

*Full Length Research Paper*

## **Management of potato leaf miner in Uganda**

**Mwesige Rose\*, Alex Barekye, Etiang Joseph, Kwikiriza Gerald, Uzatunga Innocent and Kyarisiima Sarah**

Kachwekano Zonal Agricultural Research and Development Institute, P. O. Box 421, Kabale, Uganda.

Received 12 April, 2018; Accepted 11 May, 2018

The yield of potato, an important food security and income crop in Uganda is substantially affected by pests. A survey was carried out in south western Uganda, a major potato growing area to assess the distribution and severity of potato pests in June and July 2015. In addition, leaf miner management options such as pesticide use, yellow sticky traps and mulching were evaluated for effectiveness. Trials in leaf miner hot spots in Bukimbiri and Chahi sub-counties of Kisoro district were conducted in three seasons during 2016 to 2017. In each sub-county, two sites were selected per season and trials were established in a completely randomized design with each treatment being replicated three times. From the survey, aphids and leaf miners were the major pests with high incidences in Kabale and Kisoro districts and rarely encountered in Rukungiri and Kanungu. Use of Dudu-acelemectin reduced leaf miner damage on leaves in season 1 (2017;  $P=0.001$ ) and registered significantly higher yields compared to other treatments. Yellow sticky traps trapped high leaf miner fly populations but leaf miner damage on leaves and yield were not significantly different from control and mulched plots. Judicious use of pesticides in high leaf miner populations together with yellow sticky traps can reduce leaf miner populations and damage on potato.

**Key words:** Potato, potato leaf miner, pesticides, yellow sticky traps.

### **INTRODUCTION**

Potato (*Solanum tuberosum* L.) is the fourth most important crop after corn, rice and wheat (Schwartzmann, 2010) with world's total production of 376.8 million tonnes (UNSTAT, 2016). The crop plays a significant role in human nutrition by providing essential amino acids, minerals and vitamins (Deußer et al., 2012). Today, over 140 countries engage in potato production with China being the largest producer (Kroschel et al., 2012). In sub-Saharan Africa, potato production has increased from 100 to 290 metric tonnes between 1994 and 2008 with 70% of this growth being concentrated in East Africa

(FAO, 2008). In East Africa, Kenya is the leading potato producer with 9.0 tonnes/ha, followed by Rwanda 7.7 tonnes/ha, and lastly Uganda producing 4.3 tonnes/ha (FAOSTAT, 2016).

Potato is Uganda's staple food and main source of income especially in South Western Highlands where 60% of the national crop is produced (FAO, 2008; Aheisibwe et al., 2015). However, yield has remained low compared to the 40 to 50 tonnes/ha produced in well-developed potato production systems (FAOSTAT, 2013). The low potato yield is attributed to various factors which

\*Corresponding author. E-mail: [rosie.mwesige@gmail.com](mailto:rosie.mwesige@gmail.com).

include poor quality seed, diseases, limited use of fertilizers, and invasion of the crop by insect pests among others (Wagoire et al., 2005). The most important potato pests constraining potato quality and productivity in Uganda are potato tuber moth, aphids and leaf miners (Okonya and Kroschel, 2016).

Leaf miners (*Liriomyza* species) are polyphagous pests causing severe damage on potatoes and several other crops (Parrella, 1987). Adult flies lay eggs in leaves, the larvae feed within the leaves and at high fly populations feeding can heavily reduce yield and/or lead to plant death (Spencer, 1989). Leaf miner populations vary with season and temperatures for example in Baltistan, Pakistan highest populations are recorded in July with temperatures range between 22 and 27°C (Rizvi et al., 2015).

