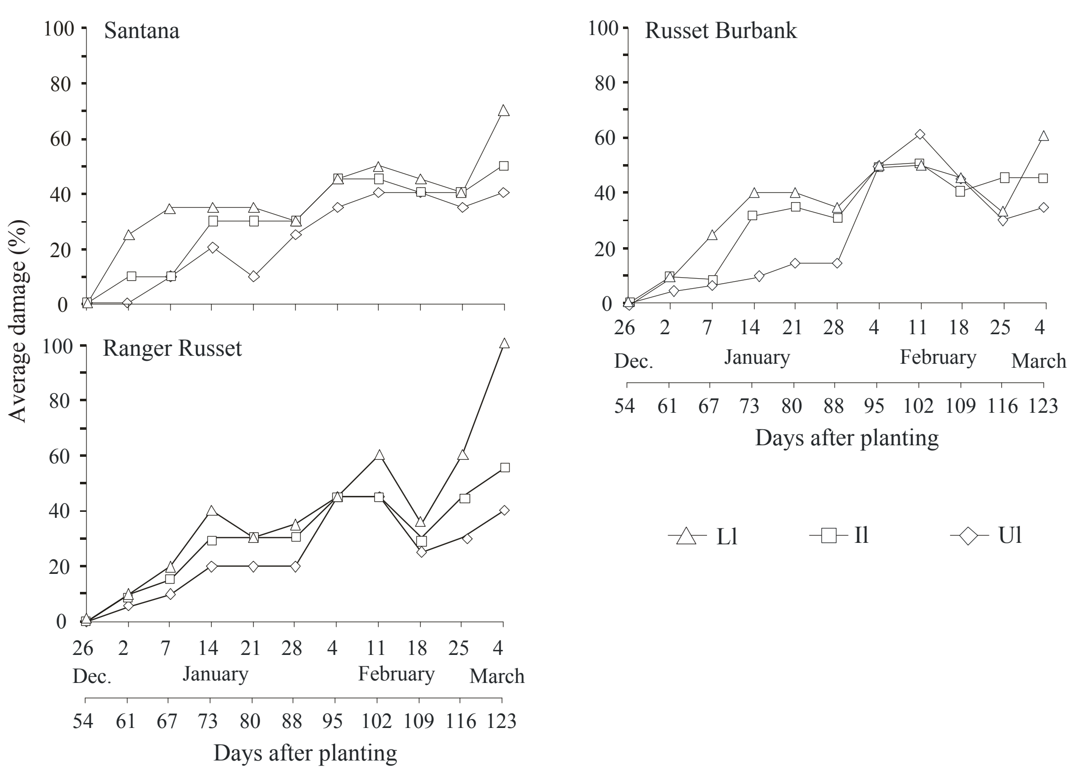

Fig 4 Damage progression on the least damaged varieties. Balcarce, Buenos Aires province. 2002-2003. (Ll: lower layer, Il: intermediate layer and Ul: upper layer).

larvae start to mine the mesophyll (Mujica & Cisneros 1997, Facknath 2005). Similar results were found by Videla & Valladares (2007) in Argentina, in young potato plants of the variety Spunta.

By 70-80 DAP a moderate damage (40-60%) was observed in the intermediate layer of Frital, Innovator, Shepody and Kennebec. Fifteen days later (85-95 DAP) a similar damage index was assessed in Santana, Russet Burbank and Ranger Russet. A severe damage (80-100%) was observed a few days later in all varieties, being Shepody, Kennebec, Frital and Innovator in the top limit of the range (100%), while Santana, Ranger Russet, and Russet Burbank were on the lower limit (80%) (Fig 2). The differences found between varieties could be associated to the long growing cycle in Russet Burbank, continuous leaf production in Santana, and the darker green color of Ranger Russet foliage, which is less attractive to the leafminer fly. Glandular thrichomes and the length of the growing period of each variety were also reported to be associated with the damage caused by *L. huidobrensis* (Cisneros & Mujica 1997). Varieties with a longer cycle had lower leaf damage than those with a short cycle, probably due to their ability to recover from leaf damage.

Significant differences in damage indices were found between varieties from January 14th and onward. Based on these differences, varieties were grouped by Pearson and Spearman's correlation coefficients (Tables 2 and 3).

Damage in each crop layer was also variety-dependent. Shepody and Kennebec showed low damage (20-40%) in the lower layer from December 26th and onwards, while Innovator and Frital showed the same type of damage a few days later (January 2nd). However, within the same damage range, the latter were close to the highest value (40%; Fig 3). In Shepody, the lower layers showed low damage (20-40%) during the first week of January, but increased to moderate (60%) by the end of the 2nd week. The intermediate crop layer showed very low damage by January 2nd, but rapidly increased to moderate by January 14th. The upper layer always showed very low damage (Fig 3). That period (December 26th - January 14th) was coincident to seedling stage and the beginning of flowering crop. According to Cisneros (1992), the crop can support a higher defoliation in this period (50-100%) without suffering high yield losses. Braun & Shepard (1997) showed that the potato plant can support defoliation up to 60%, if it happens in the first 45 days after planting.

