# Sugarbeet Cultivar and Systemic Insecticide Interrelationships in the Control of Curly Top Virus[1]

R. E. FINKNER AND P. R. SCOTT[2]

*Received for Publication April 3, 1972*

Curly top of sugarbeets, caused by the leafhopper-transmitted virus *Ruga verrucosans* (Carsner and Bennett), has been a serious threat to the crop in much of the western United States. Sugarbeet varieties highly resistant to curly top have been developed. However, when these are crossed with strains resistant to leaf spot, the resulting hybrids are intermediate in resistance, and severe losses may occur. Severe attacks of leaf spot and curly top, either separately or concurrently, can occur on the southern High Plains.

Modern systemic insecticides have made it possible to effectively control certain insect pests of sugarbeets when application has been made to the soil or seed (1, 2, 4, 5, 6, 7)[3]. Malm and Finkner (7). using a cultivar known to be highly susceptible to curly top, found phorate and Furadan to be the most effective insecticides they tested for the control of curly top. Since most of the cultivars produced for the High Plains have moderate to good resistance to curly top, it seemed advisable to determine the reaction of these cultivars to curly top with the addition of systemic insecticides.

Stewart (8) and Finkner *et al.* (3) concluded that fungicidal treatment for control of Cercospora leaf spot was advantageous for both leaf spot resistant and susceptible cultivars under intense epiphytotics.

Malm and Finkner (7) found that preplant applications of systemic insecticides afforded protection from curly top for about 18 weeks and suggested a mid-season topical application to carry the crop to harvest.

These investigations were designed to test the effect on curly top infection and consequential yield of roots and comparing the following: (A) Phorate versus Disyston; (B) The insecticides applied with dry versus liquid fertilizer; (C) Topical versus no application of a mid-seasonally applied insecticide; and (D) Insecticide application to disease resistant versus disease susceptible cultivars.

## Materials and Methods

Replicated field tests were conducted on Pullman silty clay loam at Clovis, New Mexico in 1968 and 1970. In both years, phorate

---

[1]Journal article 415, Agricultural Experiment Station, New Mexico State University.

[2]Professor of Agronomy and Superintendent, Plains Branch Station, New Mexico State University, Clovis, New Mexico, and Agronomist, Holly Sugar Corp., Hereford, Texas.

[3]Number in parentheses refer to literature cited.

and Disyston were banded into the soil approximately eight inches at a rate of one pound of active material per acre.

In 1968, each insecticide was mixed with granular or liquid fertilizer and applied to the soil. The 1968 field test was a split-split plot design. The main plots consisted of a $2 \times 3$ factorial (dry versus liquid fertilizer) and (Disyston, phorate, and no treatment insecticides). These plots were equally divided, and one half was planted with the curly top-susceptible cultivar HC2 and the other with the curly top-tolerant cultivar HH10. The second split consisted of treating one half of the plot with a topical application of phorate. Plots were single rows (20 inches), 90 feet long, replicated four times, and planted April 4. The insecticide treatments were applied one day earlier. Weekly readings were taken from June 7 through August 30 and the incidence of curly top was recorded as a percentage of infected plants from an entire plot. The curly top percentages data were transformed to arc-sine for statistical analysis. The topical application of phorate was applied July 3, and the center 50 feet of each plot were harvested October 5 for yield and sucrose determination. The fertilizer rate was 125-125-0, and the plots were irrigated 10 times.

The 1970 field test consisted of the same three preplant insecticide treatments (phorate, Disyston, and no treatment) at a rate of one pound of active material per acre. The curly top-susceptible cultivar HC2 was used again, and HH17 was used as the curly top-resistant cultivar. Topical insecticide applications of one pound per acre of both Disyston and phorate were made at two times, June 15 and July 27, in all possible combinations. A non-treated check was also included. The field design was a $2 \times 2 \times (2 \times 2 + 1)$ factorial in a randomized block with four replications. The soil insecticides were applied April 6, and the two cultivars were planted that day.

A total of 12 irrigations and 100 pounds of nitrogen were applied during the growing season. Plots consisted of two rows of beets on one bed, 40 inches wide, and 85 feet long. The entire plot was harvested October 23 for yield and sucrose determinations. The incidence of curly top was reported as a percentage of infected plants from an entire plot. All curly top percentage data were transformed to arc-sine for statistical analysis.

### Experimental Results and Discussion — 1968 Test

The only variable producing a significant effect on productivity was cultivars (Table 1). However, the total difference occurring for cultivars cannot be attributed to degree of curly top resistance alone because the curly top susceptible cultivar, HC2, is also known to be inherently lower in yield in the absence of disease.