The common leaf miner species in the world are *Liriomyza trifolii* Burgess, *Liriomyza sativae* (Blanchard) and *Liriomyza huidobrensis* (Blanchard) (Murphy and Lasalle, 1999). *L. huidobrensis*, originally reported in Mexico, and Central and South America, causes serious damage on potato and has rapidly spread to other countries in Africa, Europe and Asia (Mujica and Cisneros, 2001). In Indonesia, leaf miners are reported to cause up to 100% yield loss at high fly populations (Shepard et al., 1998). In Kenya, yield losses are reported to range between 20 and 100% depending on the cultivar, crop species, crop development stage and also on leaf miner fly population (Gitonga et al., 2010). Although farmers have reported damage by leaf miners in Uganda, little is known about its severity and yield losses on potato.

Several leaf miner management strategies have been used in other countries but successful management depends on the development of a reliable and sustainable integrated pest management system. Murphy and LaSalle (1999) and Liu et al. (2009) demonstrated use of hymenopteran parasitoids as biological control agents of the leaf miner and can be complimented by planting flowering plants as sources of natural enemies. Although parasitoids are important control agents, their effective use in practice can be difficult because naturally parasitoid populations lag behind host population development (Weintraub, 2001). In such cases, growers will need to apply insecticides for leaf miner populations to keep below economically damaging levels (Reitz et al., 2013). The uses of trans-laminar insecticides with abamectin and cyromazine as active ingredients significantly reduce Agromyzid larvae with limited effects on the pest parasitoids (Reitz et al., 2013). In some instances, use of pesticides in leaf miner management has not been effective because the pest tends to develop resistance (Suryawan and Reyes, 2016). Additionally, there are potato plants resistant to *L. huidobrensis* and the mechanism of resistance is attributed to varieties having a high density of glandular trichomes which restrict oviposition sites and reduce feeding (Weintraub and Horowitz, 1995). The effectiveness of the

aforementioned leaf miner management strategies have not been tested in Uganda.

In view of the aforementioned, there was need to assess the status of potato pests in the region and the present study assessed the distribution, severity of potato pests and evaluated the effectiveness of different management options for the potato leaf miner in South Western Agro Ecological Zone of Uganda.

## MATERIALS AND METHODS

### Survey site

A survey on the distribution and severity of potato pests was carried out in south western Uganda in June and July, 2015 in the districts of Kabale, Kisoro, Rukungiri and Kanungu. A total of 12 sub-countries were selected namely Chahi, Bukimbiri, Nyakabande and Kanabi from Kisoro; Muko, Bubare, Rwamucucu and Kamuganguzi from Kabale; Nyakishenyi and Nyarushanje from Rukungiri; Kihihi and Rutenga from Kanungu.

Four farmers were selected from each sub-country for house hold interview and field sampling. A distance of 2 to 6 km was used from one farmer to another depending on the availability of the farmer and the potato garden.

### Pest and damage assessment

Thirty plants in each sampled field were selected diagonally and checked for the type of pests present and infestation severity scored.

Damage by leaf miners was scored on a scale of 1 to 5 where 1 represented no symptoms and 5 the most severe symptom (Nukene et al., 2002). Potato leaves were checked for any signs of leaf miner damage.

Aphids were counted on three leaves of each plant (the top, middle and bottom) and recorded. Aphid severity on plants was scored at a scale of 1-5 where 1 represented no aphid, 2=1-10 aphids, 3=11-50 aphids, 4=51-100 aphids, and 5=≥100 aphids per three leaves

Leaf miner and aphid severity index were calculated using the following formula according to Nelson et al. (1999):

$$[1*P1+2*P2+3*P3+4*P4+5*P5/N (G-1)] \times 100$$

where P1 to P5 = Total number of observed plants at each site. G = Number of grading = 5 and N = Total number of observations.

### Evaluation of leaf miner management options

The study was conducted in Chahi and Bukimbiri sub-counties of Kisoro district for 3 seasons with two sites being planted per sub-county. Trials were planted on 30th March 2016, 18th October 2016 and 27th April 2017. New sites were selected for the following seasons within the same sub-counties. Clean potato seed of variety Rwangume was used because it is the most cultivated variety in the region. Potato was planted at a spacing of 30x75 cm in a 3x3 m plot, each plot separated by 2 m space from the other. N.P.K fertilizer was used to boost soil fertility and Ridomil was used as a fungicide to protect the crop against late blight and other fungal diseases.

