The Use of Systemic Insecticides to Reduce the Incidence of Curly Top Virus Disease in Sugarbeets[1]

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Curly top virus of sugarbeets, named for the extreme curling and distortion it causes to the leaves of infected plants, severely restricted the sugar beet industry in several western states from 1916 to 1934. This disease is transmitted by the beet leafhopper, *Circulifer tenellus* (Baker), and is characterized by sporadic and destructive outbreaks varying in intensity from year to year. The leafhopper migrates from adjacent and distant semi-desert flora to agricultural areas.

Sugarbeet varieties highly resistant to curly top have been developed, that yield reasonably well, despite losses in the worst years. However, when these resistant strains are hybridized with leaf spot resistant strains, the resulting hybrids are intermediate in resistance, and severe losses may occur. Eastern New Mexico and western Texas are ecologically susceptible to both diseases, and a higher degree of protection from these diseases is desirable.

The curly top virus can be transmitted in only a few minutes of feeding, so the leafhopper would theoretically have to be controlled before the insect completes a transmission feeding. Such drastic control was not feasible before the advent of modern systemic insecticides.

Control of certain insects on sugarbeets by seed or soil treatment has been reported by various workers. Hills et al. (4, 5)[3] and Dorst (1, 2) reported the effectiveness of phorate and Disyston applied to the seed for beet leafhopper control on sugarbeets grown for seed. Georghion et al. (3) showed a substantial reduction in the spread of curly top virus of sugarbeets in California by the application of phorate.

The objectives of this investigation were to determine: (a) if any of the insecticides would give protection; (b) which of four systemic insecticides give the best protection; (c) which

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[3] Number in parentheses refer to literature cited.

of two rates was the most effective in reducing curly top; (d) the length of effectiveness of the insecticides; and (e) to measure the influence of insecticides on yield.

Materials and Methods

Before seeding, four systemic insecticides, each at one and two pounds of active material per acre, were banded into the soil at a depth of approximately eight inches. The insecticides used were NIA 10242, Timek, phorate, and Di-syston. The eight treatments plus an untreated check were randomized in a field test with four replications. The experiment was conducted for two years, 1966 and 1967. A curly top susceptible sugarbeet variety, HC 2, from the Holly Sugar Corporation, was planted both years. Plot sizes were single 40-inch beds (two rows per bed) 100 feet long. Plot harvest consisted of 100 feet of row harvested by hand. A sample of 15 roots was taken from each plot for sucrose and tare analysis. Curly top counts were started approximately 10 days after thinning, when plants were six weeks old, and taken weekly for a period of 13 weeks. A plant was considered as infected with curly top virus if the leaf curling and distortion could readily be observed. Plants were not prudently scrutinized for curly top disease symptoms. No insect records were taken, and the curly top counts were assumed to indicate beet leafhopper control.

Curly top data were analyzed by weeks for the two years combined since readings were made on approximately the same date each year and the plants were nearly the same in growth and biological development. The two years of data were also combined for analyses of stand, yield and sugar content. Analyses of variance were computed to estimate the primary sources of variation and interactions and to test for their statistical significance. Duncan's multiple range test was applied, where applicable, to differentiate specific means.

Table 1 gives the comparison of the two years for several agronomic practices and dates.

Results and Discussion

The percentages of curly top differed significantly between years in 11 out of 13 weeks (Table 2). Overall, the disease was three times more severe in 1966 than in 1967, but more plants were affected during the first four weeks in 1967 than in 1966. During the two weeks of June 18 and June 25, the severity of curly top was similar each year. Although the amount of curly top increased during the 13 week season in both years, the increase occurred more rapidly after June 25 in 1966 than in 1967.

Table 1.—Dates and agronomic practices in the insecticide tests with sugarbeets, Plains Branch Station, Clovis, New Mexico, 1966 and 1967.

	1966	1967
Insecticide applied	3/15	3/22
Variety	HC 2	HC 2
Date planted	3/16	3/23
Emergence	3/30	4/3
Thinned	5/9	5/10
Number of irrigations	7	7
Fertilizer applied	100-44-0	150-100-0-55S
Harvest	11/15	11/16
First curly top readings	5/23	5/20
Last curly top readings	8/15	8/12
Field design	Randomized complete block	3 × 3 lattice

Table 2.—Mean curly top percentage, all sugarbeet plots, for 13 weeks, Plains Branch Station, Clovis, New Mexico, 1966 and 1967.

