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# Identifying suitable management options of pea leafminer (*Liriomyza huidobrensis*, Agromyzidae: Diptera) through field experimentation

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**Abstract**
The study on the management of *Liriomyza huidobrensis* was carried out in farmers' field condition in Tukucha Nala place of Kavre district, which is a hilly area. The experiment was carried out in Randomised complete block design with six replications and four treatments. The treatments included yellow sticky trap, abamectin, yellow sticky trap and abamectin together and control. The result indicated that yellow sticky trap was better compared to abamectin in catching more number of leaf miner insects except in the middle stage of growth of the plants, where abamectin was more effective in catching the number of insects. The efficiency of the yellow sticky trap was high because colour yellow was more attractive to the adults and abamectin was satisfactory as it has the trans-laminar action that could penetrate the leaf tissues of the plant. Thus, it can help farmers to implement bio-rational compounds for the control of pea leaf miner in field level.

**Keywords:** Abamectin, attractive, leafminer, trans-laminar, yellow sticky trap

## 1. Introduction
The pea leaf miner (PLM), *Liriomyza huidobrensis* Blanchard, is a highly polyphagous, cosmopolitan pest that has remained geographically isolated within the Holland Marsh since it was first found in Southern Ontario in 1998 [1]. Although the pea leaf miner has known hosts in at least 14 families of plants [2], little is known about adult host preferences and host suitability for development of larval stages in this leaf miner species. It can cause direct damage to the photosynthetic tissue of host plants because of larval leaf mining and aesthetic damage because of oviposition and feeding punctures (stipples) produced by adult females [3]. It has been realized that the use of insecticide will bring about the pest to be resistant as reported by Abe and Tahara in Japan [4]. Insecticide application also causes a negative impact on such natural enemy like parasitoid [5, 6, 7].
Leaf miner has become one of the major constraints of low productivity of potato in Nepal [8]. Due to the wide range of insecticide resistance, the control of *L. huidobrensis* by chemicals remains a great challenge and especially that it is difficult to implement biological control for the pest where it is not indigenous [9]. Moreover, with the increasing awareness of society's concern about pesticides' residues in food and the desire for a healthy and aesthetic environment, the use of bio-rational insecticides for the control of leaf miner is of prime importance in its management. Integrated Pest Management (IPM) is a comprehensive technique used to reduce pests below tolerance level using multiple pest control tactics that are effective, economically feasible and ecological compatible, and that meet the needs of agricultural growers and society [10]. Also, IPM is a desirable technique to control agricultural pests that cause crop losses from 20 to 50 percentages in important agricultural commodities around the world [11]. This study considered monitoring of the pest, field survey from the commercial potato growing areas, biology study, and test of different management options against the pest *L. huidobrensis*.

## 2. Materials and methods
### 2.1 Geographical location of the experimental site
The study was conducted in the farmers' field at Tukucha, Nala of Kavre district. The experimental site is located at an altitude of 1598 masl (metre above sea level) within 27.68062° N and 085.50430° E.

### 2.2 Experimental design
The experiment was conducted in Randomized Complete Block Design (RCBD) with six replications. The research area was the hilly region of the Nepal and each farmer was taken as a replication. Each treatment plot was of 1 ropani (508.50 m²) and the observations were made in the triangular fashion in each treatment plot; each of 1.5m$^2$. The plot to plot distance was more than 10 m to control the migration effect of the insects as well as to avoid the border effect.

### 2.3 Treatment details
$T_1$- Yellow stick trap: Yellow sticky trap was made locally. For this 2m long yellow flex print with width of 50 cm was used. Then grease was painted all over the flex. At the both end of the flex it was sewed and bamboo was placed to hold the flex for its easy application in the field. Yellow sticky trap was used as double swung to catch out the *L. huidobrensis*. This treatment was applied at weekly interval.