Management strategies that were evaluated include: use of pesticides (Dudu acelamectine), use of yellow sticky traps (used locally available mouse traps), use of mulching with bean residues (since the pest pupates in soil, we hypothesized that mulching would hinder the emergence of the adults and reduce pest

population) and a combination of yellow sticky traps and mulching.

The pesticide (Dudu acelamectine) was applied as soon as pest damage in the field was observed. All sprays were done in the morning during calm weather conditions to avoid pesticide drifts. Manufacturers' application rates of 15 ml in 15 L of water sprayed after every 7 days were followed. Yellow sticky traps were installed after 3 weeks of crop emergency for population monitoring and control. In a 3 × 3 m plot, five sticky traps were placed and these would be changed in case they were damaged by weather or if they were full of insects. All other strategies were put in place after the pest had appeared. Plots with no treatment were also established for comparison. The experimental design was a completely randomized design with 3 replications per site.

#### **Data collection**

Data were collected on leaf damage after 3 weeks of application of a management strategy and yield at maturity. Leaf damage data were collected according to Lopez et al. (2010) where ten plants were randomly selected per plot and on each plant the canopy was divided into three layers, that is, lower leaves (0-20 cm), middle leaves (20-40 cm) and upper leaves (>40 cm). Damage was observed as mines and punctures. Depending on the leaf area damage, a damage score was used according to Lopez et al. (2010) as follows: low (20-40%), moderate (40-60%), high (60-80%) and severe (80-100%).

#### **Data analysis**

Genstat 14th edition statistical package was used in data analysis to generate descriptive statistics. ANOVA was used to generate differences in districts, altitude, crop age, treatments and time of planting.

## **RESULTS**

### **Distribution and severity of potato pests**

Leaf miners and aphids were the common pests on potato at 41.7 and 55%, respectively (Table 1). Leaf miners were found in Kisoro district in the sub-counties of Chahi, Bukimbiri and Nyakabande. In Kabale, the pest was found in Muko and Bubare sub-counties and rarely encountered in Kanungu and Rukungiri districts (Figure 1). Leaf miner damage was higher at high altitudes compared to low altitudes (Table 2) and no leaf miner damage was observed at altitudes below 1000 m above sea level (Table 2). There was a significant difference in leaf miner damage on potato plants at different growth stages ( $P=0.001$ ) with potato at two and three months after planting showing more damage than potato at one month old (Table 2).

Aphids were found in all the districts but more prevalent in Kabale and Kisoro districts (Figure 1). Aphids were encountered at all altitudes but high altitudes had significantly more aphid numbers than low altitudes ( $P<0.001$ ) (Table 2). Aphid severity was associated with the age of the crop with the highest numbers on potatoes of three months old and the lowest on potatoes of one month old ( $P=0.001$ ) (Table 2).

### **Evaluation of management options for potato leaf miner**

Analysis of variance (Table 3) shows a significant difference ( $P=0.001$ ) in yield for time of planting while other evaluated management options (pesticides, yellow sticky traps and mulching) were not significantly different. There was no significant difference on leaf damage for time of planting. Management options were statistically different in terms of leaf damage ( $P=0.001$ ). The interaction between time of planting and management options had no effect on yield and leaf miner damage (Table 3).

### **Yield and leaf damage under leaf miner management options**

In the first season 2016A, plots treated with pesticide (Dudu acelamectin) were significantly less damaged compared to the ones with yellow sticky traps, mulch and control plots ( $P=0.03$ ). Leaf damage in plots with yellow sticky traps and mulches was not significantly different from control plots (Table 4). There was no significant difference in yield between managed and control plots ( $P=0.951$ ) (Table 4).

In season 2016B, leaf miner populations were very low and the pest manifested when the crop was almost mature. Damage data was not collected, but the crop was harvested for yield data. Yield from all treatments was not significantly different ( $P=0.63$ ) (Table 4).

