Effect of Aphid-Borne Beet Yellows and Beet Western Yellows on Sugar Beet Seed Production Under Conditions of Varying Fertility[1]

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Received for publication February 28, 1966

Beet yellows, a virus disease transmitted primarily by the green peach aphid (*Myzus persicae* (Sulzer)), was first reported in 1955 in the beet seed crop in the Salt River Valley of Arizona, though it had occurred somewhat earlier in the seed producing areas of Oregon. Bennett and McFarlane (1)[5] found that virus yellows reduced the yield of sugar beet seed in experiments near Salinas, California, but under the conditions of these tests the virus did not affect germination. Field plot experiments by Hills *et al.* (4) on the 1958 beet seed crop in southern Arizona showed that the virus yellows reduced the yield of seed and that infection at an early stage of development caused greater reduction than at a later stage. In some instances reductions in germination were also indicated.

Duffus in 1960 (2) and in 1961 (3) found that two viruses are involved in the yellowing of beets in the western United States, beet yellows virus (BYV) and beet western yellows virus (BWYV). Although these two viruses are unrelated, the symptoms they produce in sugar beets are similar. Field plot tests made by Hills *et al.* (5) between 1959 and 1962 to determine the effect of BYV and BWYV alone and in combination with the curly top virus[6] revealed that both BYV and BWYV reduced seed yield. Mixtures of the two viruses caused greater loss than either virus alone. Fall inoculations of curly top virus on beets resistant to curly top did not reduce seed yield either alone or in combination with one or both yellows viruses. Spring inoculations of curly top virus on curly top susceptible beets did not reduce yields. However, when this inoculation was followed by yellows infection, losses were greater than with yellows alone.

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[5] Numbers in parentheses refer to literature cited.

[6] Vectored by the beet leafhopper, *Circulifer tenellus* (Baker).

The question of the comparative effect of BYV and BWYV on the beet seed crop in fields of various levels of fertility has arisen repeatedly. Field plot studies therefore, were conducted on the 1963 and 1964 beet seed crops in an attempt to answer this question.

Methods and Materials

The experiments were conducted in grower-cooperative field plots consisting of 2 rows of sugar beets (1 bed) 20 ft long with 2-row buffer strips on each side and a 10-ft alley at each end. The 1962-63 plots were planted to a monogerm variety, American 3N-803; the 1963-64 plots were planted to another monogerm variety, American 2-413. Seed stalks on the buffer rows were cut to prevent them from tangling with the test rows; and as bolting progressed, wires were stretched to prevent lodging.

In the 1962-63 test, 8 treatments were replicated 5 times in randomized blocks. In one series of plots, fertility was maintained at a high level. In the other series, fertility was low. Four applications of fertilizer were made (Table 1). The first 2 application rates in the high fertility plots were 3 times those of the low fertility plots. The last 2 application rates were 4 times those of the low fertility plots.

Table 1.—Fertilizer applications to seed beet plots (Phoenix, Arizona, 1962-63).

Application dates	Fertilizer formulation	Pounds per acre			
		Low		High	
		N	P_2O_5	N	P_2O_5
10/5/62	13-39-0	13	39	39	117
10/25/62	Ammonium nitrate	33	0	99	0
3/11/63	Ammonium nitrate	33	0	132	0
3/29/63	Urea	45	0	180	0
Total applied		124	39	450	117

Plots of both levels of fertility were inoculated with BYV and BWYV alone and in combination by artificial infestation with infective green peach aphids. Insects for this work were bred in large numbers on malva (*Malva parviflora* L.,) in two walk-in cages 10×24×6 ft. Several weeks before they were introduced into the field plots, the aphids were placed in separate greenhouses, one containing New Zealand spinach infected with BYV and the other containing radishes infected with BWYV. Since these plants are specific for the virus isolates used, intermixing was prevented. On January 31, 1963, the viruliferous aphids were introduced into the plots. To prevent excessive movement and undue spread of the viruses, winged aphids were

first removed by aspiration from the heavily infested leaves in the greenhouses. The leaves were then cut into small pieces, placed in sealed paper bags, and taken to the field where the leaf fragments were scattered along the rows of the plots to be infested. Two days later the plots were dusted heavily with benzene hexachloride to kill the aphids and prevent spread of the viruses to adjoining plots. From this time on until harvest, plots were kept free from aphids by periodic dusting.

In the 1963-64 plots 6 treatments were replicated 6 times in latin squares. Three levels of nitrogen fertility, low, intermediate and high, were maintained, and plots at each level were inoculate with a combination of BYV and BWYV. A similar series was maintained uninoculated.

The amount of nitrogen fertilizer used on the plots of intermediate fertility was similar to that used by the average beet seed grower. The amount used on plots of high fertility was about double that of the intermediate plots, and the amount used for the plots of low fertility was less than half that of the intermediate plots. Dates of application, fertilizer used, and actual pounds of nitrogen per acre are shown in Table 2.

Table 2.—Fertilizer applications to seed beet plots (Phoenix, Arizona, 1963-64).

