

# Hopper Hunt: IPM Decision-making in Alfalfa

Farmers must consider many variables when deciding to treat their crops for pests. Using real-world agricultural research, students can sample an alfalfa field for pests and make decisions on the future of the crop based on profit margin and pest management techniques.

**Suggested Level(s):**

Grades 9-12

**Subject(s):**

Science & Technology,  
Environment & Ecology, Math

**Standards:**

*Science & Technology*

3.8 Science, Technology, &  
Human Endeavors

*Environment & Ecology*

4.5: Integrated Pest  
Management (IPM)

*Math*

2.2 Computation & Estimation

2.6 Statistics & Data Analysis

**Skills:**

Observing, Sampling, Recording data, Interpreting data, Making a decision, Considering economic consequences

**Technology Connection:**

Internet resources

**Materials:**

Pencil/Pen

Paper grocery bags

Construction paper (2 colors)

Data sheet

Decision charts (Table 1)

**Time Consideration:**

Preparation: 20 minutes

Activity: 45-60 minutes

**Objective(s):**

Student will

- describe migrations and life cycle patterns of a key alfalfa pest, the Potato Leafhopper
- define Economic Injury Level and Economic Threshold
- evaluate data in relation to profit as it applies to IPM
- describe a pest population sampling technique
- compare sampling results to Economic Threshold to determine management action
- investigate how the stage of crop development and other factors influence thresholds

**Assessment Opportunities**

- As seen in the activity, there is no hard and fast answer for “how many pests are too many?” The answer is always “It depends!” Discuss with students the variables that determine real-world, on-farm decisions.
- Using the data they’ve collected, have each student answer the following questions in their own words:
  - Describe the sampling results and the ET comparisons.
  - What actions should the farmer take given the sampling results?
  - How should the farmer’s actions change if (a) alfalfa price rises or falls, and (b) insecticide prices increase or decrease?
  - How would your decisions change if the sampling results were found in a younger or older crop?
  - In addition to pesticides, what other tactics would you recommend for use against the PLH in an IPM program?

**Background:**

Alfalfa is an important forage crop to the Northeast. As a deep-rooted perennial, alfalfa is very beneficial in farmer’s crop rotations. A legume, alfalfa can “fix” nitrogen. Nitrogen is one component of amino acids and proteins. Organisms need proteins to build new body tissues. Thus, alfalfa is the primary protein source for

dairy cattle. Depending on the year and location, alfalfa can be cut 3 or more times a year. After each cutting, the plant re-grows from the crown and roots that are left behind.

The potato leafhopper is the most destructive insect of alfalfa in Pennsylvania and the northeastern U.S. It causes yield losses, reduces alfalfa quality (especially protein content), and contributes to reduced longevity of stands. In new seedlings the pest can cause serious stand losses and weak plants.

The insect does not over winter in Pennsylvania, but in states along the Gulf of Mexico and up the eastern seaboard into southern Maryland. For this reason adult leafhoppers must migrate into the state on spring storm fronts that originate in the Gulf of Mexico or along the eastern seaboard. The insect typically reaches Pennsylvania between May 1 and June 15. The arrival time of the insect is influenced by the frequency and intensity of these storm fronts as well as the changes in air pressure as they move towards the northeast. Because the pest tends not to arrive in most years until late May, the pest's feeding seldom injures the first cutting of alfalfa. Potato leafhopper is primarily a pest of the second and third cuttings of alfalfa in Pennsylvania.

In its life cycle, the potato leafhopper undergoes incomplete metamorphosis. Females lay eggs in plant tissue from which nymphs emerge in 7-10 days, and then reach adult stage about two weeks later. Nymphs and adults are very similar in appearance, although nymphs are smaller and do not have wings. They are yellow - green in color and both nymphs and adults have piercing-sucking mouthparts. The entire life cycle takes approximately one month and 3-4 generations per growing season can occur during the time the pest is found in the Northeast.

The pest injures alfalfa plants by inserting its beak-like mouthparts into the cells that surround the phloem tissue and sucking out the cell contents. This causes the cells to swell around the phloem, pinching it shut and preventing carbohydrate movement in the plant. Injured plants are stunted and have yellow "V" shaped areas at the tips of leaves ("Hopperburn"). In severely injured fields plants may drop their leaves. Once plants are stunted by leafhopper they will not grow until after the alfalfa is cut.