Date	Year 1966	Year 1967	Differences
5/21	0.5	3.1	2.6**
5/28	1.3	4.5	3.2**
6/4	2.6	5.1	2.5**
6/11	5.2	7.2	2.0*
6/18	8.7	8.6	—0.1NS
6/25	12.3	10.2	—2.1NS
7/2	22.0	10.9	—11.1*
7/9	28.7	12.2	—16.5**
7/16	36.4	13.4	—23.0**
7/23	40.1	15.9	—24.2**
7/30	49.7	16.6	—33.1**
8/6	61.0	18.5	—42.5**
8/13	81.6	24.5	—57.1**

NS Non-significant
* Significant at the 5% level of probability
** Significant at the 1% level of probability

The mean responses (percentages of curly top) to insecticide treatments are shown in Table 3. The insecticides reduced the amount of curly top below that in the untreated checks at all periods except the first two where the disease obviously had not become well established. The final curly top counts showed that the means of the chemically treated plots and the checks were beginning to converge which suggests that the length of effectiveness of the chemicals was about 18 weeks.

Differential effects among the various insecticides were indicated with significant differences among the nine periods during June and July. Evidently, about three weeks were required for the curly top disease to become established, hence, the failure of mean separation among the treatments during the first two weeks. Much of the effectiveness of the insecticides seemed to have been lost by August so that the differences in treatment responses were not significant in the last two periods. NIA 10242 was consistently most effective in preventing curly top, and Di-syston was the least effective. Responses from Timek and phorate were intermediate at all periods.

Differences between the one and two pound rates and the rates by insecticide treatment interactions were consistently non-significant. The only significant year by treatment interaction found in the June 25 data must have been a chance deviation. The consistent response of these four systemic insecticides in extremely different years suggests that these results could be applied over a wider range of conditions.

Figure 1 graphically compares the insecticides and the check for the average curly top percentage during the 13-week period. The means for the insecticides were the results of 16 estimates (4 replications, 2 rates and 2 years). The check mean contained only eight estimates (4 replications and 2 years).

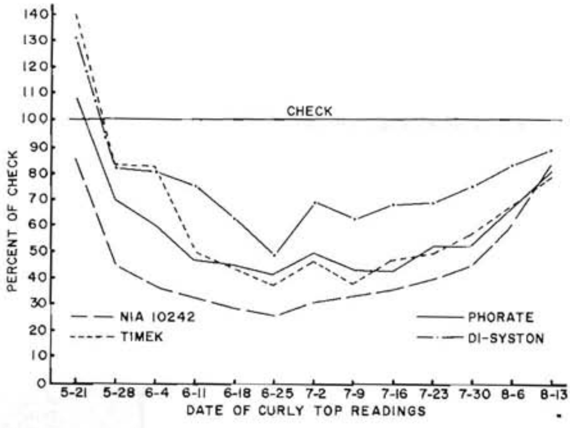

Figure 1.—Mean percentages of curly top in sugarbeets treated with four insecticides (averaged over rates and years). Plains Branch Station, Clovis, New Mexico, 1966-67.

Figure 2 shows the mean curly top counts for the four insecticides, given as percentages of the check. The insecticide lines slope downward for six weeks, indicating effective control of the leafhopper. However, after six weeks, the lines begin to slope upward, indicating the decreased effectiveness of the insecticide. Apparently, the systemic insecticides maintain some control of the leafhopper for about 18 weeks after application.

Table 4 shows a comparison of the two rates averaged over insecticides replications and years. In the first seven weeks there

Table 3.—Mean curly top percentage of sugarbeets during a 13-week period, when treated with four different systemic insecticides, Plains Branch Station, Clovis, New Mexico, 1966-1967.