The intensity of the disease was obviously low in 1968 as indicated by the lack of difference in productivity between non-treated and insecticide-treated plots and the low percentage of infected plants. Treatment effectiveness, as measured by percent of curly top-infected plants on August 30 (Table 1), indicated that the differences between main effects variables were significant except for differences between dry and liquid fertilizers.

The analysis of variance indicated three significant interactions between variables. Figure 1 shows that phorate and Disyston treatments lowered the percentages of beets with curly top for cultivar HC2 while the natural resistance of HH10 was sufficient to withstand the mild disease pressure. The topical application x variety interaction (Figure 2), might be expected under this low incidence of infection. Topical application to HC2 effectively held curly top in check while the inherent resistance in HH10 again was effective enough to prevent infection.

**Table 1.—Main effects of insecticides, fertilizers, cultivars, and topical insecticide applications for stand, yields, and percent curly top, Plains Branch Station, Clovis, New Mexico, 1968.**

| Treatment | Stand 50 feet | Yield of roots tons/A | Sucrose percent | Yield of Sucrose tons/A | Curly top percent 8/30 |
|---|---|---|---|---|---|
| Insecticides (soil applied) | | | | | |
| Phorate | 71.6 a* | 24.1 a | 15.7 a | 3.88 a | 5.5 a |
| Disyston | 67.0 a | 23.9 a | 15.5 a | 3.71 a | 7.1 b |
| Non-treated | 69.8 a | 23.8 a | 15.7 a | 3.75 a | 9.5 c |
| Fertilizer | | | | | |
| Dry | 67.4 a | 24.1 a | 15.6 a | 3.81 a | 7.5 a |
| Wet | 71.6 a | 23.8 a | 15.7 a | 3.74 a | 7.1 a |
| Cultivars | | | | | |
| HH10 | 75.1 a | 28.9 a | 15.7 a | 4.75 a | 3.5 a |
| HC2 | 63.9 b | 19.0 b | 15.6 a | 2.98 b | 12.3 b |
| Topical application | | | | | |
| Phorate | 69.1 a | 24.2 a | 15.8 a | 3.81 a | 6.1 a |
| Non-treated | 70.0 a | 23.7 a | 15.5 a | 3.74 a | 8.2 b |

* Numbers with the same letter are not significantly different at the 5% level.

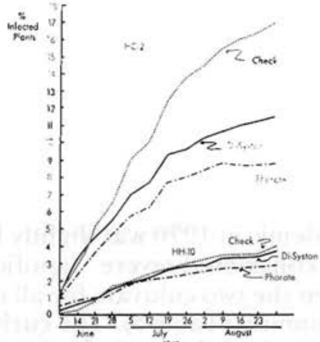


**Figure 1.—Percentage of plants infected with curly top, two sugarbeet cultivars treated with three different insecticides, Plains Branch Station, Clovis, N.M. 1968**

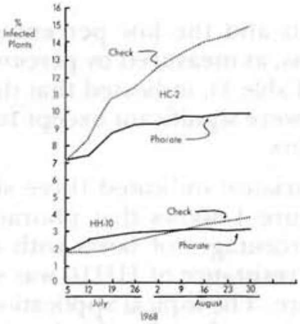


**Figure 2.—Percentage of plants infected with curly top, two sugarbeet cultivars with and without a topical application of Phorate, Clovis, N.M. 1968**

**Table 2.—Significant interaction of soil-applied insecticide x topical application of phorate, affecting tons of sucrose per acre, Plains Branch Station, 1968.**

| Mid season Treatments | Soil insecticides | | | |
|---|---|---|---|---|
| | **Disyston** | **Phorate** | **Check** | **Mean** |
| | Tons Sucrose per Acre | | | |
| Topical | B. 3.44 b | A. 4.17 a | AB 3.83 a | 3.81 a |
| Non-Treatment | A. 3.99 a | A 3.58 b | A 3.66 a | 3.74 a |
| Mean | A 3.71 | A 3.88 | A 3.75 | 3.78 |

Any two means followed by the same letter are not significantly different. (Duncan's multiple range at 5% level).

The topical application x insecticide interaction for stand, yield, and curly top percentage was unexpected. The yield reduction (Table 2) was probably due, for the most part, to a 25% stand reduction which was apparently caused by the topical application of phorate to previously Disyston-treated plots. The results indicated that phorate and Disyston may be incompatible when Disyston was used in the soil and phorate applied topically. Since this conclusion did not seem completely logical, an additional test was conducted in 1970.

## Experimental Results and Discussion — 1970 Test

The curly top epidemic in 1970 was slightly heavier than in 1968. Neither year could be considered severe. Significant differences were again detected between the two cultivars for all measurements except stand of beets after thinning (Table 3). The curly top-resistant hybrid HH17 is also known to be inherently higher in productivity than HC2; therefore, differences in yield again cannot be totally attributed just to curly top resistance. In this test, HC2 had a significantly higher percentage of sucrose.