In 2017A, the pest manifested early on the crop and there was a significant difference in leaf damage ( $P=0.006$ ) and yield for management options ( $P=0.001$ ). In terms of yield, pesticide application gave a higher yield that was significantly different from all other management options. Yield from other management options was not different from control. Plots treated with pesticide had a significant low leaf damage compared to other plots (Table 4).

## **DISCUSSION**

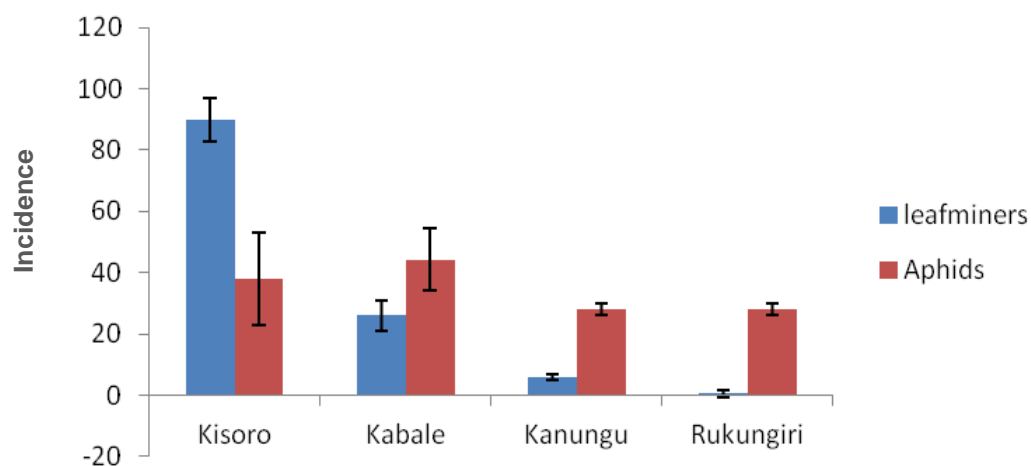
### **Distribution and severity of potato pests**

Aphids and leaf miners were the common pests in potato fields. They are important potato production constraints in east African countries (Were et al., 2013). The higher incidence of pests particularly in the districts of Kisoro and Kabale could be attributed to continuous potato growing throughout the year giving a chance to pests to thrive.

Potato leaf miner damage severity increased with elevation while potatoes planted at elevations below 1000 m being less damaged. Leaf miner abundance at high altitudes could be explained by their natural occurrence in

**Table 1.** Occurrence of potato pests in south western Uganda in the survey carried out between June and July 2015.

Potato pests	Number	Percentage
Aphids	33	55.0
Leaf miners	25	41.7
Others (Cutworms, potato tuber moth and ants)	2	3.3

**Figure 1.** Incidence of leaf miners and aphids in districts of South Western Uganda.**Table 2.** Mean severity score and severity index for potato leaf miners and aphids from the districts of south western Uganda.

Variable	Mean severity score for leaf miners damage	Severity index for leaf miners	Mean severity score of aphids	Severity index for aphids
<b>District</b>				
Kabale	1.49	1.0	1.8	2.3
Kanungu	1.08	0.06	1.4	0.08
Kisoro	3.52	8.84	1.6	0.87
Rukungiri	1.01	0.027	1.4	0.18
LSD	0.15	-	0.15	-
F-prob	0.001	-	<0.001	-
<b>Altitude</b>				
≤1000	1.00	1.19	1.06	1.27
1001-1500	1.3	1.59	1.13	1.9
1501-2000	2.16	2.74	1.604	2.15
2001-2500	2.3	3.19	1.58	2.13
LSD	0.3	-	0.3	-
F- prob	0.001	-	<0.001	-
<b>Crop age</b>				
1	1.13	0.1	2.3	0.10
2	2.17	3.84	2.5	2.98
3	3.62	6.49	2.6	4.07
LSD	0.261	-	0.26	-
F-prob	0.001	-	0.001	-

**Table 3.** Analysis of variance of yield and leaf damage for potato leaf miners management options and planting time in south western Uganda.