$T_2$-Yellow sticky trap and Abamectin: Yellow sticky trap was prepared as described above. Abamectin is made up of a mixture of avermectins obtained through fermentation of a soil actinomycete, *Streptomyces avermitilis* Burg. Abamectin was sprayed 30-40 days after sowing for the first time and second application before the initiation of flowering. Its application rate was 1.5ml per litre of water.

$T_3$-Abamectin: The detail of Abamectin is mentioned in the above paragraph.

$T_4$-Control: This plot was maintained just to compare with the other treated plot**.**

### 2.4 Treatment application time
Treatment was started only when more than 10 adult leaf miners were caught in the delta trap. Delta trap was installed in the middle of the plot. Its colour was yellow since the leaf miner prefers the colour. Main purpose of this was to know about the population status and application time of treatment.

### 2.5 Package of practices
#### 2.5.1 Preparation of seed
The potato tuber weight, of variety Kufri Sindhuri, was maintained within the range of 25 to 50 grams as planting materials. The planting materials were collected from National Potato Research Programme (NPRP), collected from the cold storage 30 days before planting for pre-sprouting. They were kept in well ventilated open floor at room temperature for uniform sprouting.

#### 2.5.2 Field preparation
The field was ploughed and the soil was well pulverized to make the land final for tuber plantation. Previous crop stubbles, potato sprouts and weeds were cleaned before making the soil well pulverized. Since the experiment was conducted in the farmers' field, the field was made final as per the judgment of farmers.

#### 2.5.3 Manure and fertilizers
Farm yard manure (FYM) @ 20 mt/ha and NPK @ 80:80:60 kg/ha were used [12]. Full doses of compost, phosphorus, potash and half dose of nitrogen were applied as a basal dose and remaining half dose of nitrogen was applied as a top dressing at the time of earthing up [13]. The sources of nutrients were urea, di-ammonium phosphate (DAP), and murate of potash (MOP). Both farm yard manure and chemical fertilizers were applied in furrow. Chemical fertilizers were mixed in one place and remaining half quantity of urea was kept for top dressing. Firstly, the well mixed chemical fertilizer was applied in the furrow line and it was covered by FYM. The objective of doing so is to avoid the possibility of touching the tubers against chemical fertilizer

#### 2.5.4 Planting
The fully sprouted tubers were planted in the furrow over the farm yard manure. Tubers were buried with the soil by making a 15 cm high ridge. The planting depth was maintained at 5-10 cm.

#### 2.5.5 Weeding
The first weeding operation was performed at 20 days after planting (DAP) and the second 10 days after the first weeding. No weedicides were applied for controlling weeds in the experimental field.

#### 2.5.6 Irrigation
The first irrigation was applied at 40 days after planting (DAP) and the second 10 days later. The furrow method of irrigation was followed as recommended by National Potato Research Program (NPRP), Khumaltar. Two-third of the ridge was covered with water during irrigation operation.

#### 2.5.7 Earthing up
Earthing up was done once during the crop period. The first earthing up was performed at 60 DAP.

### 2.6 Observation
Ten plants were selected randomly in each plot and tagged with the red ribbon. Observation on foliar damage was taken from these tagged plants.

### 2.7 Data recording
All the data regarding damage score of the sample plant and leaf miner caught in delta trap were taken weekly but the yield attributing character like average tuber number per plot and average weight of tuber per plot were recorded only once.

### 2.8 Data calculation
Firstly, the data taken from the experimental field were entered in Microsoft Excel spread sheet. After completing the data entry and data processing operations, they were analysed by using MSTAT-C soft package. The means were compared by using Duncans' Multiple Range Test (DMRT) test [14].

## 3. Results
### 3.1 Catches of PLM in delta trap
Table 1 reveals that the mean numbers of maximum catches were in the control plots in each time. The minimum and maximum temperature during this date was 13.6 and 24°C, respectively, which is shown in Table 2.

