BWYV symptoms on susceptible sugarbeet from outside California (left) and resistant variety developed in the state.

Beet western yellows can cause heavy losses in sugarbeet

Robert T. Lewellen □ Irvin O. Skoyen

BWYV symptoms on sugarbeet hybrids about eight weeks after inoculation. Center four rows (l to r) are US H11, Mono 309, US H10, and GW D2.

Virus yellows disease of sugarbeet is caused by a complex of aphid transmitted viruses. The three most important components of this complex in California are beet yellows virus (BYV), beet western yellows virus (BWYV), and beet mosaic virus. Each component is distinct and has unique virus particle structure, vector characteristics, and host range.

Virus yellows apparently became severe in California when spring-planted crops were grown adjacent to fields in which beet crops had overwintered. This cultural practice provided a continuum of host plants and virus sources. One way to break this continuum was to plant spring and fall crops in separate districts and provide "beet-free" (host-free) periods between successive crops. Beet-free periods generally have worked well to control beet yellows and beet mosaic, which have a limited host range with beet as the most important virus source.

However, despite beet-free periods, BWYV is still a prevalent disease in California sugarbeet fields, although it has not always been recognized because of the masking effects of moderately yellows-resistant hybrids. BWYV continues to be ubiquitous because of its wide host range, which includes a broad spectrum of other crops and weeds. Also, the virus persists in the aphid vector. Although potentially less damaging than beet yellows, beet western yellows is probably of greater economic importance now, since it is the most widespread component of the complex.

Because BWYV is more difficult to control with beet-free periods and other cultural practices, resistant varieties would be the ideal means of controlling damage in the sugarbeet crop. Breeding for virus yellows resistance in sugarbeet started at the U.S. Agricultural Research Station at Salinas, California, in 1955. Until recently, breeding was primarily aimed at obtaining resistance to BYV, but both BYV and BWYV were transmitted to test populations to be selected. This program resulted in development of the extensively grown, moderately resistant hybrid cultivars US H9, US H10, and US H11. However, it was uncertain whether resistance was to BYV or BWYV or both. Because of the severity of BYV and its masking effects on BWYV, the actual damage due to BWYV and the level of host resistance remained unresolved. Studies were initiated in 1977 to determine the damage caused by BWYV and to assess the range of host-plant resistance.

More recently, seed companies from Europe and other sources outside California have become interested in marketing sugarbeet hybrids in California. Because hybrids from their programs may have been bred without exposure to beet western yellows, it is of interest to compare representatives of these hybrids and moderately resistant hybrids currently used in California for their reaction to BWYV.

Field tests of hybrids

Effects of BWYV in different sugarbeet breeding lines and hybrids were determined from plantings in split-block designs with BWYV inoculated and noninoculated blocks at the U.S. Department of Agriculture Salinas station. Viruliferous green peach aphids reared on infected sugarbeet plants in a screened greenhouse were placed in juvenile beet plants in the field. After a two-day transmission period, the aphids were destroyed with a systemic insecticide. The plantings were subsequently sprayed at about six-week intervals to prevent movement of the virus into noninoculated checks. A mixture of BWYV isolates was used that was representative of the types found naturally in the Salinas Valley.

Field plots were planted on 28-inch beds and were one or two rows wide and 30 to 40 feet long. Recommended cultural practices were followed. The effects of BWYV were determined by comparing performance in the corresponding inoculated and noninoculated plots.

Approximately eight weeks after inoculation, BWYV-induced symptoms (yellowing) were scored on a 0 to 9 scale (0 = normal green color; 9 = all matured leaves yellowed). Harvest data collected for root yield and sucrose content were used to calculate gross sugar yield. The field tests included eight to 20 varieties, but data from only two or three from the various trials are reported here. Appropriate analyses of variance were run to determine if differences occurred between varieties for the several variables.

Results

BWYV caused significant losses in sugar yield (tables 1 and 2). It was also apparent that considerable differences exist within sugarbeet breeding lines

TABLE. 1 Sugar yield losses and yellowing scores due to BWYV of sugarbeet breeding lines tested at Salinas*

Breeding line†	Test 1		Test 2		Test 3		Mean	
	Loss‡	Score§	Loss‡	Score§	Loss‡	Score§	Loss‡	Score§
	%		%		%		%	
C17	5 a	3.0 a	6 a	1.5 a	9 a	3.0 a	7	2.5
US 75	23 b	7.0 b	22 b	5.6 b	22 b	6.4 b	22	6.3
SP6822-0	37 c	8.3 c	32 c	7.1 c	45 c	8.0 c	38	7.8

*Means in each column with the same letter are significantly different (P = 0.05).
†C17 pollinator of yellows-resistant hybrid US H10; US 75 = source of C17 and an obsolete California variety; SP6822-0 = pollinator of US H20 grown in the upper Midwest of the United States.
‡Yield loss in comparison with noninoculated check plots.
§Scale: 0 = no foliar yellowing at 8 weeks after inoculation; 9 = all mature leaves yellow.