Source of variation	Yield			Damage on lower leaves		
	df	F-Statistic	F-Value	Df	F-statistic	F-value
Management option	4	1.19	0.33	4	10.92	0.001
Time of planting	2	39.99	0.001	1	0.56	0.463
Management option* time of planting	8	0.35	0.938	4	1.71	0.182

**Table 4.** Percentage leaf damage and mean yield for different potato leaf miner management options.

Treatment	Yield (kg/ha)			Damage on lower leaves (%)			Damage on middle leaves (%)		
	2016A	2016B	2017A	2016A	2016B	2017A	2016A	2016B	2017A
Control	43259	39111	6167.5	51.0	-	73.2	36.8	-	56.0
Mulching	51852	57556	7653.4	51.7	-	60.5	35.3	-	42.5
Pesticide (Dudu acelamectin)	57963	52111	10694.4	26.7	-	20.2	20.0	-	22.5
Yellow sticky traps	50185	56000	8093.3	58.0	-	65	30.3	-	40.0
Yellow sticky trap+ Mulch	52074	41556	8491.3	50.5	-	54	26.7	-	48.3
LSD	NS	NS	2368.9	24.57	-	20.17	NS	-	10.56
F-prob	0.952	0.634	0.006	0.030	-	0.001	0.498	-	<0.001

temperate regions and cooler highlands (Specer, 1973; Parrella, 1987). For instance, *L. huidobrensis* is reported to have first invaded higher and cooler altitudes of Indonesia and Costa Rica (Weintraub, 2001). In addition, Rodriguez-Castaneda et al. (2017) noticed a physiological restriction for *L. huidobrensis* at 28 to 29°C above which adult flies failed to emerge. Lanzon et al. (2002) noticed that *L. huidobrensis* developed faster at lower temperature of 15°C and much slower at 30°C. This temperature ranges are the same for Kabale and Kisoro. Moreover, potato production in Kanungu and Rukungiri is still very low and the area has a relatively long dry spell without the host crop, most likely does not allow the pest population to increase. Chavez and Raman (1987) reported a significant negative correlation between the activity of adult female leaf miners and temperature explaining their limited occurrence in the warmer areas of Kanungu and Rukungiri. Significant differences in leaf miner damage in older plants than young plants are supported by findings of Mujica and Kroschel (2011) who reported increased crop injury by leaf miners with crop development.

#### Evaluation of management options for potato leaf miner

In the first season of 2016 where planting was done in March, leaf damage on insecticide treated plants was significantly lower compared to other management options but yield was not different from control plots and other treatments. This could have been as result of lower

leaf miner populations in that season or because of early planting, which could have made the crop vigorous and overpowered the effects of leaf miner damage. Similar findings were reported in Israel whereby the arrival of *L. huidobrensis* and its conspicuous damage on leaves did not result in any yield loss (Weintraub, 2001). However, in 2017A when leaf miner attack was pronounced, significantly high leaf damage was observed on control plots compared with pesticide treatments and insecticide treated plots yielded higher. Similar trends were reported by Guantai et al. (2015) where pesticide use in the management of the pea leaf miner reduced crop damage. Dudu acelamectin is an insecticide having abamectin as an active ingredient. Abamectin has systemic and translaminar properties and has been found to be effective against leaf miner larval stages (Weintraub and Horowitz, 1995; Reitz et al., 2013). Yellow sticky traps were observed to trap leaf miner populations but plots with traps were not significantly different in yield and leaf damage with control plots. The same trends were reported by Kroschel et al. (2012) where trapping reduced leaf miner flies but would not effectively prevent yield reductions and larval mining and development. Therefore, in such cases judicious use of insecticides with yellow sticky traps would be more effective. Planting in March and October increased yields and reduced pest damage on potato compared to planting late in April. In Uganda, crops planted in March experience enough rainfall suitable for crop growth.