### 3.2 Effect of different treatments on incidence of leaf miner
After seven days of the first spray on 12$^{th}$ March, the foliar damage due to pest was significant in case of lower and middle leaves whereas it was non-significant in upper leaves. The lowest damage in both of the lower and middle leaves was obtained from the yellow sticky trap used plots and the highest foliage damage was in case of control plots.

Similarly, after the second spray on 19th March, in case of lower leaves had significant foliar damage where, the control plot seemed to be more infested and the least foliage damage was obtained in case of yellow sticky trap + Abamectin treated plots in lower leaves. The middle and upper leaves had the non-significant foliage damage which is shown in Table 3.

Similarly, after seven days of the third spray on 27th March, significant result was obtained in case of both lower and middle leaves. Here, the least damage was recorded in the Abamectin plots and highest damage was obtained in a control plot in both of the lower and middle leaves which is shown in Table 3.

Again, after seven days of the fourth spray on 4th April, the highest damage was recorded in case of control plots and least damage was in Abamectin plots. In case of middle leaves, the highest foliage damage was recorded in yellow sticky trap used plots and lowest in Abamectin plots. In upper leaves, where the significant result was achieved, control plots recorded the highest damage and Abamectin plots recorded the lowest.

Similarly, after the seven days of fifth spray on 12th April, damage was significant in all lower, middle and upper leaves with a highest damage, recorded in case of control plots and yellow sticky trap plots recorded the least foliage damage.

Lastly, after seven days of the sixth treatment on 19th April, the highest damage in case of lower and upper leaves was recorded in case of control and the least was in case of yellow sticky trap used plots. In upper leaves, where the significant result was achieved, control plots recorded the highest damage level and yellow sticky trap + Abamectin plots recorded the least damage. These are shown in table. 4.

**Table 1:** Effect of climatic factors on the number of potato leaf miner (PLM) adults trapped in the delta sticky traps (March 11 to April 17, 2012) at Tukucha, Nala of Kavre, Nepal

| Treatments | Mean number of PLMF trapped in delta sticky trap at different dates | | | | | |
|---|---|---|---|---|---|---|
| | March 11 | March 17 | March 26 | April 3 | April 11 | April 17 |
| $T_1$ (Yellow sticky trap @ double swinging per plot) | 10.83 | 20.5 | 17.5 | 24.83 | 483.33 | 516.66 |
| $T_2$ (Yellow sticky trap @ double swinging per plot) + Abamectin @ 1.5ml/litre) | 15.66 | 26.33 | 16.66 | 23.83 | 533.33 | 641.66 |
| $T_3$ (Abamectin @ 1.5ml/litre) | 7.66 | 22.33 | 23.66 | 27.5 | 550 | 591.66 |
| $T_4$ (Control) | 16.83 | 28.83 | 20.66 | 21.66 | 566.66 | 650 |

**Table 2:** Maximum and minimum temperatures during trapping of potato leaf miner at Tukucha, Nala of Kavre, Nepal, 2012

| Date | Maximum temperature (°C) | Minimum temperature (°C) |
|---|---|---|
| March 11, 2012 | 19.6 | 6.5 |
| March 17, 2012 | 17.2 | 6.5 |
| March 26, 2012 | 21.0 | 9.8 |
| April 3, 2012 | 20.0 | 13.3 |
| April 11, 2012 | 15.0 | 5.5 |
| April 17, 2012 | 24.0 | 13.6 |

**Table 3:** Effect of different treatments on *L. huidobrensis* damage score after the first, second and third spray at Tukucha, Nala of Kavre, Nepal