Differences were also detected among the soil insecticide treatments (Table 3). Phorate-treated plots were more productive and had fewer diseased beets than did either the Disyston or the check plots. No significant differences were found between the Disyston-treated plots and the non-treated check. The superiority of soil-applied phorate in controlling curly top disease was reported by Malm and Finkner (7), and the results of both tests reported here support that conclusion.

Cultivars and soil-applied insecticides interacted for root yield, sucrose per acre (Table 4), and percentage of curly top-diseased beets (Figure 3). The application of systemic insecticides was of little value in increasing the yield and affording disease protection to cultivar HH17. However, when applied to the susceptible cultivar HC2, phorate was more effective in increasing yield and decreasing disease than Disyston.

**Table 3.—Main effects of soil-applied insecticides, cultivars, and chemical insecticides applied topically at two dates on sugarbeets for stand, yield, and percent curly-top, Plains Branch Station, 1970.**

| | Stand | | | | | |
|---|---|---|---|---|---|---|
| Treatment | After thinning 180 Feet | At harvest 180 Feet | Yield of roots tons/A | Sucrose percent | Yield of Sucrose tons/A | Curly top percent |
| Insecticides (soil-applied) | | | | | | |
| Phorate | 179.5 a | 167.0 a | 25.5 a | 13.9 a | 3.54 a | 5.5 a |
| Disyston | 180.2 a | 156.0 a | 23.7 b | 13.7 a | 3.25 b | 14.1 b |
| Non-treated | 18 1.6 a | 158.9 a | 23.3 b | 13.7 a | 3.19 b | 15.3 b |
| Cultivars | | | | | | |
| HH17 | 180.7 a | 176.2 a | 28.0 a | 13.6 b | 3.91 a | 3.4 a |
| HC2 | 180.1 a | 141.1 b | 23.3 b | 14.0 a | 2.84 b | 22.8 b |
| Topical application | | | | | | |
| Non-treated | 175.0 a | 158.4 a | 23.4 a | 13.7 a | 3.20 a | 14.7 a |
| Phorate | 184.5 a | 160.6 a | 24.1 a | 13.7 a | 3.29 a | 10.9 a |
| Disyston | 182.4 a | 161.0 a | 24.5 a | 13.8 a | 3.38 a | 8.8 a |
| Phorate Twice | 177.9 a | 165.6 a | 24.7 a | 14.0 a | 3.46 a | 10.8 a |
| Disyston Twice | 182.3 a | 157.7 a | 24.0 a | 13.8 a | 3.31 a | 11.2 a |
| Topical | | | | | | |
| Phorate | 181.2 a | 163.1 a | 24.4 a | 13.8 a | 3.38 a | 10.8 a |
| Disyston | 182.2 a | 159.3 a | 24.2 a | 13.8 a | 3.34 a | 10.0 a |
| Check | 175.0 a | 158.4 a | 23.4 a | 13.7 a | 3.20 a | 14.7 a |
| Applications | | | | | | |
| Single | 183.4 a | 160.8 a | 24.3 a | 13.8 a | 3.33 a | 9.8 a |
| Double | 180.0 a | 161.6 a | 24.4 a | 13.9 a | 3.38 a | 11.0 a |

Numbers with the same letters are not significantly different at the 5% level of probability.

**Table 4.—Interaction of cultivars and soil treatments of systemic insecticides affecting tons sucrose per acre yields, Plains Branch Station, 1970.**

| | Tons sucrose per acre | | | |
|---|---|---|---|---|
| **Cultivars** | **Phorate** | **Disyston** | **Check** | **Mean** |
| | A | A | A | |
| HH17 | 3.84 a | 3.82 a | 3.79 a | 3.81 a |
| | A | B | B | |
| HC2 | 3.24 b | 2.68 b | 2.59 b | 2.84 b |
| | A | B | B | |
| Mean | 3.54 | 3.25 | 3.19 | 3.33 |

Any two means followed by the same letter are not significantly different. (Duncan's multiple range at 5% level).

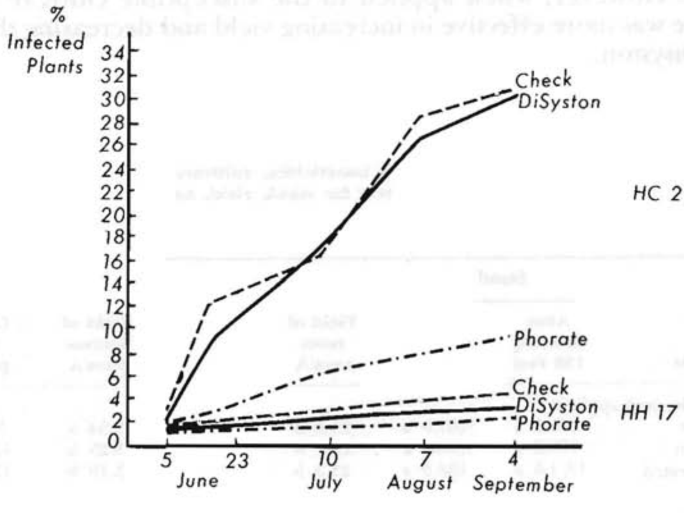


**Figure 3.—Percentage of curly-top-infected plants for two sugarbeet cultivars treated with three different soil insecticide treatments, Plains Branch Station, 1970.**