Planting late April is off season meaning the crop will meet drought in June and chances of performing well are minimal. Barros et al. (2017) noted that environmental

and cultural conditions including off season cultivation, monocultures and occurrence of drought periods increase pest attacks and limit crop yields.

## Conclusion

Aphids and leaf miners were the major potato pests in south western highland agro-ecological zone of Uganda. Use of Dudu-acelemectin in high leaf miner populations resulted in reduced leaf miner damage and increased yield. Yellow sticky traps are good for population monitoring and reduction. Planting clean seed at the beginning of rains results in healthy and vigorous plants with high yields. Therefore early planting is the best practice as it reduces costs involved in leaf miner management. Further research should focus on the effect of planting dates on leaf miner management.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

## REFERENCES

- Aheisibwe AR, Barekye A, Namugga P, Byarugaba AA (2015). Challenges and opportunities for quality seed potato availability and production in Uganda. *Uganda Journal of Agricultural Sciences* 16(2):149-159.
- Barros LS, Guimarães HO, Carvalhais J, Carvalho MM, Czepak C, Oliveira, IP, De Castro WA (2017). Agronomic effectiveness and practicability of insecticides in *Liriomyza huidobrensis* control (Diptera: Agromyzidae) of potato. *Global science and technology* 10:1.
- Blanchard E (1926). A dipterous leaf-miner on *Cineraria*, new to science. *Journal of the Entomological Society Argentina* 1:10-11.
- Capinera J (2001). *Hand book of vegetable pests* 1<sup>st</sup> Edition, Academic Press, New York ISBN-13; 178-0121588618, P. 2700. <https://www.elsevier.com/books/handbook-of-vegetable-pests/capinera/978-0-12-158861-8>
- Chavez GL, Raman KV (1987). Evaluation of Trapping and Trap types to Reduce Damage to Potatoes by the leafminer, *Liriomyza huidobrensis* (Diptera: Agromyzidae). *Insect Science and its Application* 8(3):369-372.
- International Potato Center (CIP) (1992). Program Report. Lima, Peru. <https://www.cgiar.org/research/center/cip/>
- Deußer H, Guignard C, Hoffmann L, Evers D (2012). Polyphenol and glycoalkaloid contents in potato cultivars grown in Luxembourg. *Food Chemistry* 135(4):2814-2824.
- Food and Agriculture Organization (FAO) (2008). Workshop to Commemorate the International Year of Potato. Bangkok, 6 May 2008 Proceedings. [www.potato2008.org/en/potato/index/html](http://www.potato2008.org/en/potato/index/html)
- FAOSTAT (2013). Food and Agriculture Organization statistical database, United Nations, Rome, Italy. Available online. URL: <http://www.faostat3.fao.org/home/index.html>
- FAOSTAT (2016). Food and Agricultural Organization Statistic data available on <http://www.fao.org/faostat/en/#data/QC> accessed on 22/02/2018.
- Gitonga ZM, Chabi-Olaye A, Mithofer D, Okello, JJ, Ritho CN (2010). Control of invasive *Liriomyza* leafminer species and compliance with food safety standards by small scale snow pea farmers in Kenya. *Crop Protection* 29(12):1472-1477.
- Guantai MM, Ogol CPKO, Salifu D, Kasina JM, Akutse KS, Fiaboe KKM (2015). Differential effects of pesticide applications on *Liriomyza huidobrensis* (Diptera: Agromyzidae) and its parasitoids on pea in Central Kenya. *Journal of Economic Entomology* 108(2):662-671.
- Kroschel J, Mujica N, Alcazar J, Canedo V, Zegarra O (2012). Developing integrated pest management for potato: experiences and lessons from two distinct potato production systems of Peru. In *Sustainable potato production: global case studies*. Springer, Dordrecht pp. 419-450.