Although the potato leafhopper infestations can cause severe injury to alfalfa, only a percentage of fields need to be treated each year. Because of weather patterns and the population growth characteristics of the pest, very few fields have worrisome infestations in some years. This variation in threat by the pest makes it advantageous for farmers to scout their fields and determine the need for control. This exercise is designed to teach potato leafhopper scouting methods and how to determine if control is needed.

In most crops, and most seasons, pest insect species that feed on the crop will be present at some point in the plant life cycle. However, just because the pest is present does not necessarily mean that the farmer needs to take action against the pest. How does the farmer know when the number of pests in his/her crop is too many? Is this number the same every year in all fields?

To help farmers decide when there are too many pests, the concept of the "**Economic Injury Level (EIL)**" is used. The EIL allows the farmer to compare the value of the damage the number of pests in the field might do to the crop with the cost of taking action against the pest. In other words, is the **cost of taking action** (e.g spray) **more** or **less** than the **value of crop lost** to the pest if no action is taken? The point where the cost of control equals the value of loss is called the **EIL**.

Definition: Economic Injury Level (EIL) is the pest population density where the cost of control equals the value of the damage prevented if a control treatment is applied.
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There is one more concept that is important. Given that we can calculate the EIL, by the time that the farmer determines that the pest population is getting to unacceptable levels and finds the time, equipment and help he/she needs to take action, the pest population has had a chance to exceed the EIL and eat into the farmer's profit. To account for this management 'lag' another measure, the **Economic Threshold** sometimes called Action Threshold, has been calculated to account for the farmer's reaction time.

Definition: Economic Threshold (ET) is the EIL minus some portion of the pest density that accounts for management lag of the farmer.

These thresholds are pre-calculated by researchers, so all the farmer has to do is take a proper sample of the pest to answer the question: Are we above or below the Economic Threshold for pest X?

To calculate Economic Threshold you must:

1. know how to identify the pest
2. know how to sample the crop environment to assess level of infestation
3. know the stage of crop development & how that relates to severity of damage
4. know the approximate economic threshold levels (available from Penn State Extension)
5. consider how the action threshold may vary with stage of crop development, value of the crop and cost of control.

To learn how this works, we will use **alfalfa** as the crop and **potato leafhopper (PLH)** as the pest. In actual practice, from May until the final alfalfa harvest in the fall, PLH are '**sampled**' using sweep nets.

Definition: Sampling is a statistical procedure that allows the estimation of population density by counting only a portion of the population in a very structured way. Counting only a tiny portion of the population saves time and provides acceptably accurate population estimates for decision-making purposes.

To sample, the farmer walks across the alfalfa field sweeping the net in front of him/her, skimming the tops of the plants to catch PLH. The number of sweeps and walking direction is predetermined by the sampling protocol. The farmer opens the sweep net and counts the number of PLH in it. This number is recorded. For this activity, students will make an additional 4 sweep samples, making a total of 5 samples taken in the paper bag alfalfa field. Then the farmer compares the **average** number of PLH caught in the 5 samples with the economic threshold value in a decision chart (Table 1). If the average number of PLH caught exceeds the Economic Threshold value, the farmer needs to take action against the pest. If the average number of PLH caught does not exceed the Economic Threshold, then the farmer does not need to take any action. This procedure is repeated periodically from the time PLH arrives from their hibernating area in the southern U.S. (usually in May) until the final harvest.

The decision charts containing the Economic Thresholds (Table 1) allow a decision to be made under different conditions including various plant heights, prices of alfalfa hay per ton and costs of an insecticide application per acre. These conditions relate measures of crop value and control costs as they affect the **profit** derived from the alfalfa field. In general, farmers try to maximize profit.

Definition: Profit equals income minus expenses. Therefore, profit can be increased either by increasing the income, decreasing the expenses, or both.

Inspect the decision charts on Table 1 and observe the trends in Economic Threshold:

As plant height increases the Economic Threshold increases. Younger plants are much more sensitive to insect damage. Damage to a young plant will significantly decrease the value of the plant (yield and quality) and reduce the farmer's income from that alfalfa field. Older plants can tolerate more insects and will not lose as much value so older plants (=taller) have higher Economic Threshold. In other words the farmer can let PLH populations get to higher levels in older plants before he/she has to control them.

As the price of alfalfa hay increases the Economic Threshold decreases. A given amount of damage by PLH to high priced alfalfa will decrease the value of the crop more than that same amount of damage to low priced alfalfa. The marketplace determines the price of the alfalfa, so the farmer will have to guess what the price of alfalfa might be at the time he/she wants to sell it.

