INSECTICIDE USE DURING SUGARBEET STAND ESTABLISHMENT IN THE IMPERIAL VALLEY CAN BE REDUCED

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ABSTRACT

Insect predation on emerging seedlings is considered a serious problem in fall-planted fields in the Imperial Valley. Growers rely on the use of carbamate and organo-phosphate pesticides to control insect pests of seedlings, but these chemicals will become restricted in the future because of environmental concerns. To quantify losses and to evaluate new plant protection methods, different ways of protecting emerging sugarbeet seedlings were compared over three years. Treatments included current practices and alternative seed treatments using imidicloprid at 45 and 20 g a.i. per unit. Seedlings were labeled and counted weekly until thinning. Spacing of established seedlings was measured in fall and again at harvest. Yields were collected and root quality determined. Pre-emergence insecticide applications, applied either to the soil or the seed, resulted in significantly more seedlings emerging and surviving compared to treatments without insecticides in all three years. Seed treatments were as effective as the soil and post-emergence aerial insecticide treatments. When fields were pre-irrigated, establishment rates with insecticides were 65 % or greater. In all three years, much less post-emergence loss was observed than growers anticipated, ranging from 1% to 15% of the emerged seedlings. Over-wintered plant losses in the last two years ranged from 0% to 15%. There were no significant differences in any year among treatments in root and gross sugar yields.

INTRODUCTION

Sugarbeet planting in the Imperial Valley takes place during September and early October when the populations of flea beetles and armyworms (*Spodoptera* sp.) can be large. These insects prey on sugarbeet seedlings. Growers and pest control advisors believe that insect control should commence as soon as seedlings appear and continue until late fall when insect activity declines. Otherwise, the risk of stand failure and the need to replant is considered great or even certain. Management based on this assumption has been successful for many years, but it has been largely based on grower experience and tradition. There have been no quantitative estimates for the loss of sugarbeet seeds and seedlings following planting, and no assessment of when or how those losses occurred. The most commonly used materials for control (methomyl or Lannate®, chlorpyrifos or Lorsban® and diazinon) are carbamate or organophosphate type compounds. Growers may become responsible for loss of these compounds from their farms to nearby surface water bodies in the future. Currently, there are no recommended alternatives to the use of these materials for sugarbeet seedling protection.

Pesticides found in surface waters are considered to be a non-point source pollution problem, but farmers have been exempt from the requirement for a waste discharge permit required for most point sources by the federal clean water act. Beginning in January, 2003, the waiver for this permit expires and farmers must begin to control the runoff leaving their farms. Eventually they will be responsible for the quality of farm runoff water. Starting in 1999, the California Beet Growers Association in cooperation with scientists from the University of California received a grant from the California Department of Pesticide Regulation to investigate the effects of alternative, less toxic methods of protecting emerging sugarbeet seedlings and mature sugarbeet crops from the effects of beet armyworms and other insects.

METHODS

To evaluate alternative seedling protection strategies and document loss to insects and other causes, three trials were conducted in the Imperial Valley near Brawley in the fall of 1999 through spring 2002. Planting dates and seeding rates are provided in Table 1. After planting, the amount of seed remaining was weighed to get an exact weight for the seed planted. This amount was divided by the known field area to get the seed population per acre and per foot of row. We assumed that planting occurred uniformly. Different pre- and/or post emergence treatments were compared (Table 2). Each treatment was replicated three times in plots that were 20 rows wide running the length of the field. Three of the five treatments were used in all three years. Emerging seedlings were counted in two sets of adjacent twenty foot long rows in the middle three rows of the plot four or five times after the start of irrigation. At the last date, the above-ground portions of 30 seedlings were collected from the center row of each subplot, dried and weighed for comparison. Differences in dry weights at approximately the six to eight leaf stage indicate the amount of damage that occurred to seedlings after emergence in the different treatments. Yields were measured early in April approximately six and a half months following planting, at the beginning of the sugarbeet harvest in the Imperial Valley.