| | 1st spray | | | 2nd Spray | | | 3rd spray | | |
|---|---|---|---|---|---|---|---|---|---|
| | L | M | U | L | M | U | L | M | U |
| T1 | 14.35 ±1.71$^{b}$ (3.78) | 5.82±2.38$^{b}$ (2.42) | 1.07±1.07$^{a}$ (1.03) | 29.06±2.68$^{b}$ (5.39) | 12.20±2.28$^{b}$ (3.492) | 0.64±0.64$^{b}$ (0.8) | 68.43±11.34$^{a}$ (8.272) | 48.86±12.44$^{a}$ (6.989) | 28.95±14.31$^{a}$ (5.38) |
| T2 | 21.14±4.78$^{b}$ (4.59) | 7.97±3.21$^{b}$ (2.82) | 0.19±0.18$^{a}$ (0.43) | 28.81±3.62$^{b}$ (5.367) | 15.12±4.12$^{ab}$ (3.884) | 4.35±1.80$^{ab}$ (2.085) | 73.42±9.56$^{a}$ (8.568) | 48.37±13.47$^{a}$ (6.954) | 22.77±6.82$^{a}$ (4.771) |
| T3 | 24.20±3.21$^{b}$ (4.90) | 7.02±3.15$^{b}$ (2.64) | 0.00±0.00$^{a}$ (0.00) | 47.07±10.40$^{a}$ (6.90) | 31.43±13.47$^{ab}$ (5.606) | 13.45±7.02$^{a}$ (3.667) | 67.198±10.53$^{a}$ (8.198) | 45.41±13.05$^{a}$ (6.738) | 21.95±10.69$^{a}$ (4.685) |
| T4 | 34.67±4.15$^{a}$ (5.88) | 14.65±1.5$^{a}$ (3.82) | 1.14±0.73$^{a}$ (1.06) | 56.45±7.62$^{a}$ (7.513) | 34.57±10.40$^{a}$ (5.879) | 12.41±6.82$^{ab}$ (3.552) | 75.30±5.77$^{a}$ (8.677) | 57.05±12.90$^{a}$ (7.553) | 32.61±7.96$^{a}$ (5.71) |
| LSD (P=0.05) | 3.35 | 2.096 | 0.52 | 5.302 | 6.57 | 3.87 | 6.89 | 8.58 | 9.73 |
| CV (%) | 34.81% | 57.93% | 215.64 | 32.19 | 68.98 | 122.95 | 23.77 | 42.12 | 89.74 |
| P-value | ** | * | NS | ** | NS | NS | ** | ** | NS |

CV: Coefficient of variation, LSD: Least Significance Difference, NS: Non-Significant, Value with same letters in a column are not significantly different at á=5% by DMRT, Figures before ± indicate treatment means and figures after ± indicate standard error calculated by SD/SQRT(N).,*: significant at 5%á, **: significant at 5% and 1% á. The figures in parentheses are square root transformations. L, M and U represent the lower, middle and upper damage of leaves respectively.

**Table 4:** Effect of different treatments on *L. huidobrensis* damage score after fourth, fifth and sixth spray at Tukucha, Nala of Kavre, Nepal

| | 4th spray | | | 5th Spray | | | 6th spray | | |
|---|---|---|---|---|---|---|---|---|---|
| | L | M | U | L | M | U | L | M | U |
| T1 | 81.07±4.57$^{a}$ (9.003) | 75.37±6.70$^{a}$ (8.68) | 63.07±11.85$^{a}$ (7.94) | 57.68±9.89$^{b}$ (7.59) | 50.75±7.18$^{b}$ (7.13) | 26.19±7.11$^{b}$ (5.1) | 76.42±3.45$^{c}$ (8.74) | 54.06±6.57$^{b}$ (7.352) | 35.43±7.22$^{b}$ (5.952) |
| T2 | 86.58±5.43$^{a}$ (9.30) | 74.44±8.68$^{a}$ (8.62) | 59.08±12.37$^{a}$ (7.68) | 75.92±10.25$^{ab}$ (8.71) | 59.15±5.32$^{b}$ (7.69) | 35.57±5.37$^{b}$ (5.96) | 83.53±5.07$^{bc}$ (9.139) | 69.54±2.75$^{a}$ (8.334) | 23.29±1.42$^{b}$ (4.825) |
| T3 | 78.11±5.44$^{a}$ (8.837) | 72.89±3.87$^{a}$ (8.53) | 52.07±12.26$^{a}$ (7.24) | 85.23±5.11$^{a}$ (9.237) | 66.37±8.48$^{b}$ (8.146) | 25.27±6.79$^{b}$ (5.026) | 85.96±2.59$^{b}$ (9.27) | 73.02±3.31$^{a}$ (8.545) | 37.35±4.10$^{b}$ (6.11) |
| T4 | 86.72±3.23$^{a}$ (9.31) | 74.56±11.88$^{a}$ (8.63) | 66.73±14.49$^{a}$ (8.168) | 95.19±2.51$^{a}$ (9.756) | 85.14±4.04$^{a}$ (9.227) | 71.01±9.59$^{a}$ (8.426) | 95.44±2.06$^{a}$ (9.76) | 75.74±3.96$^{a}$ (8.702) | 57.23±9.02$^{a}$ (7.565) |
| LSD (P=0.05) | 3.72 | 7.02 | 9.81 | 6.15 | 5.43 | 6.86 | 2.49 | 4.75 | 6.42 |
| CV (%) | 10.96 | 23.15 | 39.90 | 19.20 | 20.37 | 42.50 | 7.15 | 17.10 | 41.07 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| P-value | * | NS | * | * | * | * | ** | * | ** |

