COMPARISON OF CALENDAR DAYS AND GROWING DEGREE-DAYS FOR SCHEDULING HERBICIDE APPLICATIONS IN SUGAR BEET

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Introduction

Timely herbicide application is critical to achieve effective weed control in sugar beet. Often, the amount of time between sequential herbicide applications is based on a given number of calendar days since the prior herbicide application. Under most circumstances this approach works well. When spring weather is cooler than normal, applying herbicides on a calendar day schedule may result in applications too close together. This can result in greater injury to the beets or herbicides being applied before they are needed. Since weed and beet growth depend on temperature, it is logical that using accumulated growing degree-days (GDD) to schedule herbicide applications may be superior to calendar days. GDD accounts for variations in the weather and gives a more accurate idea of how fast plants are growing. If the weather is ideal for weed and beet growth, herbicide applications are made closer together; if the weather is cool, then applications are spaced further apart. Evaluation of a GDD model for timing herbicide applications may provide producers with a tool to improve the efficacy of the herbicides they are using.

Methods

A trial was established at the Malheur Experiment Station under furrow irrigation on April 8, 2004. Sugar beets (Hilleshog 'PM-21') were planted in 22-inch rows at 2-inch seed spacing. On April 9, the trial was corrugated and Counter 20 CR® was applied in a 7-inch band over the row at 6-oz/1,000 ft of row. Sugar beets were thinned to an 8-inch spacing on May 10 to 13. Plots were sidedressed on June 2 with 175 lb nitrogen (N) (urea), 30 lb potash (K_2O), 35 lb sulfates (SO_4), 38 lb elemental sulfur (S), 3 lb manganese (Mn), 2 lb zinc (Zn), and 1 lb/acre boron (B). All plots were treated with Roundup® (0.75 lb ai/acre) on April 13 prior to sugar beet emergence. On May 26, Temik 15G® (14 lb prod/acre) was applied for sugar beet root maggot control. Poast® at 16 oz/acre plus crop oil concentrate at 1 qt/acre were applied to the trial area on June 16. For powdery mildew control, Headline® (12 fl oz/acre) was applied on June 25, Topsin M® (20 oz prod/acre) plus S at 6 lb/acre, phosphate (P_2O_5) at 1.5 lb/acre, and Zn at 0.2 lb/acre were applied on August 4, and Headline® (12 fl oz/acre) plus S at 6 lb/acre were applied on August 8. All fungicide treatments were applied by air. Herbicide treatments were broadcast applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were 4 rows wide and 27 ft long and treatments were arranged in a randomized complete block design with 4 replicates.

Standard rate, increased standard rate, and micro-rate treatments were compared when applied on fixed calendar day schedules or when applied on different GDD accumulation schedules. The standard and high-standard-rate treatments were applied every 7 or 10 days and these timings were compared to applications at 150, 175, or 225 accumulated GDD since the previous application. The micro-rate treatments were applied on a 5- or 7-day schedule or at 150, 175, or 225 GDD since the previous application. Growing degree-days were calculated on a base of 34°F using the equation GDD = [(daily high temperature – daily low temperature)/2] – 34. GDD were calculated beginning the day after each herbicide application. Herbicide application dates and GDD measured between applications are shown in Table 1.

Table 1. Application dates for herbicide treatments applied to sugar beet on calendar day or growing degree-day (GDD) schedules, Malheur Experiment Station, Ontario, OR, 2004.

		Application				
Treatment*	Timing†	PRE	1st	2nd	3rd	4th
		Calendar date (GDD since previous application)				
Standard/High Rate	7 Day	4/13	4/26	5/3	5/10	--
Standard/High Rate	10 Day	4/13	4/26	5/6	5/16	--
Standard/High Rate	150 GDD	4/13	4/26	5/3 (151)	5/10 (199)	--
Standard/ High Rate	175 GDD	4/13	4/26	5/4 (187)	5/12 (173)	--
Standard/High Rate	225 GDD	4/13	4/26	5/6 (252)	5/17 (228)	--
Micro-rate	5 Day	4/13	4/23	4/29	5/4	5/9
Micro-rate	7 Day	4/13	4/23	5/1	5/8	5/15
Micro-rate	150 GDD	4/13	4/23	5/1 (152)	5/7 (164)	5/15 (153)
Micro-rate	175 GDD	4/13	4/23	5/2 (180)	5/9 (206)	5/22 (201)
Micro-rate	225 GDD	4/13	4/23	5/4 (249)	5/12 (220)	5/26 (228)