During the five following weeks (January 21th – February 18th) moderate to severe damage (60-90%); moderate (50%) to severe damage (90%) and low to high damage (35-70%) were observed for the lower, intermediate and upper crop layers, respectively. In this period (tuber bulking), damage was more severe due to the higher photosynthesis demand from the growing tubers (Cisneros 1992, Caldiz 2006). In the present study, during the tuber bulking period, damage was moderate and probably contributed to reduce tuber growth and yield (Fig 4). A study is in progress in order to establish a possible correlation between adult population density, damage degree and yield reduction, to be incorporated in a *L. huidobrensis* management program on potato crop.

During the last two2 weeks of crop development (tuber maturity period), high to severe damage was observed through all plant layers (70-90%, Fig 3). In this period, the importance of the leaves related to the yield diminish, as their losses did not have an effect on the yield (Cisneros 1992)

Pearson´s (Table 2) and Spearman´s (Table 3) coefficients showed the highest correlation value between dates for the variety Shepody. This variety also showed the highest damage index, followed by Innovator, while Kennebec and Frital showed the lowest ones (Fig 2), representing the group of the four varieties that showed higher damage severity.

Santana, Russet Burbank and Ranger Russet showed a pattern of temporal damage similar to the most damaged varieties group, but damage index never exceeded 60% (average for the whole crop) (Fig 2).

The high correlation values between damage indices and varieties (Table 4) showed an increased damage as the crop developed, with damage increasing from the beginning to the final period of potato crop development.

We conclude that *Liriomyza huidobrensis* is present during the whole development cycle of the seven potato varieties most utilized in the south east of Buenos Aires

Table 2 Pearson correlation coefficients between sampling dates related to damage scale (upper part), and significance values (lower part).

Dates	2-Jan	7-Jan	14-Jan	21-Jan	28-Jan	4-Feb	11-Feb	18-Feb	25-Feb	4-Mar
2-Jan	1	0.6799	0.6639	0.878	0.9604	0.4893	0.804	0.7791	0.8975	0.9369
7-Jan	0.092	1	0.5664	0.7207	0.684	0.0606	0.7019	0.5512	0.7103	0.5817
14-Jan	0.103	0.184	1	0.7942	0.6932	0.1837	0.8694	0.702	0.8058	0.7847
21-Jan	0.009	0.067	0.0328	1	0.9522	0.3779	0.9782	0.7641	0.9249	0.9178
28-Jan	0.0005	0.09	0.084	0.0009	1	0.5433	0.8875	0.752	0.9427	0.9704
4-Feb	0.265	0.89	0.69	0.403	0.207	1	0.2125	0.2235	0.3372	0.438
11-Feb	0.029	0.078	0.011	0.0001	0.007	0.64	1	0.6966	0.8717	0.8773
18-Feb	0.0389	0.199	0.078	0.045	0.051	0.629	0.082	1	0.864	0.7564
25-Feb	0.006	0.073	0.028	0.002	0.001	0.459	0.009	0.012	1	0.9503
4-Mar	0.0018	0.170	0.036	0.003	0.0002	0.325	0.009	0.049	0.001	1

Table 3 Spearman correlation coefficients between sampling dates related to damage degree.

Dates	2-Jan	7-Jan	14-Jan	21-Jan	28-Jan	4-Feb	11-Feb	18-Feb	25-Feb	4-Mar
2-Jan	0.0003	0.7567	0.4144	0.8288	0.9549	0.8288	0.8288	0.7387	0.7748	0.7748
7-Jan	0.066	0.0003	0.75	0.7142	0.8214	0.3928	0.7142	0.7857	0.8928	0.7857
14-Jan	0.35	0.066	0.0003	0.6071	0.6071	0.1785	0.6071	0.5714	0.75	0.8571
21-Jan	0.034	0.088	0.166	0.0003	0.8214	0.7857	1	0.8571	0.8571	0.8571
28-Jan	0.002	0.034	0.166	0.034	0.0003	0.75	0.8214	0.6785	0.8571	0.8928
4-Feb	0.034	0.39	0.713	0.048	0.066	0.0003	0.7857	0.6428	0.6428	0.6428
11-Feb	0.034	0.088	0.166	0.0003	0.034	0.048	0.0003	0.8571	0.8571	0.8571
18-Feb	0.066	0.048	0.200	0.023	0.109	0.138	0.023	0.0003	0.8214	0.7142
25-Feb	0.048	0.012	0.066	0.023	0.023	0.138	0.023	0.034	0.0003	0.8928
4-Mar	0.048	0.048	0.023	0.023	0.012	0.138	0.023	0.088	0.0123	0.0003

Table 4 Correlation between damage indices and varieties.