CV: Coefficient of variation, LSD: Least Significance Difference, NS: Non-Significant, Value with same letters in a column are not significantly different at á=5% by DMRT, Figures before ± indicate treatment means and figures after ± indicate standard error calculated by SD/SQRT(N).,*: significant at 5%á, **: significant at5% and 1% á. The figures in parentheses are square root transformations. L, M and U represent the lower, middle and upper damage of leaves respectively

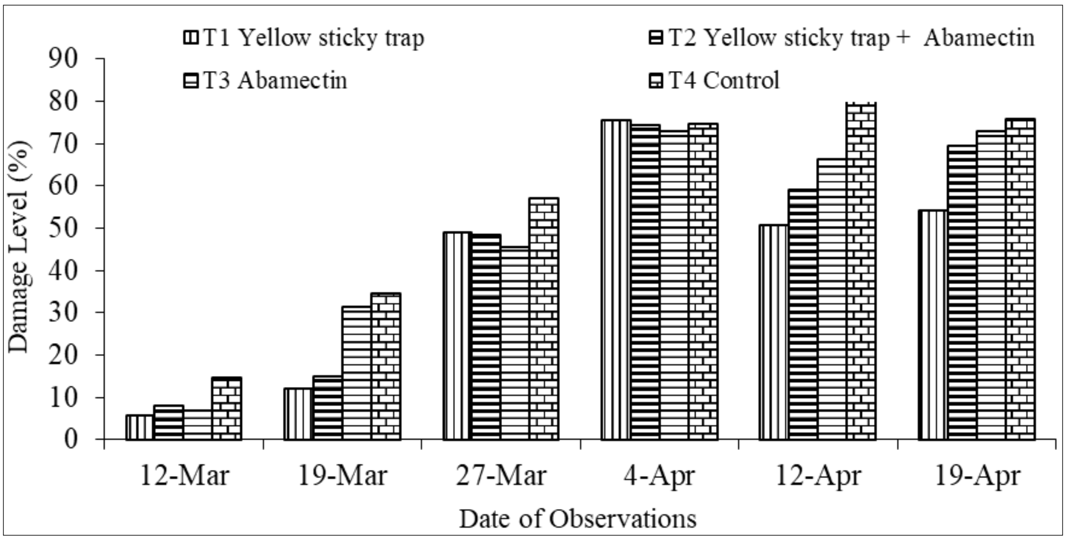


**Fig 1:** Effect of different treatments on damage pattern of lower leaves on progressive dates by *L. huidobrensis*, 2012