	Date of curly top rating[2]												
Insecticides[1]	5/21	5/28	6/4	6/11	6/18	6/25	7/2	7/9	7/16	7/23	7/30	8/6	8/13
NIA 10242	1.38	1.81	2.12 a	3.56 a	4.88 a	6.44 a	9.25 a	13.56 a	15.94 a	19.12 a	24.00 a	33.94	52.12
Timek	1.75	2.75	3.44 ab	5.12 a	7.62 a	10.31 ab	14.92 a	17.56 ab	19.12 a	25.31 ab	27.94 a	34.31	50.56
Phorate	2.25	3.31	4.12 b	5.44 a	7.31 a	9.31 ab	14.00 a	15.19 a	21.06 ab	24.19 ab	30.19 ab	35.81	48.94
Di-syston	2.12	3.25	4.62 b	8.25 b	10.75 b	12.12 b	20.69 b	25.25 b	30.50 b	32.12 b	40.12 b	46.56	55.50
Sig. Level	NS	NS	*	**	**	*	**	*	*	*	*	NS	NS
Mean (Insect)	1.88	2.78	3.58	5.59	7.64	9.55	14.72	17.89	21.66	25.44	30.56	37.66	51.78
Check (Mean)	1.62	4.00	5.75	11.00	17.25	25.25	30.25	40.88	45.25	48.75	54.00	56.62	63.12
Ck. vs. insect.	NS	NS	**	**	**	**	**	**	**	**	**	**	*
Rates	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rates × Insect.	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Yrs. × Treatments	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS

[1] Average of 1 and 2 lbs/A. rates

[2] Duncan's multiple range test

NS Non-significant

* Significant at the 5% level of probability

** Significant at the 1% level of probability

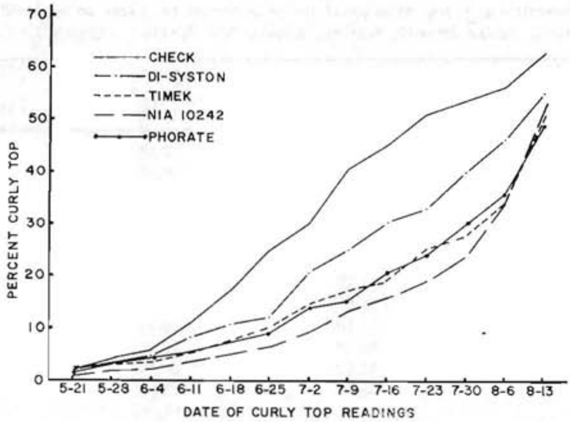

Figure 2.—Mean curly top count as a percentage of the check in sugarbeets treated with four insecticides (averaged over rates and years). Plains Branch Station, Clovis, New Mexico, 1966-67.

was little difference between the one and two pound rates. However, in the next four weeks, the plots treated at the one-pound rate had 7 to 15 percent more curly top than those treated at the two-pound rate. The curly top counts became similar again in the 12th and 13th weeks. Although the differences were not significant, the trend in the data suggests a longer residual effect from the higher rate of application.

Systemic insecticides are absorbed and translocated inside of a living plant. Plants and plant material are now scrutinized very carefully for pesticide residues by the Food and Drug Administration. Therefore, it would be desirable to have a systemic insecticide which would give good leafhopper control during that growing season but would be completely dissipated at harvest time. Some of the chemicals used in this test are approaching this ideal. Perhaps a split application of these insecticides, approximately ten weeks apart, at the one-pound rate would give better control of the disease for a longer time with no excess residue at harvest time. This would remain within the use limitations of the approved insecticides.[4]

Averages of stand and yield for the two years are shown in Table 5. Tonnage yield, sucrose percentages, stand and sugar per acre were all higher in 1967 than in 1966, and all differences

[4] NIA 10242 and Timek are not approved for sugarbeets. Recent correspondence (October 1, 1968) with Niagara Chemical Division of FMC Corporation indicated that they are hoping for registration of NIA 10242 (Furadan) for use on sugarbeets in the 1970 growing season.

Table 4.—Percent curly top of sugarbeets as affected by rates of insecticides (average of four insecticides), Plains Branch Station, Clovis, Nw Mexico, 1966-1967.