	Frital	Innovator	Kennebec	Ranger R.	Russet	Santana	Shepody
Frital	1	0.8	0.83	0.927	0.939	0.939	0.8787
Innovator		1	0.94	0.948	0.8085	0.917	0.9483
Kennebec			1	0.89	0.769	0.89	0.9515
Ranger R.				1	0.903	0.975	0.9272
Russet					1	0.927	0.878
Santana						1	0.939
Shepody							1

Province. There were clearly two different groups of varieties related to the different severity damage indices. Future research must focus on the incidence of the different damage indices on the potato crop yield.

Acknowledgments

To Mr Antonio Riero for his support in the field work and Mc Cain Argentina SA for kindly provide its Experimental Field to carry out this trial. Thanks are due to Dr Graciela Valladares (Institución) by specimens' identification. This work was supported by FONCyT and Mar del Plata University, Argentina.

References

Braun A, Shepard M (1997) Leafminer fly: *Liriomyza huidobrensis*. Technical Bulletin. The International Potato Center and The Clemson University Palawija, IPM Project, 6p. [On line] http://www.eseap.cipotato.org/file-library.htm. [12/01/04].

Caldiz DO (2006) Producción, cosecha y almacenamiento de papa en la Argentina. McCain Argentina SA – BASF Argentina SA, Buenos Aires, Argentina. 226p.

Cisneros F H (1992). El manejo integrado de plagas. In Guía de Investigación CIP 7. Centro Internacional de la papa. Perú, 38p.

Cisneros F, Mujica N (1997) The leafminer fly in potato: plant reaction and natural enemies as natural mortality factors, p.129-140. In CIP program Report 1995-96.

Chávez G (1985) Evaluación de diferentes modelos de trampas para mosca minadora. Facultad de Ciencias Biológicas, Universidad Ricardo Palma, Lima, 60p.

Chávez G, Raman K (1987) Evaluation of trapping and trap types to reduce damage to potatoes by the leafminer, *Liriomyza huidobrensis* (Diptera: Agromyzidae). In ICIPE Science Press (reprinted from) 8: 369-372.

Facknath S (2005) Leaf age and life history variables of leafminer: the case of *Liriomyza trifolii* on potato leaves. Entomol Exp Appl 115: 79-87.

Kang L, Cheng B, Ning Wei J, Tong-Xian L (2009) Roles of thermal adaptation and chemical ecology in *Liriomyza* distribution and control. Annu Rev Entomol 54:127-45

Larrain, P (2003) Plagas de la papa y su manejo. Colección Libros INIA Núm. 9. Instituto de Investigaciones Agropecuarias, Ministerio de Agricultura, Gobierno de Chile. La Serena, Chile, 110p.

Mujica N, Cisneros F (1997) Developing IPM Components for leafminer fly in the Cañete Valley of Peru, p.177-184. In CIP Program Report 1995-96.

Mujica N, Cisneros F (2001) Biología de la mosca minadora *Liriomyza hidobrensis*. Módulo 1: investigación biológica. Manual de capacitación, Lima, 7p.

Mujica N, Fonseca C, Suárez F, Fabian F, Marchena M, Cisneros M (2000). Reducción del uso de insecticidas en el control de la mosca minadora *Liriomyza huidobrensis* Blanchard, por medio del uso de técnicas etológicas. Taller de planificación, implementación, monitoreo y evaluación de programas de MIP en el cultivo de papa Lima, p.153-162.

Parrella M (1987) Biology of *Liriomyza*. Annu Rev Entomol 32: 201-224.

R Development Core Team (2004) R: a languaje and environment for statistical computing. R Foundation for Statistical Computing, Viena, Austria. ISBN 3-900051-07-0 [On line] http//www.R-project.org [28/07/04].

Robert Y (1999) Plagas. La patata: producción, mejora, plagas y enfermedades, utilización, p.169-224. In Rouselle P, Robert Y, Crosnier JC (eds) La patata, Mundi-Prensa, Madrid, 607p.

Valladares G, Pinta D, Salvo A (1996) La mosca minadora (*Liriomyza huidobrensis* Blanchard) en cultivos hortícolas de Córdoba. Hortic Argentina 15: 13-18.

Vincini A M, Carmona D M (2006) Insectos. Producción, cosecha y almacenamiento de papa en la Argentina. (ed. By DO Caldiz) McCain Argentina SA – BASF Argentina SA. Buenos Aires, p.165-169.

Weintraub P (2001) The pea Leafminer, *Liriomyza huidobrensis*, in Israel. Gilat Research Center, 6p. [On line]: http:/www.molcho.org.il/leafminer english.htlm.[15/10/07]

Received 02/III/09. Accepted 07/IX/09.