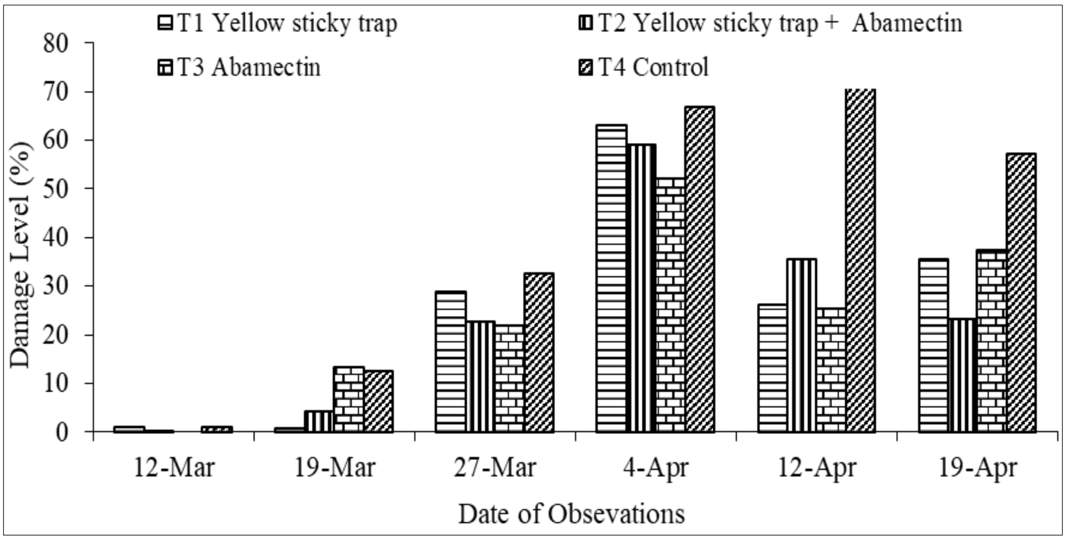


**Fig 2:** Effect of different treatments on damage pattern of middle leaves on progressive dates by *L. huidobrensis*, 2012

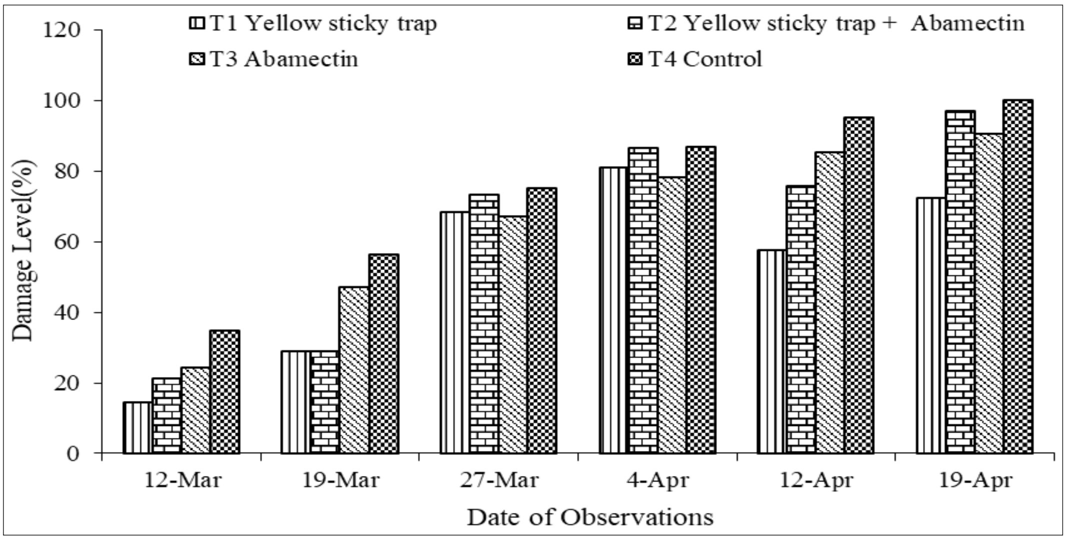


**Fig 3:** Effect of different treatments on damage pattern of upper leaves on progressive dates by *L. huidobrensis*,

## 4. Discussion

During the first date of observation after seven days of the first treatment application, the pest damage score was minimum in yellow sticky trap used plots (14.35±1.71%) and the highest damage level was in the control plots (34.67±4.15%). This is due to the fact that yellow sticky cards were first used to sample adult leaf miners in the genus *Liriomyza* (Mk) by Musgrave *et al.* and Tryoneh *et al.* which confirmed that yellow was more attractive to adults than other colours [15, 16].