TABLE 2. Sugar yields of commercial sugarbeet hybrid varieties in check noninoculated) and BWYV inoculated plots and sugar yield loss due to BWYV, Salinas*

Test and variety†	Sugar yield		Sugar yield loss	Yellows score‡
	Not inoculated	BWYV inoculated		
1979	*lb/acre*		%	
US H11	7,600 a	6,800 b	10 a	2.9 a
GW D2	8,200 b	5,600 a	30 b	5.9 b
B1443	8,300 b	5,600 a	32 b	7.1 c
1980				
US H11	9,600 a	8,600 c	10 a	3.3 a
Mono 309	9,200 a	6,700 a	27 c	7.4 b
GW D2	10,000 b	7,700 b	23 b	6.9 b
1982				
US H11	9,600 a	8,200 b	14 a	5.0 a
BJ 19	11,000 b	7,000 a	36 b	8.1 b

*Means in each column within each test with the same letter are not significantly different (P = 0.05).
†US H11 is a commercial hybrid widely grown in California. Proprietary hybrids GW D2, B1443, Mono 309, and BJ 19 are grown in other U.S. sugarbeet districts and are representative of cultivars without prior selection against BWYV.
‡Scale: 0 = no foliar yellowing 8 weeks after inoculation; 9 = all mature leaves yellow.

and varieties for reaction to BWYV.

The sugar yield losses for SP6822-0, a pollinator line developed outside California, and several of the commercial hybrids were higher than previously reported (about 38 percent, table 1). The yield reduction of about 22 percent for US 75, an open-pollinated variety used extensively in California before the development of hybrids, is fairly typical of previous reports in the literature. US 75 was developed in California, but the more susceptible varieties were produced in breeding programs outside California and without exposure to BWYV. These results suggest that, in comparison with SP6822-0 and other non-California developments, US 75 and similar germplasm selected in California have some degree of resistance to BWYV. This yellows resistance was probably incidentally selected in the normal course of breeding for yield and other disease resistance.

Of all the breeding lines and varieties evaluated at Salinas for reaction to BWYV, C17 (pollinator of US H10), C36 (pollinator of US H11), and similar lines have the highest level of resistance. These lines have fairly consistently shown a loss of about 6 to 8 percent under severe BWYV infection.

Germplasm with immunity or higher levels of resistance has not been found within the sugarbeet species, *Beta vulgaris* L. Among the commercial hybrids tested, US H10 and US H11 were the most resistant and showed losses in the 10 to 15 percent range (table 2). Experimental hybrids with higher levels of resistance have been developed. In contrast, commercial hybrids currently grown on the irrigated high plains and in the upper Midwest were quite susceptible: losses greater than 30 percent were not unusual, and these hybrids were much yellower when infected than US H11.

Traditionally, variety development in California has concentrated on producing breeding lines and hybrids that are resistant to bolting and a number of potentially severe diseases, including curly top, virus yellows, downy mildew, and Erwinia root rot. As is evident in table 2, in the near-absence of yellows and other diseases, hybrids with significantly higher sugar yields can be produced. However, even under the exposure of only one of these diseases (BWYV), this advantage disappears.

US H10 and US H11 hybrids have yellows-resistant pollinators (C17 and C36) but have moderately susceptible seed-bearing parents. Thus, their losses to BWYV are greater than those shown by their pollinators. One of the continuing goals of the yellows resistance breeding program at Salinas is to develop male (multigerm) and female (monogerm) germplasm with increased levels of combined disease resistance and higher productivity.

In variety trials at Salinas, under severe virus yellows conditions caused primarily by BYV, there has been little association between yellowing symptoms and levels of host-plant reaction. However, under the conditions of these BWYV inoculated tests, a close association (r = 0.6 to 0.9) was found between foliar symptoms and sugar yield losses (tables 1 and 2).

Often associated with BWYV infection is a leaf spot or blight caused by *Alternaria* spp. *Alternaria* infection was usually much more severe on susceptible varieties than on more resistant varieties. For example, whereas C17 rarely shows significant leaf blight, SP6822-0 and several of the susceptible commercial hybrids, such as Mono 309 from northern Europe, show high levels of infection and subsequent early leaf loss. The contribution of *Alternaria* to sugar yield losses and apparent BWYV susceptibility is not known. However, a portion of the resistance to BWYV is probably, in fact, resistance to *Alternaria*.

As seed companies become more active in marketing proprietary sugarbeet varieties in California, growers and processors will need to be aware of the potential damage that BWYV infection can do in highly susceptible varieties. In the Salinas tests, losses were greater than 30 percent. We found that losses were in both root yield and sucrose content. Reductions in percent sugar ranged from 0.5 percentage point for the most resistant varieties to more than 2 percentage points for highly susceptible hybrids. These losses not only affect returns to the grower but decrease sugar extraction efficiency for the processor.

From the BWYV inoculated tests at Salinas, it is obvious that the virus can be a significant hazard to sugarbeet production. Beet-free periods and adherence to recommended planting and harvest dates do decrease the potential incidence of BWYV but are not always successful in controlling this disease. Resistant varieties are necessary so that even high levels of the virus will not cause severe losses. Reactions of the varieties to BWYV in the Salinas tests demonstrate that the virus yellows resistance breeding project has been successful. In fact, most of the resistance against the virus yellows complex may be accounted for by the reduced losses to BWYV rather than to BYV.

Robert T. Lewellen is Research Geneticist, U.S. Department of Agriculture (USDA) - ARS and Associate in the University of California Agricultural Experiment Station, and Irvin O. Skoyen is Agronomist, USDA - ARS. Both are stationed at the U.S. Agricultural Research Station, Salinas, California.
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