Disease Thresholds and Increases in Fall Sucrose Yield Related to Powdery Mildew of Sugar Beet in California

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ABSTRACT

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Near El Centro, in California's Imperial Valley, powdery mildew appeared 18 wk after seedling emergence. Little or no additional crop loss of sugar occurred when the topical applications of sulfur for disease control were not started until 40% of the mature leaf area was diseased. At Davis, where disease control was initiated at the first sign of disease, retreatment after 30% of the mature leaf area became diseased was tolerated without crop loss. Also at Davis, after 1 October, there was little difference in increase in sucrose yield for plants where disease had not been controlled compared with plants where disease was well controlled all season. These experiments support the importance of controlling this disease of sugar beet during periods of rapid root growth but indicate that disease control is less critical before and after this period.

Additional key words: *Erysiphe polygoni*

Sugar beet (*Beta vulgaris* L.) powdery mildew, caused by *Erysiphe polygoni* DC., has occurred in California in epidemic proportions since 1974 (4,6). Control is usually achieved by two or three aerial applications of dusting sulfur at about 45 kg S/ha per application. The disease is seldom seen until the crop leaf canopy closes the open space between plant rows, which (depending on planting date and temperature) is usually between 8 and 12 wk after emergence (6). Field tests in northern California have shown that delay of the start of control by as little as 2 wk after the first sign of the disease can result in considerable crop loss of sugar (2). Most trials have shown that the first application of sulfur is the most important and gives the major protection from crop loss (3,7). However, additional applications of sulfur have reduced crop loss, which was shown to be related to the earliness of disease development at Davis, CA (1).

In California's Imperial Valley, powdery mildew occurs later in the crop cycle, and the existence of an initial disease threshold has not been investigated. In northern California where disease develops during July and August, a period of rapid crop growth, there is little information about the level of disease that might be tolerated before retreatment following a treatment at the first sign of disease. Also, many sugar beet fields in California are harvested in the late fall or are overwintered for harvest the following spring. Little is known as to how long powdery mildew control should persist to prevent increases in crop loss in these fields. The experiments reported here were designed to furnish information concerning these aspects of disease control.

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MATERIALS AND METHODS

The sugar beet cultivar used in these trials was US H10 or US H11. These cultivars are closely related and equally susceptible to powdery mildew. The experimental designs were randomized complete blocks with four replicates of fungicide treatments. When more than one harvest was involved, the plots were split at random or at random within a block for the several harvest dates, resulting in split plot or split block designs. Individual plots were four planting beds wide and 15 m long. Spacing between plant rows was 76 cm except for the Imperial Valley trial, where the row spacing was 36 × 66 cm (two rows on a single planting bed). Sulfur was applied by a CO_2-pressurized backpack sprayer with at least 234 L of water per hectare. From 6 to 12 m of the center two rows were hand harvested. Tops were removed below the oldest living leaf. Two random samples of eight to 10 roots each were taken from each plot for sucrose and tare determinations. Results are reported as means of all replications.

Disease was evaluated by rating 25 leaves in each plot on a pretransformed arcsine scale. The 0–5 ratings estimate 0, 10, 35, 65, 95, and 100% of the leaf area covered by the powdery mildew fungus mycelium. This rating procedure is given in detail elsewhere (1). Assessment was carried out at 2-wk intervals from the onset of disease to 2 wk before harvest, or to 1 October, whichever came first. In most years in northern California, disease declines rapidly after late September.

RESULTS AND DISCUSSION

Initial disease threshold, Imperial Valley. In the Imperial Valley of southern California, planting is in September–October. The crop grows relatively slowly during the moderate winter temperatures of the area, and 50% of the final yield of a 1 June harvest is not achieved until about 1 April, 180 days from emergence (5). This is in contrast to Davis, in northern California, where sugar beet planted in April–May grows more rapidly, with 50% of the root yield of a 1 November harvest being achieved in about 90 days (Hills, *unpublished data*).

In an Imperial Valley trial to evaluate the timing of the start of disease control, powdery mildew was not noted until 4 February, 126 days after emergence. Delaying the first application of sulfur for 3 wk until the percentage of mature leaf area diseased had reached 40% did not significantly ($P = 0.05$) reduce sucrose yield compared with plants where disease

was well controlled from its onset (Table 1). Thus, in situations where powdery mildew develops on plants with a large leaf area and a relatively slow growth rate, the application of sulfur at the first sign of the disease does not appear to be as critical as in situations where the disease develops when plants are growing more rapidly as at Davis.