After seven days of the second treatment, the yellow stick trap + Abamectin application resulted into a minimum damage of the lower foliage level (28.81±3.62%) and the more damage of lower foliage damage level was in control plots (56.45±7.62%). This is due to the trans-laminar and attractive property of Abamectin and yellow sticky trap respectively. This is again due to fact that yellow is more attractive to adults than other colors [16] and that reflectance throughout the yellow part of the spectrum increased catch [17] and Abamectin was effective against a number of important pests, such as mites, ants, cockroaches, and selected pest species of Lepidoptera [18]. It is considered a selective insecticide with relatively low toxicity to many non-target arthropods [19]. It is used at low rates and degrades rapidly (having a half-life of four to six hours) when exposed to light, especially when applied as a thin film on inert surfaces or leaves [20]. Despite its rapid photodecomposition following application, Abamectin provides residual activity in the field because of its trans-laminar action and rapid penetration of leaf tissue [19]. Abamectin alone, applied at the commercially recommended dosage, showed a satisfactory level of control of the eggs and larvae of the leaf miner fly, confirming reports of several authors [21].

After seven days of the third treatment, the lower leaves damage was the least with the use of Abamectin (67.198±10.53%). Abamectin (avermectin B1a and avermectin B1b) is a macrocyclic lactone, and targets the nervous system as a chloride channel activator. Avermectins bind to ligand-gated chloride channels (GABA or Glutamate) where they cause inhibition of nerve firing [22]. Lambdacyhalothrin is a pyrethroid insecticide, which acts on the nervous system as a sodium channel modulator. This axonic poison preventssodium channels from closing, causing overexcitation and subsequent paralysis [23].

Again in the fourth spray, the Abamectin application was quiet good in controlling the damage, here also the lower leaf damage was the least with this treatment (78.11±5.44%). After seven days of the fifth spray, yellow sticky trap application seemed good in controlling the damage (57.68±9.89%). The severe damage by the pest was seen in the control plots (95.19±2.51%). In the sixth sprays also, yellow sticky trap used was good i.e. resulted in the low infestation of lower leaves (76.42±3.45%).

## 5. Conclusions

The present study was also conducted for the development of proper management technique of this pest in the field condition. The management techniques used were: Yellow sticky trap, Yellow sticky trap + Abamectin and Abamectin only. These were sprayed and applied in the field. Yellow sticky trapping was quiet good in controlling the damage, but seemed less effective during the middle stage of plant growth. This type of control could be mainly due to the mass trapping and mating disruption of the pest. Yellow is more attractive to adults than other colors and that reflectance throughout the yellow part of the spectrum increased the catch. Abamectin application also gave a satisfactory result for controlling the *L. huidobrensis*. This might be due to its trans-laminar action and rapid penetration of leaf tissue.

Not only escaping, this pest can also resist pesticides, alternative management tactics are essential. Eco-friendly treatments, yellow sticky trap use followed by Abamectin spray performed better in reducing this pest, resulting lower damage, increasing yield of potato. So, these eco-friendly treatments could be excellent and economically viable alternatives to the hazardous chemical pesticides for this insect pest in the integrated pest management and conserving the sound environment. However, one crop season of field research is inadequate to draw the conclusion about the effectiveness of these bio-rational compounds, which must be evaluated under different climatic conditions and different ecological zones as well. Further study in this regard is imperative. Also, the study for the cause of less effectiveness of yellow sticky trap during the middle growth stage of the plant is needed.

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