Insect Crop Losses and Insecticide Usage for Head Lettuce in Arizona: 2006/2007

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Abstract

Impact assessment is central to the evolution and evaluation of our local Insect Pest Management (IPM) programs. Quantifiable metrics on insecticide use patterns, costs, targets, and frequency, crop losses due to all stressors of yield and quality, and other real world economic data (e.g., crop value) are our most objective tools for assessing change in our systems. We recently initiated a project to measure the impact of insect losses and insecticide uses in head lettuce grown in Yuma, AZ and the Bard–Winterhaven area of Imperial County, CA. The data generated in this report is useful for responding to pesticide information requests generated by EPA, and can provide a basis for regulatory processes such as Section 18 requests, as well as for evaluating the impact of our extension programs on risk reduction to growers. This information also confirms the value of PCAs to the lettuce industry by showing the importance of cost-effective management of insect pests in desert lettuce production.

Introduction

The development of accurate "real world" data on crop insect losses and insecticide usage is important to the assessment of our IPM programs in Arizona. Quantifiable measurements of insecticide use patterns, costs, target pests, and yield/quality losses due to key insect pests are our most objective tools for assessing change in our systems. These data allow us to build relevant databases for measuring user behaviors and adoption of new IPM technologies. This is information important for several reasons. First, specific data on pesticide use patterns and insect losses can be useful for providing information to EPA and other regulatory agencies in submitting Section 18 and 24c requests, as well as support the tolerance of older active ingredients that are critical to the lettuce industry. In addition, it can directly demonstrate the value of new pest control technologies and IPM tactics. From an academic perspective, these databases help to re-direct the efforts of the College of Agriculture by providing key stakeholder input to our applied research and extension programs. This "real world" input from the industry documents the relevancy of key pest problems and has become mandatory for competing for federal grant funding. Finally, for pest control advisors (PCAs), it can translate their efforts into economic terms for their clientele and confirms their value to the lettuce industry by showing the importance of key insect pests and their cost-effective management in desert lettuce production. This report documents the development of "real world" data on actual insect loss data for head lettuce and estimates of the level of insecticidal control needed to prevent key insect pests from reducing yield and quality.

Data Collection

The data was developed through the administration of a three-part survey that was conducted in an interactive process with stakeholder input. Growers, PCAs, Extension personnel and industry professionals attended a Head Lettuce Insect Losses and Impact Assessment Workshop in Yuma in April of 2007 and completed surveys in a guided process. The workshops were conducted in an interactive manner where participants were given a presentation that established the incentives for participation, explained the crop insect loss system, and further walked the participants through the estimation process. The three part survey instrument collected the following information:

Part I: Information was collected on the actual head lettuce acreage represented by the respondent, estimates of actual yields and potential yields for this acreage (Table 1), and overall percent reductions in yields due to several biological, environmental and management factors (Table 2). In addition, costs associated with aerial and ground applications (Table 3) and insect management fees for scouting (Table 4) were estimated.

Part II. Information was collected on IPM and crop insect losses through the description of the percentage of acres where key insect pests were present and insecticide sprays were required to prevent yield reductions. Included with those estimates are the frequency and costs of insecticide applications directed towards those insects. Overall, these costs represent an economic loss to the grower associated with preventing insects from damaging plants and reducing yields. Finally, actual percent yield losses (heads not harvested due to insect damage or reduced quality) for individual insect species were estimated (Table 5 and 6).

Part III: Data on insecticide use patterns was collected. These data identify the frequency of use of various chemistries (identified by both product name and IRAC mode-of-action classification) and the percentage of treated acres for each product (Table 9).

To provide data consistent with head lettuce production in the desert southwest, separate information was collected for fall lettuce acres (crops grown from September through November) and spring lettuce acres (December-March) because of differences in weather and insect pressures. Ideally, this data will allow us to track changes in insect crops losses and insecticide use patterns over time in great detail for both fall and spring head lettuce.

Results and Discussion

Part I: The 2006-2007 Head Lettuce Insect Losses workshop in Yuma was attended by 35 growers, PCAs, Extension personnel and other stakeholders. A total of 14 surveys were completed, representing a little more than 70% of the combined lettuce acreage in the Yuma and Imperial Valley areas (Table 1). The large majority of acres reported were for head lettuce grown in Yuma county (~90%), with the reminder representing the adjacent Bard/Winterhaven area of Imperial County, CA. Because of their proximity and similarities to each other, data were combined for these two growing areas. Estimates of yields (both actual and potential) varied slightly between year and crop season, and estimates for yield losses were about 16%. These values are also fairly consistent with the PCA and grower estimates of specific factors responsible for yield losses shown in Table 2.