Both phorate and Disyston were applied topically with some plots receiving one and others two applications. In the 1970 test, no significant differences were detected for the main effects between the topical insecticides or for either single or double applications (Table 3). Curly top disease of sugarbeets is caused by a virus, transmitted by the beet leafhopper *Circulifer tenellus* (Baker). If there were no migration of leafhoppers into sugarbeet fields after June 15, then no control of leafhoppers would be needed, and no curly top virus would be transmitted. Figure 3 shows a continued increase in the percentage of infected plants. This increase may have been due to a light infestation of leafhoppers, or it may have been due to an earlier curly top infection, but the symptoms were not recognized until the plants became older and larger.

This test was designed to determine if any incompatibility existed between insecticides applied to the soil and later applied topically to the same plots. No evidence was found to support the incompatible theory. Topical application of systemic insecticides had very little measurable effect on the sugar beet plant in 1970.

## Summary and Conclusion

During 1968 and 1970, tests were conducted with systemic insecticides for controlling the sugarbeet leafhopper and, in turn, the curly top virus of sugarbeets. The insecticides were applied to the soil preplant, and about 10 weeks later a topical application was made to the beets. Liquid and dry fertilizers were used in one test as carriers for the soil-applied insecticides. No differences were found between the two types of fertilizers used as carriers. Either type could be used to apply the insecticides to the soil. Phorate gave the best control and the highest yields of the soil-applied insecticides. A sugarbeet cultivar with good to excellent curly top resistance would withstand the curly top disease pressure of the southern High Plains most years. In years with light to moderate curly top infection, there was no advantage to using a soil-applied systemic insecticide with a resistant cultivar. Soil-applied phorate was effective in reducing the percentage of curly top and increasing the yield of the susceptible cultivar HC2. Topical application of systemic insecticides showed little effects in limiting curly top or increasing yield. The 1968 data indicated a possible incompatibility between systemic insecticides used in the soil and topically. The 1970 test did not produce any results to support this theory, but the topical treatments produced no significant effect at all that year.

Additional research is needed to determine the effectiveness of topical application under more severe curly top conditions. It would be desirable to test the use of soil-applied insecticides and curly top-resistant cultivars under a severe epidemic of curly top.

Since severe epidemics of curly top cannot be easily predicted, a preplant soil application of phorate is a sound treatment in protecting sugarbeet crops.

## LITERATURE CITED

(1). Dorst, H.E. 1960. Experimental control of the beet leafhopper on sugar beets grown for seed. J. Am. Soc. Sugar Beet Technol. 11(1): 12-14.

(2) Dorst, H.E. 1965. Insect control on sugar beets by seed or soil treatments. J. Am. Soc. Sugar Beet Technol. (13)7: 649-653.

(3) Finker, R. E., D. E. Farus, D. B. Ogden, C. W. Doxtator, and R. H. Helmerick, 1962. Chemical control of Cercospora leaf spot in sugarbeets. J. Am. Soc. Sugar Beet Technol. 12(1): 43-52.

(4) GEORGHION, C.P., E.F. LAIRD, JR., and A.C. VAN MAREN, 1964. Systemic insecticides reduce the spread of curly top virus of sugar beets. Calif. Agr. 18(7): 12-14.

(5) HILL, ORIN A., F.H. HARRIES, and A. C. VALCARCE. 1956. Treatment of sugar beet seed with systemic insecticides for control of the beet leafhopper. J. Am. Soc. Sugar Beet Technol. 9(2): 124-128.

(6) HILL, ORIN A., A. C. VALCARCE, H. K. JEWELL, and D. C. COUDRIET, 1960. Beet leafhopper control in sugar beets by seed or soil treatment. J. Am. Soc. Sugar Beet Technol. 11(1): 15-24.

(7) MALM, NORMAN R., and RALPH E. FINKNER. 1968. The use of systemic insecticides to reduce the incidence of curly top virus disease in sugarbeets. J. Am. Soc. Sugar Beet Technol. 15(3): 246-254.

(8) STEWART, DEWEY. 1948. The damages induced by a severe epidemic of Cercospora leaf spot on susceptible and resistant varieties of sugar beets. Proc. Am. Soc. Sugar Beet Technol. 5: 528-530.

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