As the cost of control (insecticide application) increases the Economic Threshold increases. In terms of profit, an expensive control cost can result in lower profit unless the value of the crop is also high to compensate for it. If the alfalfa price does not justify the high control cost then Economic Threshold is allowed to rise (allowing more PLH to exist in the field before action must be taken).

To learn how this works, we will “sample” an “alfalfa field” and decide if we need to take action against PLH. Ideally, this exercise should be done in an alfalfa field in the mid-summer, but since most public schools do not meet in the summer, and not everyone has access to alfalfa field, this is a classroom alternative – The Paper Bag Alfalfa Field!

### **Getting Ready:**

Please refer to the Hopper Hunt Bag Information Sheet at the end of the lesson for specific data to create five bags.

1. The paper or plastic bag represents the alfalfa field. Each bag (field) will be sampled, so enough bags are needed to present several pest/crop scenarios. Having at least three bags is recommended. If desired, the bags can be decorated by drawing an alfalfa plant on the side.
2. On the side of the bag indicate the projected price per bale that is expected for the alfalfa in that ‘field.’ Also indicate the cost of an insecticide spray, if one should be needed, for that ‘field.’
3. Cut one of the colors of construction paper into 2-inch squares. On each square write a number representing the number of PLH found in each sweep sample. Some planning is required here because several scenarios should be planned that illustrate the different situations that the farmer may encounter. For instance, if one scenario is meant to demonstrate that there are not enough PLH to justify taking action, then the numbers written on the squares should tend to be low.
4. Cut the other color of construction paper into 2-inch diameter circles. On each circle write a number representing plant heights found in that field. Again, planning is required so that when samples are drawn the desired plant height for a given scenario will be obtained.
5. Place 20 numbered, paper squares and 20 numbered paper circles into each bag.
6. Make copies of the “Potato Leafhopper Worksheet” and “Table 1: Potato Leafhopper Economic Threshold Charts for Established Stands of Alfalfa” for groups or individual students.

### **Doing the Activity:**

### PLH Sampling:

1. Form teams of two. Have one team member do the sampling, the other record the data.
2. The sampler reaches into the bag, pulls out one numbered paper square and reads the number to the recorder who records the number in the average number of PLH column of the data sheet. Repeat 5 times.
3. Similarly, the sampler retrieves a numbered paper circle from the bag and reads the number to the recorder who records the number in the plant height column of the data sheet. Repeat 5 times.
4. Once all of the samples have been taken, first add up the total number of PLH caught in the 5 samples. Record this number. Then, add up the total inches measured for plant height for the 5 samples. Record this number.
5. Using the totals derived in #4, find the **average** number of PLH caught and record this number. Find the average number of inches for plant height and record this number.
6. Use the information on the paper bag alfalfa field to fill in the “price of alfalfa hay at harvest” and “cost of insecticide application” blanks on the worksheet.
7. To find the Economic Threshold (ET), use the data from “average plant height, price of alfalfa, and cost of insecticide” in conjunction with the charts on Table 1. (Hint: first make sure you first find the correct chart based on plant height). Record the ET in the blank on the worksheet.
8. Compare the average PLH count obtained from sample with ET.
9. If sample average is equal to or greater than ET then farmer should apply an insecticide. If the sample mean is less than ET then farmer does nothing and samples again next week. Provide recommendations for the alfalfa field based on the findings. Visit the Pennsylvania Integrated Pest Management Web site for more information on the PLH and Integrated Pest Management techniques (<http://paipm.cas.psu.edu/>)

### **Enrichment Activities:**

1. Visit a local alfalfa farm or invite an alfalfa farmer to visit the classroom. Have the farmer discuss his/her experiences with growing alfalfa, pests encountered on the farm, and management techniques used to combat pests. Students can discuss the results of their sampling and their recommendations with the farmer.
2. Using sweep nets, have students practice the sweeping technique used to sample for Potato Leafhoppers. Have them evaluate the technique and discuss the importance of obtaining accurate data. For pictures and more detailed instructions on sampling for the Potato Leafhopper, please visit <http://www.ento.psu.edu/extension/factsheets/potatoLeafhopperAlfalfa.htm>