Application dates	Fertilizer formulation	Pounds per acre					
		Low		Intermediate		High	
		N	P_2O_5	N	P_2O_5	N	P_2O_5
9/13/63	13-39-0	26	78	26	78	26	78
10/14/63	Urea	0	0	112	0	225	0
3/26/64	Urea	45	0	112	0	225	0
4/16/64	Urea	0	0	112	0	225	0
Total applied		71	78	362	78	701	78

Yellows inoculations were made with infective green peach aphids, as in the 1962-63 tests. These aphids were mass-produced in large outdoor cages. Infected radishes held in the greenhouse were the source of inoculum for the BWYV, and New Zealand spinach was the source for the BYV. Prior to field inoculation, the viruses were moved to sugar beets in another greenhouse, and after the beets showed yellows symptoms, they were heavily infested with aphids. Three days later, on February 11, 1964, the winged aphids were removed and infested leaves were cut into small pieces, placed in sealed bags and used to infest the field plots, as in 1963.

In both 1962-63 and 1963-64 the seeds from each plot were harvested, cleaned separately over a 7/64 inch round hole screen, and weighed to determine yield. Samples were taken for germ-

ination analyses and from these samples the weight of 1000 seeds was determined.

Results

Each virus treatment produced significantly more seed in high fertility plots than did the same treatment in low fertility plots, but there was no significant difference in seed yield from high and low fertility plots under virus free conditions (Table 3). At a given fertility level seed yield from BYV-infected plants was not significantly different than seed yield from BWYV-infected plants. Neither the germination of the seeds nor the weight of 1000 seeds was affected by the fertilizer or the viruses.

Data from the 1963-64 plots (Table 4) show a statistically significant difference in seed yield caused by treatment. Yields from plots of different levels of nitrogen were significantly different when the yellows viruses were present, but when plots were virus-free, there were no differences between the yields

Table 3.—Effect of the yellows viruses on the sugar beet seed crop in plots of high and low fertility (Phoenix, Arizona, 1962-63).

Treatment				
Virus[a]	Plot fertility	Yield (lb/acre)[b]	Percent germination[c]	Weight of 1000 seeds (grams)[c]
BYV	High	5249 a	86	11.3
BWYV	High	4875 ab	88	11.3
No virus	High	4740 ab	89	11.3
BYV + BWYV	High	4394 bc	87	11.5
No virus	Low	4282 bc	88	11.6
BYV	Low	4083 cd	86	12.7
BWYV	Low	4051 cd	88	10.7
BYV + BWYV	Low	3636 d	86	11.2

[a] Infested with viruliferous green peach aphids.

[b] Values not followed by the same letter are significantly different at the 5% level. Duncan's Multiple Range Test.

[c] Not significant by the F Test.

Table 4.—Effect of yellows viruses on the sugar beet seed crop in plots of varying fertility (Phoenix, Arizona, 1963-64).

Treatment				
Viruses[a]	Plot fertility	Yield (lb/acre)[b]	Percent germination	Weight of 1000 seeds (grams)[c]
Noninfested	High	4111 a	80 ab	8.3
Noninfested	Intermediate	4025 a	83 a	8.1
Noninfested	Low	3037 b	76 bc	8.1
Infested	High	2931 b	73 cd	7.8
Infested	Intermediate	2351 c	73 cd	7.6
Infested	Low	1533 d	70 d	7.6

[a] Infested with green peach aphids carrying both BYV and BWYV.

[b] Values not followed by the same letter are significantly different at the 5% level. Duncan's Multiple Range Test.

[c] Not significant by the F Test.

from plots of intermediate and high nitrogen, but yields of both were greater than from plots of low fertility. Germination of seed was somewhat better in the virus-free plots than in the inoculated plots.

There was a definite tendency toward the production of lighter seed in yellows infected plots of all levels of fertility than in uninfected plots (Table 4), but the difference was not statistically significant.

Discussion

The 1963 data show that statistically significant increases in seed yield resulted from additional nitrogen fertilizer when either or both yellows viruses were present. The 1964 data also show that additional nitrogen partially offsets the loss in seed yield caused by the yellows viruses.

Although these data indicate that the high rate of application of nitrogen fertilizer (701 lb actual/acre) was desirable where the yellows viruses were present, little was gained when nitrogen beyond the level required for intermediate fertility (362 lb/acre) was used if the yellows were not present. Although losses from the yellows viruses were partially averted by additional fertilizer, the higher rate of application was not a substitute for prevention of yellows virus by aphid control. Yields from infected plots of high fertility were not significantly different from yields from virus-free plots of low fertility and were 1,094 lb/acre less than yields from virus-free plots of intermediate fertility. Also, the 1964 data indicate that reduction in the percentage of germinating seed may accompany lower yields caused by the yellows viruses. The 1963 data indicate little or no difference in the effect of BWYV or BYV on the seed crop which further corroborates previous work by Hills *et al.* (5).

Summary

Sugar beet seed plots, fertilized to different levels were inoculated with beet yellows virus and beet western yellows virus to determine the effect of these viruses alone and in combination on the seed crop under different levels of nitrogen fertility. The inoculations were accomplished by artificially infesting the plots with viruliferous green peach aphids. A combination of BYV and BWYV resulted in a statistically significant decrease in seed production. Either virus alone tended to decrease seed production. Increasing nitrogenous fertilizers above the amounts commonly used by growers increased seed yields in the infected plots but were of little value in the yellows-free plots. Some

reduction in seed germination accompanied the yellows infection. No statistically significant differences in the effect of BWYV and BYV on the beet seed crop were found.

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