Dates	Pounds active/acre		Differences
	1	2	
5/21	1.88	1.88	0
5/28	2.84	2.72	.12
6/4	3.59	3.56	.03
6/11	5.69	5.50	.19
6/18	7.69	7.59	.10
6/25	9.59	9.50	.09
7/2	14.22	15.22	—1.00
7/9	18.66	17.12	1.54
7/16	23.19	20.12	3.07
7/23	26.38	24.50	1.88
7/30	31.69	29.44	2.25
8/6	37.78	37.53	.25
8/13	51.81	51.75	.06

Table 5.—Yearly means for yield, stand, and percent sucrose of sugarbeets, insecticide tests, Plains Branch Station, Clovis, New Mexico, 1966 and 1967.

Years	1966	1967	Differences
No. of beets/100 ft.	82.5	97.5	15.0**
Tons per acre	17.11	26.76	9.65**
Percent sucrose	13.91	14.54	0.63NS
Pounds sugar/A	4781	7777	2996**

NS Non-significant
** Significant at the 1% level of probability

were significant except between the sucrose percentages. Curly top was more severe in 1966 (Table 2) and caused a greater reduction in yield and stand.

Table 6 summarizes results from the 1966-67 tests for the yield components. This analysis showed that a significant difference was obtained between the check mean and the mean of the insecticide-treated plots for tonnage and sugar per acre. Furthermore, mean yields in tons of beets and pounds of sugar per acre were significantly higher for plots treated with NIA 10242 and phorate than those treated with Di-syston. Rate effects, rate by insecticide treatment interaction, and year by insecticide treatment interaction were all found to be non-significant.

Table 7 summarizes the results of insecticide rates for yield and stand. Although no significant differences were found between rates, the two-pound rate gave consistently better yield and stand. A similar trend was noted in curly top percentage (Table 4).

The yield results appeared negatively associated with the curly top counts. For example, the check plots and the Di-syston-treated plots had the most curly top and the lowest yields. This

Table 6.—Years and rates combined analysis of yield, stand and level of significance from the application of insecticides on sugarbeets. Plains Branch Station, Clovis, New Mexico, 1966-1967.

Treatment	No. of beets per 100 ft	Tons per acre[1]	Percent sucrose	Pounds sugar per acre[1]
NIA 10242	87.1	23.30 a	14.35	6704 a
Timek	96.4	22.97 a	13.76	6352 ab
Phorate	91.2	24.24 a	14.29	6988 a
Di-syston	85.6	19.65 b	14.43	5721 b
Sign. level	NS	*	NS	*
Insecticide mean	90.1	22.54	14.21	6441
Check mean	89.4	17.12	14.38	4982
Check vs. insecticides	NS	**	NS	**
Rates	NS	NS	NS	NS
Rates × insecticides	NS	NS	NS	NS
Insecticides × years	NS	NS	NS	NS
C.V.	21.34%	18.61%	5.56%	20.48%

[1] Duncan's multiple range test
NS Non-significant
* Significant at the 5% level of probability
** Significant at the 1% level of probability

Table 7.—Effect of insecticide rates on yield, stand, and sucrose of sugarbeets, Plains Branch Station, Clovis, New Mexico, 1966-1967.

Insecticides	Rate/acre 1 lb	Rate/acre 2 lbs
No. of beets/100 ft.	88.8	91.3
Tons per acre	21.80	23.28
Percent sucrose	14.08	14.33
Pounds sugar/acre	6186	6696

was expected because effective systemic insecticides will control the leafhopper which transmits the curly top virus. If the curly top disease can be controlled, higher production can be expected. Phorate and NIA 10242 showed the greatest promise of controlling the sugarbeet leafhopper.

Summary

Four systemic insecticides applied preplant to sugarbeet plots approximately eight inches below the soil surface at one and two pounds per acre for two years resulted in no important year × insecticide interactions. The insecticides were effective in reducing the amount of curly top infected plants and in increasing yield. Phorate and NIA 10242 gave the best control and the highest yield. Timek was intermediate for effectiveness, and Di-syston was the least effective.

Even though no significant differences were detected for rates, the two-pound rate consistently gave better results. The years differed significantly as shown by less curly top and greater production in 1967.

Acknowledgment

The authors wish to express appreciation to Holly Sugar Corporation for their cooperation in conducting these experiments.

Reference to a company or product name does not imply approval or recommendation of the product by the Agricultural Experiment Station, New Mexico State University, to the exclusion of others that may be suitable.

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