Midseason disease tolerance, Davis. An important point for the efficient use of sulfur in the control of powdery mildew is the tolerance of sugar beet to infection developing after the first sulfur treatment. In a 1981 test at Davis, the disease was kept completely controlled by biweekly applications of sulfur (Table 1). In other plots of this experiment, the pathogen was allowed to reinfect after an initial control treatment, with the second treatment not given until percentage of

Table 1. Effect of various sulfur treatments on tolerable early season (Imperial Valley) and midseason (Davis) levels of powdery mildew on sugar beet in California

Location Sulfur (kg/ha)	Date applied	Mature leaf area diseased (%)							Sucrose yield (tons/ha)[x]
Imperial Valley[y]		Feb.	Mar.		Apr.		May		May
		26	12	27	10	23	7	28	29
0	Control	41	70	67	82	68	90	45	11.02 a
22	4 Feb.; 3, 31 Mar.	6	14	4	0	0	3	20	14.02 b
22	27 Feb.; 27 Mar.; 4 Apr.	41	41	15	1	0	2	5	13.52 b
LSD, 5%									(1.10)

Davis[z]		July	Aug.			Sept.	Oct.
		20	3	17	31	14	14
0	Control	2	26	58	45	20	10.41 a
11	8, 21 July; 13, 18 Aug.; 15, 29 Sept.	0.4	0.3	0.4	0.3	0.5	11.49 b
22	8, 17 Aug.	0.1	0.4	15	17	7	12.36 b
22	8, 31 Aug.	0	1	16	34	21	11.78 b
LSD, 5%							(1.12)

[x] Means not followed by the same letter are significantly different by the restricted LSD (ie, F for treatments is significant [$P = 0.05$]).
[y] Planted 28 September 1979.
[z] Planted 29 April 1981.

Table 2. Effect of sulfur for powdery mildew control on disease progress and sugar beet sugar yield over the fall harvest period at Davis, CA

Sulfur (kg/ha)	Date applied	Mature leaf area diseased (%)						Sucrose yield (tons/ha)			
		July	Aug.			Sept.		Aug.	Sept.	Oct.	Nov.
	1976	19	2	16	30	10	24	17	13	12	9
0	Control	29	40	80	81	86	90	6.88	7.97	8.78	10.40
9	2 July	0	1	33	75	81	86	7.30	9.89	10.08	11.87
9	2, 30 July; 27 Aug.; 30 Sept.	0	0	0	6	4	2	7.54	10.86	12.86	14.43
LSD, 5%								(0.66)[y]	(0.70)[z]		

		July		Aug.		Sept.		Aug.	Sept.	Oct.	Nov.
	1977	11	25	8	22	5	22	15	12	10	11
0	Control	2	54	75	89	60	41	4.80	6.38	7.29	8.64
45	27 June	0	4	26	78	72	53	6.10	7.50	8.43	9.88
45	27 June; 25 July; 22 Aug.	0	4	4	11	6	1	5.57	8.13	10.35	12.36
LSD, 5%								(1.08)	(0.51)		

		July		Aug.		Sept.		Aug.	Sept.	Oct.	Nov.
	1978	19	31	14	28	11	25	15	12	10	7
0	Control	0	18	33	85	98	64	3.98	6.08	7.95	8.97
11	19 July	0	0	1	28	81	97	3.90	6.95	8.77	9.51
11	19 July; 16 Aug.; 9 Sept.	0	0	1	8	58	55	3.90	7.13	9.52	10.22
LSD, 5%								(0.55)	(0.53)		

		July		Aug.		Sept.		Sept.	Oct.	Nov.
	1979	16	30	13	27	10	24	10	8	5
0	Control	<1	35	93	79	60	11	6.11	6.97	7.74
11	16 July	0	3	51	73	56	13	6.97	7.82	8.66
11	16 July; 6, 28 Aug.	0	4	28	26	22	4	7.28	8.68	9.67
LSD, 5%								(0.82)	(0.65)	

[y] Restricted least significant difference between harvest means for the same treatment (F for interaction significant at $P = 0.05$).
[z] Restricted least significant difference between treatment means for the same or different harvest (F for interaction significant at $P = 0.05$).

mature leaf area diseased had reached 16 or 34%. In this instance, there was no crop loss by delaying the second treatment until 34% of the mature leaf area was diseased. Thus it appears safe to delay a second sulfur treatment until the disease distinctly reappears.

Effect of disease control on late season sucrose yield, Davis. In 4 yr at Davis, increases in sucrose yield during early fall were greater for plants where powdery mildew had been controlled (Table 2). From October to November, however, when plant growth had greatly slowed, increases in sucrose yield were comparable in all but the 1977 trials regardless of earlier disease control. For example, in 1976, yield from nontreated plots increased by 1.09 tons of sucrose per hectare in July–August compared with 3.32 tons for plots that were kept essentially disease free by four sulfur applications. From October to November, however, yield from plots of the same treatments increased by 1.62 and 1.57 tons/ha, respectively.

At Davis from late September on, cooler temperatures and dew appear to arrest powdery mildew development. At this time, leaves previously severely diseased have died and younger leaves are smaller but more numerous and not as severely affected by the disease. The photosynthate produced by this smaller leaf canopy appears to be adequate to sustain storage root growth and provide for sugar accumulation, under these conditions of cooler temperatures and shorter days, almost as well as plants with larger leaf canopies on which powdery mildew has been controlled.

Conclusions. Our results suggest the following guidelines with respect to the use of sulfur for the control of powdery mildew in California. In the Imperial Valley, it is not as critical to begin disease control at the first sign of the pathogen as it is in northern California. Waiting until about 25% of the mature leaf area is diseased should avoid most crop loss and might save an additional sulfur application later on.

In northern California, after the initial sulfur control treatment, it is safe to allow the disease to increase to about 25% before initiating additional control. It is apparently not necessary to control powdery mildew beyond 1 October, whether the crop is to be harvested later that fall or the following spring.

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