Estimates for specific factors responsible for seasonal yield reduction varied as well (Table 2). Overall, weather and disease constituted the factors that PCAs and growers felt were most responsible for yield reduction, particularly in spring lettuce. This is commonly when lettuce is grown in cooler temperatures and higher amounts of rainfall. Disease pressure was reportedly light compared to the previous two years, presumably due to the dry growing conditions in 2007. Losses for all insects were estimated at 2.4 % for both seasons. This is consistent with the unpredictable nature of insect outbreaks that are often influenced by weather. Not surprisingly, yield reductions due to birds were high (>4 %, almost 2 fold higher than last year's results) and estimates among respondents varied from 0.2- 15 % losses. PCAs have reported that crop losses due to bird damage have been getting worse each year in lettuce. Percent reduction in yield by other factors included: vertebrate rodents, poor crop and irrigation management practices, poor lettuce markets, harvest problems, salt and poor weeding/thinning practices. However, in 2006-2007 these factors were responsible for < 1% of the annual crop losses in head lettuce.

Estimates for aerial and ground insecticide applications on head lettuce were fairly consistent between seasons (Table 3). In general, nearly 90% of all acres are treated by both air and ground on an average of almost 5 times per acre. Average costs for insecticides applied by ground were almost 25-30% higher than applied by air. Not surprisingly, respondents estimated that 100% of their acres where scouted, monitored and sampled for insect activity (Table 4). The number of field visits per week was higher in the fall, and may be indicative of the intense pest pressure that can occur in Sep-Oct as well as the rapid rate of plant growth. Estimates for the cost of scouting per acre was down in 2006-2007 from an average of $24.50 / acre last season. It was not documented why these costs decreased in one year, but as discussed openly after the 2006 workshop, may be a reflection of the increased cost of lettuce production, and in particular chemicals and fuel. Irregardless, these insect management costs suggest that Arizona lettuce growers find significant value in the expertise and service provided by their PCAs.

Part II: Insect Crop Losses

Fall Head Lettuce: Insects important at stand establishment such as seedling pests (ground beetles, earwigs, crickets, and salt marsh caterpillars) were treated on greater than 50 % of the lettuce acreage (Table 5). Slightly more than 1 spray treatment at an average cost of less than $15.90 per acre was used to manage these pests. However, this complex of pests accounted for an estimated 0.6% yield loss at stand establishment in the fall. Similarly, flea beetles were treated on a consistent basis in fall lettuce on > 30% of the acreage. Yield losses to flea beetles averaged about 0.3% . Leafminers were present on less than 50% of the fall acreage, but did not require treatments in fall lettuce in 2006.

The lepidopterous larval complex consisting of beet armyworm, cabbage looper and budworm/ bollworm accounted for the greatest number of applications in fall head lettuce in both years. This complex was present on nearly 100% of the acreage and required > 2 applications at an average of $41.80 / spray to control for beet armyworm, and $41.70/ spray for cabbage looper. This high cost in control likely reflects the increased price for agrichemicals that PCAs and growers often comment on. Corn earworm was less prevalent and control costs were slightly lower. Yield losses to this complex also varied by species and between years, but in general losses due to beet armyworm were highest.

Whiteflies (sweetpotato whitefly, *Bemisia tabaci* – B biotype) were reported to be present on slightly more than 60% of the fall crop, and required additional foliar sprays on 25 % of the fall acres 2006. Control costs with foliar sprays ranged from $43.95 – $59.08 / acre. Imidacloprid was applied to 56.7% of the fall acreage (Tables 7) at an average cost of $52.25/acre. The aphid complex consisting of green peach aphid, foxglove aphid and lettuce aphid accounted for higher yield losses than normal on a fall crop and the number of treated acres was higher as well. Although aphids are usually considered a pest of spring lettuce in the desert, unusually high numbers of green peach aphid were observed on crops in late October and November in 2006.

Western flower thrips has emerge as one of the key pests of desert head lettuce. Known mainly as a key pest of spring lettuce, thrips have become more numerous and troublesome in fall production. Estimates showed that almost half of fall lettuce acreage was treated for thrips at an average control cost of $26.40 per acre. Crop losses for thrips on fall lettuce were estimated at about 0.7%. , higher than any other pest. Similarly trash bugs (false chinch bugs, Lygus spp., and other insect contaminants) required treatment on about a quarter of the acres in fall lettuce, but at a much lower cost than thrips control.