**Table 1. Potato Leafhopper Economic Threshold Charts for Established Stands of Alfalfa**

*Plant Height Category I: 0 – 4 inches*

<b>Crop Value</b>	<b>Cost of an Insecticide Application Per Acre</b>					
	\$8.00	\$10.00	\$12.00	\$14.00	\$16.00	\$20.00
\$60	0.4	0.5	0.6	0.7	0.8	1.0
\$80	0.3	0.4	0.5	0.5	0.6	0.8
\$100	0.3	0.3	0.4	0.4	0.5	0.6
\$120	0.2	0.3	0.3	0.4	0.4	0.5
\$140	0.2	0.2	0.3	0.3	0.3	0.4
\$160	0.2	0.2	0.3	0.3	0.3	0.4

*Plant Height Category II: 5 – 8 inches*

<b>Crop Value</b>	<b>Cost of an Insecticide Application Per Acre</b>					
	\$8.00	\$10.00	\$12.00	\$14.00	\$16.00	\$20.00
\$60	0.7	0.8	1.0	1.0	1.3	1.7
\$80	0.6	0.6	0.8	0.9	1.0	1.3
\$100	0.4	0.5	0.6	0.7	0.8	1.0
\$120	0.3	0.4	0.5	0.6	0.7	0.8
\$140	0.3	0.4	0.4	0.5	0.6	0.7
\$160	0.3	0.3	0.4	0.3	0.5	0.6

*Plant Height Category III: 9 – 12 inches*

<b>Crop Value</b>	<b>Cost of an Insecticide Application Per Acre</b>					
	\$8.00	\$10.00	\$12.00	\$14.00	\$16.00	\$20.00
\$60	2.0	2.4	2.8	3.0	3.9	5.0
\$80	1.8	1.9	2.2	2.7	3.0	4.0
\$100	1.2	1.5	1.8	2.1	2.4	3.0
\$120	0.9	1.2	1.5	1.8	2.1	2.4
\$140	0.9	1.0	1.2	1.5	1.8	2.0
\$160	0.8	0.9	1.0	1.2	1.5	1.8

## Potato Leafhopper Worksheet

Sample Number	Number PLH	Plant Height (inches)
1	_____	_____
2	_____	_____
3	_____	_____
4	_____	_____
5	_____	_____
<b>Total</b>	_____	_____
<b>Average</b> (total/5)	_____	_____

**Price of alfalfa hay at harvest** \_\_\_\_\_

**Cost of insecticide application** \_\_\_\_\_

**Economic Threshold (from Table 1)** \_\_\_\_\_

**Recommendations:**

## Paper Bag Data for Hopper Hunt: IPM Decision-making in Alfalfa

### Bag 1

Value (\$)	Pesticide Cost (\$)	Plant Heights (inches)	Number of PLH
140.00	16.00	2 at 7	2 of 1.5
		1 at 8	1 of 1.6
		1 at 9	3 of 1.8
		3 at 10	2 of 1.9
		3 at 11	2 of 2.0
		4 at 12	1 of 2.3
		3 at 13	2 of 2.7
			1 of 2.9
			1 of 3.1
			1 of 3.3
			1 of 3.7
			1 of 3.8
			1 of 3.9
			1 of 4.0

**Bag 2**

Value (\$)	Pesticide Cost (\$)	Plant Heights (inches)	Number of PLH
60.00	20.00	2 at 8	1 of 3.7
		4 at 9	2 of 3.9
		4 at 10	1 of 4.2
		5 at 11	1 of 4.3
		3 at 12	1 of 4.6
		2 at 13	1 of 4.7
			2 of 4.9
			2 of 5.0
			1 of 5.1
			1 of 5.3
			2 of 5.5
			2 of 5.8
			1 of 6.0
			1 of 6.1
			1 of 6.3

**Bag 3**

Value (\$)	Pesticide Cost (\$)	Plant Heights (inches)	Number of PLH
80.00	14.00	7 at 1	2 of .1
		4 at 2	3 of .2
		4 at 3	4 of .3
		2 at 4	3 of .4
		2 at 5	4 of .5
		1 at 6	2 of .6
			1 of .7
			1 of .8

**Bag 4**

Value (\$)	Pesticide Cost (\$)	Plant Heights (inches)	Number of PLH
100.00	8.00	1 at 4 4 at 5 5 at 6 5 at 7 3 at 8 2 at 9	1 of .1 2 of .2 3 of .3 7 of .4 5 of .5 1 of .6

**Bag 5**

Value (\$)	Pesticide Cost (\$)	Plant Heights (inches)	Number of PLH
160.00	16.00	2 at 4 3 at 5 5 at 6 5 at 7 3 at 8 1 at 9	2 of .3 3 of .4 5 of .5 5 of .6 3 of .7 2 of .8