RESULTS

1. Pre-emergence insecticide applications resulted in significantly larger numbers of emerging seedlings than treatments without insecticides. Pre-emergence losses were the most important cause of mortality. This was true despite differences in locations, irrigation practices and planters among the trials (Table 2). Post emergence mortality was less than expected in all three trials, suggesting that once seedlings emerge, most will survive. Imidicloprid applied to seeds protected seeds and seedlings as well as soil applied chlorpyrifos in the fall of 1999 and 2001, and satisfactorily in 2000. Flea beetles were the principal cause of damage at emergence and are well controlled by imidcloprid.

2. In both 2000 and fall 2001, the lower, less expensive rate of imidcloprid resulted in equivalent numbers of emerging seedlings. In 2001, seedling dry weight at the six leaf stage was lower for the 20 g imidicloprid rate compared to the 45 g rate (not shown). Flea beetles were abundant in Fall 2001 during the trial but not in fall 2000.

3. Some post-emergence insect protection remains important in the Imperial Valley when fields are irrigated early in the fall, but the amount may be reduced by using a seed treatment insecticide like imidicloprid. Approximately 7 to 10 days after emergence, armyworm control can become important. After this point, an effective post-emergence insect control measure may be required in imidicloprid-treated plots in years or locations with large numbers of armyworms. Sugarbeet seedlings tolerate moderate amounts of damage, but there is no quantitative relationship between seedling damage and yield, so growers must use best judgement in deciding when to protect seedlings from additional post-grazing damage. This will vary with the year and location, and time of year as well. As the planting season progresses, less post-emergence control should be necessary. So delayed planting is in itself an IPM practice.

4. High emergence rates are the key to successful stand establishment. Establishing a large percentage of seeds as seedlings saves growers money on seed costs and may make thinning unnecessary. Reducing the amount of pesticides applied has imputed environmental benefits and saves growers money (Table 3).

DISCUSSION

In the Imperial Valley, where pre-emergence losses are high, an insecticide applied with or to the seed appears necessary. The larger number of seedlings emerging and becoming established in treatments including a pre-emergence insecticide in this trial leads to the inference that insect damage is occurring to seeds and emerging seedlings before they appear above ground. Such damage has been reported in England and elsewhere in Europe, where springtails (Collembola *sp.*) are sometimes implicated in losses (Durrant, et al., 1988). Growers know about the potential for such losses but the amount of loss has not been quantified before in California to our knowledge. Early post-emergence seedling damage appeared to be due almost entirely to flea beetles. Armyworm moths must first locate seedlings and then lay eggs. Eggs take several days to develop and may be subject to predation or disease themselves. In contrast, flea beetles were present in the field at planting. Imidcloprid is very effective against flea beetles even at low rates and substituted well for soil applied chlorpyrifos (Lorsban®) and the first and possibly the second or even third aerial applications of chlorpyrifos/diazinon mixtures as well. The amount of insecticide used as a seed treatment is only approximately 15 to 35 grams a.i. per acre. This is a significant reduction in pesticide use.

In addition to having adequate numbers of seedlings, growers need healthy, vigorous plants. In 1999, treatments not receiving a pre-emergence insecticide resulted in severely damaged seedlings by the last counting date. Those seedlings surviving were reduced in size, often having damage to the apical meristem region. Even the imidicloprid treated seedlings were smaller and were beginning to suffer armyworm damage at the last counting date, suggested by lower seedling weights (Table 4). They imply that some post-emergence worm control is necessary in the fall establishment period when armyworm or flea beetle pressure is significant. Compared to the standard grower's treatment, however, the amount of pesticide and the number of treatments needed could be reduced. This could spare growers a significant amount of money, as well as reduce pesticide loss to the environment in surface runoff.

Generally, when approximately 65 % to 70 % of the seed planted results in viable plants, sugarbeets can be planted to a final stand, and hand thinning is no longer needed. High emergence rates combined with lower seeding rates avoid the combination of big, unproductive gaps and too- narrow spacing between plants in the rows that occurs if more seed is used but fewer plants are established. Hand thinning costs in the Imperial Valley vary between $50 and $100 per acre. This can be saved by planting to a stand. In addition, lower seed rates also save money, provided high enough emergence and establishment rates can be achieved reliably. If seed treatments are used, lower seed rates also save money on insecticides. Another way to save money is to use a lower rate of imidcloprid as a seed treatment. Growers can order lower rates of treatment than the label specifies, but may not order higher rates. The label specifies 45 g a. i. per 100,000 seeds currently, but rates as low as 28.5 g a.i. per unit may be used.