Spring Head Lettuce: Insects important at stand establishment are generally thought to be less important on spring crops because of the cooler weather and the lack of other crops such as cotton and Sudan grass to provide a source of infestation. Data in Table 6 tends to support this, as nearly 50% fewer acres were treated for seedling pests in spring lettuce and yield losses were comparably lower. However, yield losses to seedling pests in 2004-2005 were higher compared to most other pests in spring lettuce. The presence of flea beetles and leafminers were similarly lower in the spring, requiring less control.

Lepidopterous larve also required less management on spring lettuce. Estimates showed that cabbage looper was the predominate species on spring crops, requiring higher control costs and causing slightly more yield loss than beet armyworm or corn earworm. This is consistent with our previous observations of lepidopterous larval activity on spring lettuce. Surprisingly, respondents reported that spray treatments were made on a minor number of acres for whiteflies on spring lettuce in 2007. This was not expected as we generally consider whiteflies a pest of fall crops. However, yield losses attributed to whiteflies were negligible in both years (<0.1%).

As expected, the number of acres treated for aphids on spring lettuce was much higher than reported for fall crops. The percentage of treated acres for green peach aphid was very high and accounted for about 1.0 % yield loss in 2007. Acreage treated for the foxglove aphid, which has recently become an established pest of desert lettuce, was lower in the spring of 2007 than in the previous 2 years. Although lettuce aphid is not considered a wide-spread pest in desert lettuce, PCAs estimated that about 12% of the acres were treated for this aphid species, requiring almost > 2 sprays to control the pest. Overall, aphids accounted for about 2.5 sprays this past season. It is important to note that imidacloprid applications made to spring lettuce are specifically targeted for aphid control. However, less than 40% of the acres were treated, thus a high number of foliar applications are often required. In the case of the foxglove and lettuce aphid, imidacloprid provides marginal control and can require additional foliar sprays.

Data in Table 6 indicates that thrips are by far the predominate pest of spring lettuce. Nearly 90% of the spring lettuce acreage was treated for thrips in 2007 at an average cost of $37.00 / acre. Even with this considerable expense, PCAs estimated yield losses as high as 0.9%. Trash bugs were similarly high in spring lettuce where nearly 30% of the acres were treated for false chinch bugs and Lygus spp. contaminating mature lettuce heads.

Part III: Insecticide Usage

The frequency of use and the percentage of treated acres for insecticides in head lettuce are shown in Table 9. The individual insecticide products are grouped by the IRAC mode-of-action classification (http://www.irac-online.org). This system groups chemistries with a similar mode-of-action with a common number so that users can effectively rotate different chemistries in resistance management programs. We list insecticides by a product name when possible; otherwise the chemical name is listed. Pyrethroids were listed by class only because of the numerous products registered in head lettuce. We also separated pyrethroid and diazinon by both foliar and chemigation uses.

The carbamate and organophoshphate chemistries are listed within IRAC Group 1 because of their common mode-of-action. Among this group, Lannate (methomyl) was the most commonly used product in both acreage treated and number of applications per acre. Lannate usage was highest in fall lettuce where it is targeted for both thrips and beet armyworm. No usage was reported for Larvin. Diazinon was also commonly used as a single chemigation treatment at stand establishment, particularly in fall head lettuce. Foliar diazinon use was marginal in both fall and spring crops. Orthene and Dimethoate use was minor on fall lettuce, but used at a much greater frequency and intensity on spring lettuce. Both of these products are effective tank-mix partners for aphids and thrips. Endosulfan (Group 2A) was used on about 32% of fall lettuce acres, presumably for whitefly and lepidopterous larvae control. Use of endosulfan increased to greater than 45% in spring crops, likely due to its efficacy as a tank-mix partner against aphids and thrips.

Foliar applications of pyrethroids (Group 3) were consistently the most heavily used insecticide in both spring and fall head lettuce. Use in fall lettuce was estimated at 97.6% treated acres and applied as foliar sprays 3.0 times per treated acre. A slightly higher use was estimated on spring lettuce. Pyrethroids were applied as a single chemigation treatment at stand establishment on almost 50% of the fall acreage, and on about 13% of acres in spring crops. Combined, diazinon and pyrethroids were chemigated on more than 2/3 of the fall lettuce acreage. The intensity and frequency of pyrethroid use in head lettuce is consistent with its broad spectrum activity against pests such as darkling beetle, flea beetle, thrips and lepidopterous larvae adults that are often not controlled with many of the new, selective insecticides.