- Liu TX, Kang L, Heinz KM, Trumble J (2009). Biological control of *Liriomyza* leafminers: Progress and perspective. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* 4:4.
- Mujica N, Cisneros F (2001). *Biología de la mosca minadora Liriomyza huidobrensis. Módulo 1: investigación biológica. Manual de capacitación*, Lima 7p.
- Murphy ST, LaSalle J (1999). Balancing biological control strategies in the IPM of New World invasive *Liriomyza* leafminers in field vegetable crops. *Biocontrol News and Information*, 20 91N-104N.
- Nelson MR, Orum TV, Jaime-Garcia R, Nadeem A (1999). Applications of geographic information systems and geostatistics in plant disease epidemiology and management. *Plant Disease* 83(4):308-319.
- Nukenine EN, Hassen AT, Dixon AGO, Fokunang CN (2002). Population Dynamics of Cassava Greenmite. *Mononychellus Tanajoa* (Bondar) (Acari: Tetranychidae) as Influenced by Varietal Resistance. *Pakistan Journal of Biological Sciences* 5:177-183.
- Okonya JS, Kroschel J (2016). Farmers' Knowledge and Perceptions of Potato Pests and their Management in Uganda. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* 117(1):87-97.
- Parrella MP (1987). Biology of *Liriomyza*. *Annual Review of Entomology* 32(1):201-224.
- Reitz SR, Gao Y, Lei Z (2013). Insecticide use and the ecology of invasive *Liriomyza* leafminer management. In *Insecticides-Development of Safer and More Effective Technologies*. InTech. <https://www.intechopen.com/books/insecticides-development-of-safer-and-more-effective-technologies/insecticide-use-and-the-ecology-of-invasive-liriomyza-leafminer-management>
- Rizvi SAH, Ikhtlaq MN, Jaffar S, Hussain S (2015). Population Dynamics, Efficacy of Botanical Extracts and Synthetic Insecticides for The Control of Pea Leaf Miner (*Phytomyza horticola* Goureaux) (Diptera: Agromyzidae) Under the Climatic Conditions of Baltistan, Pakistan. *International journal of Agricultural Research* 1(12):758-761.
- Rodriguez-Castaneda G, MacVean C, Cardona C, Hof AR (2017). What Limits the Distribution of *Liriomyza huidobrensis* and Its Congener *Liriomyza sativae* in Their Native Niche: When Temperature and Competition Affect Species' Distribution Range in Guatemala. *Journal of Insect Science* 17:4.
- Schwartzmann M (2010). Potato-A World Production, a European Business. 12th Euro Blight Workshop Arras, France, 3-6 May 2010, pp. 11-16.
- Suryawan IB, Reyes SG (2016). The influence of cultural practice on population of pea leafminer (*Liriomyza huidobrensis*) and its parasitoids in potato. *Indonesian Journal of Agricultural Science* 7(2):35-42.
- Shepard BM, Samsudin BA (1998). Seasonal incidence of *Liriomyza huidobrensis* (Diptera: Agromyzidae) and its parasitoids on vegetables in Indonesia. *International Journal of Pest Management* 44:43-47.
- Spencer KA (1989). Leafminers. In Kahn, P.R. (ed) *Plant protection and quarantine* Vol. II. Selected pests and pathogens of quarantine significance. Boca Raton, FL, USA; CRC Press pp. 77-98.
- UNSTAT (2016). Selected series of world statistics [https://unstats.un.org/unsd/mbs/data\\_files/t51.pdf](https://unstats.un.org/unsd/mbs/data_files/t51.pdf). Accessed on 22.2.2018
- Wagoire WW, Kakuhenzire R, Kashajja IN, Lamaga B, Demo P, Kimoone G (2005). Seed potato production in Uganda: Current status and prospects. In *African Crop Science Conference Proceedings* 7(2-3):739-743.
- Weintraub PG (2001). Changes in the dynamics of the leafminer, *Liriomyza huidobrensis*, in Israeli potato fields. *International journal of Pest Management* 47(2):95-102.
- Weintraub PG, Horowitz AR (1995). "The newest leafminer pest in Israel, *Liriomyza huidobrensis*." *Phytoparasitica* 23(2):177-184.