There were several limitations to these trials which may reduce their generality:

1. Drift from sprayed areas next to the plots, as well as control of insect populations in adjacent areas of the field may have reduced insect numbers within the plots. Plots were large in size. Twenty rows equal approximately 6.1 m wide and there were 4 unsprayed plots in every set of five. Nonetheless, the effects of drift and the possibility of reduced insect pressure within plots cannot be excluded. This difficulty is unavoidable in all experiments of this kind. If experimental plots were partially protected from damage, then post-emergence losses observed in these trials are underestimates of the amount of loss possible and may underestimate the need for post-emergence insect control. But plot size had no influence on pre-emergence losses because there was no drift to consider at planting.

2. The years during which these trials were conducted and the locations may not have been representative of the severity of insect pressure possible in the Imperial Valley. But in response to this concern, differences in insect pressure were observed in all three years, though not quantified. And three different fields resulted in similar patterns of results in all three trials, even though yearly influences and irrigation practices varied in important ways. The lower rate of imidicloprid, 20 g a.i. per 100,000 seeds, was evaluated only the last two years, but relative seedling emergence results were similar in both years.

3. Quantitative economic thresholds have not been established for tolerance to damage from armyworms and flea beetles. Growers must still use judgement in deciding if or when to control insects in the post-emergence period. Nonetheless, the survival of large numbers of seedlings in unsprayed plots and the uniformity of yields demonstrates that sugarbeet seedlings are capable of sustaining some grazing damage early in development (prior to 4 to 6 true leaves), yet survive and produce an economic crop.

Besides limitations to the trials there are some other, non-apparent obstacles to the adoption of seed treatment insecticides:

1. *The current practices work well.* Current stand establishment practices work well and growers are familiar with their use. Chlorpyrifos and diazinon are effective at controlling the insects that damage seedlings in the IV.

2. *Skepticism about new practices.* The alternatives proposed have not been widely evaluated in the Imperial Valley. Three trials provide good evidence for effectiveness, but few farmers have direct experience with the new practices. Since growers typically invest about $ $2900 per ha in a sugarbeet crop, prudent concern about newly proposed practices is appropriate. A new set of trials in more locations is underway as an extension tool to further evaluate and extend these practices.

3. *Costs.* The labeled rate for imidicloprid is 45 g ai per 100,000 seeds (per unit). It may be applied as low as 28.5 g per unit, but lower amounts are below what is listed on the label. Neither the company providing the insecticide nor the seed company applying the insecticide to seeds are willing to apply it at a lower rate, even though a lower rate appears to be sufficiently affective. It is not clear why a minimum rate of 28.5 g was established. The most cost effective treatment is the lower rate. At the lower rate, imidicloprid is economically competitive with Lorsban and diazinon, and with the use of imidicloprid as a soil treatment (Admire©). The lower the amount of active ingredient used, the better for the environment. Using lower rates may also help preserve the effectiveness of the insecticide.

4. *The need for new arrangements between growers and seed companies when ordering seed.* Seed must be treated with imidicloprid by the seed company before shipment. Growers cannot apply their own treatment. This requires both growers and seed companies to organize their plans earlier in the year than might be the case otherwise. Currently, sugarbeet seed companies will take back unused seed. If seed is treated with Imidicloiprid it becomes a toxic waste when unused and seed companies will not likely take it back. Imidicloprid is also phytotoxic. The higher the rate applied, the more phytotoxic it becomes. At the high rates used in Europe (90 g a.i. per unit of seed) it can be applied only with a pellet coating. Pelleting increases seed costs. When applied with the normal polymer film coatings used with sugarbeet seed in the U.S., seed mortality can occur after a few months, especially if seed is poorly stored. So seed treated with imidicloprid must be planted within a few months of treatment. Furthermore, the planting season in the Imperial Valley occurs at about the time that sugarbeet seed is harvested in Oregon, where it is produced. Treating seed with insecticides requires more time than current treatments and may delay seed deliveries.