Group 4A represents the neonicotinoid chemistry which includes Admire, Provado and Assail. Admire was used on about 34 % of the acreage of fall acreage and only 21% of the spring lettuce. Use of generic imidacloprid was reported for the first time and was used on about 20% of the fall and spring acres. In contrast, Provado use was minimal on head lettuce in both seasons. This low reported use of Provado use on spring lettuce is likely due to the registration of increased use of Assail and the registration of Beleaf in 2006. Another aphicide that may have been affected by Assail use was Fulfill (Group 9B), where the percentage of treated spring lettuce acres declined in 2007.

The second most heavily used compound in Arizona head lettuce was Success (Group 5). The percentage of treated acres was > 90% in both fall and spring lettuce. Usage of Success in fall lettuce is primarily targeted against lepidopterous larvae where an average of 1.9 applications / acre were made. Another product used for lepidopterous larvae control in fall lettuce was Intrepid (18A), which was treated on about 54% of the acres. Proclaim (6) use on lettuce increased more than two fold on fall lettuce since last year, whereas Avaunt (22) usage stayed about the same. These products were used at lower frequency and intensity on spring lettuce as lepidopterous larvae pressure is generally lighter in the spring. However, the percentage of acres treated with Success remained high on spring lettuce in 2007, despite lighter worm pressure and relatively moderate usage of the worm-selective Intrepid. The heavy reliance of Success on spring lettuce is likely due to its use for thrips control where it is recommended to be used in rotation with Lannate. Similarly, Agrimek (5) is an effective insecticide compound for leafminer control, but PCAs reported no use of the product in either year. Again this may be due to the high use of Success, which has good activity against leafminers on lettuce. Products that are approved for both organic and conventional lettuce production (Entrust, BT, and Azadirachtin/Neem) were used on less than 1% of the reported head lettuce acreage.

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Table 1. Number of respondents and reported acreage and yields for fall and spring lettuce in the 2006-2007 growing season.

Survey use stats	**Fall Lettuce**	**Spring Lettuce**
No. of PCA respondents	*14*	*13*
Acreage reported for these estimates	18,370	14,180
Estimated yield /acre (cartons)	828	865
Potential yield / acre (cartons)	1000	1023

Table 2. Percent reductions in yields due to several biological, environmental and management factors for fall and spring lettuce in the 2006-2007 growing season.

	Yield Reduction (%)	
Factor	**Fall Lettuce**	**Spring Lettuce**
Weather	2.4	5.8
Chemical injury	0.3	0.4
Weeds	0.7	0.8
Disease	2.3	3.8
All insects	2.4	2.4
Birds	4.3	4.3
Other factors	0.9	0.8
Avg. Total Losses	13.1	18.3
	15.7	

Table 3. Frequency and costs for aerial and ground applications on fall and spring lettuce in the 2006-2007 growing season.

Insecticide Applications	Fall Lettuce	Spring Lettuce
Aerial application		
% acres treated	93.1	91.2
No. applications	2.4	2.2
Cost ($) / application	10.50	11.23
Ground application		
% acres treated	100	100
No. applications	2.3	2.4
Cost ($) / application	16.00	15.00

Table 4. Insect management costs for aerial fall and spring lettuce in the 2006-2007growing season.

Insect Management	Fall Lettuce	Spring Lettuce
% acres scouted	100	100
No. field visits/week	4.0	3.4
Cost ($) / acre	22.10	22.36

Table 5. Insect losses and control costs on fall head lettuce in the 2006-2007 growing season.

Pest	Fall Head Lettuce				
	Acres Pest was Present *(%)*	**Acres Pest was Treated** *(%)*	**Foliar Insecticide Applications** *(No./ac)*	**Control costs** *($/ac)*	**Yield losses** *(%)*
Seedling pests	58.2	54.8	1.3	15.90	0.6
Flea beetles	59.9	37.4	1.4	18.00	0.3
Leafminer	48.4	0	0	0	0
Salt marsh caterpiller	2.6	0.2	1	35.00	0
Beet armyworm	95.1	95.1	2.5	41.80	0.6
Cabbage looper	83.7	83.3	2.3	41.70	0.4
Corn earworm	60.6	58.5	2	40.10	0.5
Whiteflies	61.9	25	1.5	48.30	0.1
Green peach aphid	24.5	24.2	1.5	33.80	0.4
Foxglove aphid	3.4	3.4	1.3	40.00	0.2
Lettuce aphid	3.3	3.3	2	45.00	0.2
Thrips	80.6	47.4	1.8	26.40	0.7
Trash bugs	73.2	25.4	1.7	20.00	0.1

Table 6. Insect losses and control costs on spring head lettuce in the 2006-2007 growing season.

	Spring Head Lettuce				
Pest	**Acres Pest was Present** *(%)*	**Acres Pest was Treated** *(%)*	**Foliar Insecticide Applications** *(No./ac)*	**Control costs** *($/ac)*	**Yield losses** *(%)*
Seedling pests	39.0	24.8	1.2	14.60	0.3
Flea beetles	40.6	26.1	1.2	16.60	0.3
Leafminer	0	0	0	0	0
Salt marsh caterpiller	0	0	0	0	0
Beet armyworm	54.2	52.2	1.6	38.20	0.2
Cabbage looper	73.0	64.7	1.5	38.20	0.3
Corn earworm	78.4	38.1	1.5	30.50	0.4
Whiteflies	23.6	4.5	2	47.00	0.1
Green peach aphid	79.6	79.4	2.5	38.40	1.0
Foxglove aphid	12.2	11.8	2.4	38.92	0.7
Lettuce aphid	12.5	12.3	2.5	38.70	0.7
Thrips	98.6	89.7	2.5	37.30	0.9
Trash bugs	64.7	29.8	1.8	26.3	0.1

Table 7. Frequency and costs of chemigation and soil-applied insecticides at stand establishment on fall head lettuce in the 2006-2007 growing season.

Treatment	Fall Head Lettuce		
	Acres Treated (%)	**Applications (no.)**	**Cost ($)**
Chemigation treatments used at stand establishment	63.6	1.1	12.54
Soil applied insecticide used (Admire Pro, generic imidacloprid, Venom)	56.7	1	52.25

Table 8. Frequency and costs of chemigation and soil-applied insecticides at stand establishment on spring head lettuce in the 2006-2007 growing season.

Treatment	Spring Head Lettuce		
	Acres Treated (%)	**Applications (no.)**	**Cost ($)**
Chemigation treatments used at stand establishment	41.5	1	13.50
Soil applied insecticide used (Admire Pro, generic imidacloprid, Venom)	39.4	1	48.60

Table 9. Insecticide usage on fall and spring head lettuce in the 2006-2007 growing season

IRAC MOA Group	Product	Fall Head Lettuce: Treated acres *(%)*	Fall Head Lettuce: No. times applied *(No./ac)*	Spring Head Lettuce: Treated acres *(%)*	Spring Head Lettuce: No. times applied *(No./ac)*
1A	Lannate	49.0	1.3	41.8	1.7
1A	Larvin	0	0	0	0
1B	Diazinon - foliar	2.9	1.0	1.3	1.0
1B	Diazinon-chemigation	17.0	1.0	21.2	1.0
1B	Dimethoate	4.6	1.0	10.7	1.2
1B	Metasystox -R	0	0	0	0
1B	Malathion	1.6	1.0	3.3	1.0
1B	Orthene (acephate)	10.9	1.0	34.6	1.2
2A	Endosulfan	32.5	1.1	47.5	1.1
3	Pyrethroids- foliar	97.6	3.0	99.1	3.0
3	Pyrethroids-chemigation	48.5	1.0	13.6	1.0
4A	Admire	34.5	1.0	21.7	1.0
4A	Generic imidacloprid	22.2	1.0	17.6	1.0
4A	Provado	0.8	1.0	3.5	1.0
4A	Assail	21.1	1.5	37.4	1.5
4A	Venom	0	0	0	0
5	Success	98.2	1.9	92.1	1.8
5	Entrust	0.1	0.5	0.1	0.5
6	Proclaim	44.7	1.3	12.0	1.2
6	Agrimek	0	0	0	0
9B	Fulfill	0	0	9.5	1.0
9C	Beleaf	6.9	1.0	34.6	1.2
11B	Bt (i.e. Dipel/Javelin)	0	0	0	0
18A	Intrepid	53.8	1.3	46.4	1.2
18B	Azadirachtin / Neem	0	0	0	0
22	Avaunt	22.9	1.0	14.0	1.0
23	Oberon	0	0	0	0