5. *Competing alternative practices.* Imidicloprid can be applied as a soil treatment called Admire©. This requires no special planning on the part of the grower or seed company. Its use is untested but trials similar to the ones discussed here are underway currently in the Imperial Valley. Applying insecticides to the soil is similar to current practices and uses the same equipment and methods as current practices. A larger amount of insecticide is used in this way, however, and its use is less discriminating. The development of resistance may be more likely with higher rates of use. The chance of

phytotoxic effects due to higher rates and application difficulties could increase.

CONCLUSIONS

Imidicloprid used as a seed treatment appears to protect sugarbeet seedlings from pre-emergence losses in the Imperial Valley. Pre-emergence losses are the most important sources of seed and seedling mortality. Using seed treatments is arguably the most environmentally sensitive way to apply insecticides, and reduces worker exposure as well. Despite these advantages, there are a number of practical and financial obstacles to the adoption of seed treatments that have not yet been overcome.

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Table 1. Cultural comparisons between years.

Year	Irrigation date	Planter type	Planting rate (seeds/ha)	Pre-irrigation	Days observed (since irrig.)
1999-2000	19 Sept.	Monosem*	357,000	yes	10/16/19/25
2000-2001	15 Sept.	Milton	220,000	no	10/19/26/46
2001-2002	16 Sept.	Milton	172,800	yes	10/17/22/28

**vacuum type. Sugarbeet cultivar Beta 4776 was planted in all three years.*

Table 2. Seedling emergence and establishment at thinning.

**Some plots damaged by cultivation before counting. Pre-emergence mortality includes approximately 5% non-viable seed.*

Treatment	Cumulative emergence (% of seed)	Cumulative post-emergence mortality (% of seed)	Cumulative post-emergence mortality (% of seedlings)	Established (% of seed)	Pre-emergence mortality (% of seed)
			1999-2000		
Grower's	82.2	2.7	3.5	79.3	17.8a
Imid.@45g	79.4	5.1	6.9	74.1	20.6a
Control	**56.3**	**8.1**	**15.6**	**47.5**	**43.7b**
			2000-2001		
Grower's	49.2	6.6	13.4	42.6	50.8a
Imid.@45g	38.7	—*	—*	29.0	61.3b
Imid.@20g	38.9	5.6	14.6	33.2	61.1b
Control	**32.9**	**9.4**	**28.6**	**23.5**	**67.1c**
Imid.@45g + (1x)	38.3	7.4	19.2	31.5	61.7b
			2001-2002		
Grower's	68.3	1.3	1.9	67.0	31.7a
Imid.@45g	64.4	1.9	3.0	62.5	35.6a
Imid.@20g	68.8	2.5	3.6	66.4	32.1a
Control	**51.7**	**0.7**	**1.4**	**51**	**48.3b**
Imid.@45g + (1x)	66.8	0.8	1.2	66.1	31.2a

Table 3. Comparative direct costs, not including field preparation, seed, or thinning ($/ha)

(a.) The Growers treatment involved chlorpyrifos at planting and up to 4 post emergence applications of chlorpyrifos/diazinon. The greater the cost, the more post-emergence applications applied. (b.) The cost of imidicloprid (Gaucho©) declined each year because the amount of seed used declined each year (see table 1). Imidicloprid@45 is imidicloprid applied at the rate of 45 g a.i. per 100,000 seeds. Similary, Imidicloprid@20 is 20 gram per 100,000 seeds. Controls received no insecticides. All treatments included fungicides. (Imidicloprid+1x) means that one post-emergence aerial application of chlorpyrifos/diazinon at approximately 14 to 16 days after irrigation. The cost of imidicloprid seed treatment was estimated at $1.00 per gram applied to each unit. This may underestimate the actual current price. (c.) Included one post-emergence aerial application of chlorpyrifos/diazinon at approximately 14 to 16 days after irrigation. No insecticides were used in the control treatments.

Treatment	1999-2000	2000-2001	2001-2002
Growers[a]	181.50	158.50	130.10
Imidicloprid@45[b]	178.90	107.20	77.80
Imidicloprid@45g+[b,c]	---	149.50	121.00
Imidicloprid@20[b]	---	47.65	34.60
Control	0	0	0