*Standard and high-standard-rate treatments were applied on the same dates.
†Application timing based on GDD were determined by calculating the number of GDD beginning the day after the previous application, using the equation GDD = [(daily high temperature – daily low temperature)/2] – 34.

Sugar beet injury was evaluated on May 29 and June 9, and weed control was evaluated on September 3. Sugar beet yields were determined by harvesting the center two rows of each plot on October 8 and 9. Root yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Syngenta Seeds Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval (P = 0.05). The untreated control was not included in the analysis of variance for weed control or crop response.

Results and Discussion

For the standard and high-rate herbicide treatments, the number of days between herbicide applications was the same for the 7-day schedule and the 150-GDD schedule. Applications on the 10-day schedule were within a day of the applications based on 225 GDD. The 175-GDD-spray schedule was between the other schedules. The final application of the standard and high rate herbicide treatments varied by as much as 7 days between application schedules. For micro-rate treatments, the 5-day application schedule was shorter than all other application schedules with the final application made by May 9. The 7-day application timing was almost the same as the timing based on 150-GDD. Applications based on 175 GDD were generally 1 to 7 days later than the 150-GDD schedule and applications with the 225-GDD schedule were likewise delayed 2 to 4 days compared to 175 GDD. The final application date among the different application schedules varied by as much as 17 days. In different years, the GDD application schedules could be significantly different from the fixed day application timings, depending on the weather patterns.

Postemergence treatments were very effective this year and timing had little effect on weed control. Pigweed and common lambsquarters control were reduced when the micro-rate was applied on a 225-GDD interval compared to all other treatments (Table 2). All other treatments and timings provided 94 percent or higher control of pigweed, common lambsquarters, hairy nightshade, kochia, and barnyardgrass. It is surprising that such a wide range of application timings could produce such complete control of all species. Since the standard rate was so effective, no differences were observed between the standard rate and the high-standard-rate treatments.

On May 24, injury from the standard or high-standard-rate treatments was among the greatest with the 175-GDD-application timing (Table 3). This does not appear to be related to the interval between herbicide applications, but seems to be related to rainfall events preceding those herbicide applications. There was no difference in sugar beet injury among the micro-rate treatments. By June 9, there were no differences in sugar beet injury between any of the herbicide treatments or application timings.

All herbicide treatments increased sugar beet root yield and estimated recoverable sugar compared to the untreated check (Table 3). There were no differences in percent extraction or sugar content for any treatment. Root yields were not different among the herbicide treatments and application timings. The high rate applied on a 10-day interval produced more estimated recoverable sucrose than the standard rate applied on the same 10-day schedule or the micro-rate applied on the 225-GDD-application schedule.

This year application timing was not critical because the postemergence treatments worked very well. In addition, the initial postemergence applications were made at the correct time while weeds were small. If the initial timing is delayed, the time between subsequent applications may be much more critical.

Table 2. Weed control in sugar beet with standard rate, high-standard-rate, and micro-rate herbicide treatments applied on a calendar day schedule or at different growing degree-day (GDD) intervals, Malheur Experiment Station, Ontario, OR, 2004.

			Weed control[‡]				
Treatment*	Rate	Timing[†]	Pigweed spp.	Common lambsquarters	Hairy nightshade	Kochia	Barnyard -grass
	oz ai/acre or % v/v	--	----------%----------				
Standard Rate							
Progress + UpBeet	4.0 + 0.25	7 Day	99	100	100	100	96
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5						
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5						
Standard Rate	Same as above	10 Day	97	100	100	100	98
Standard Rate	Same as above	150 GDD	100	100	100	100	100
Standard Rate	Same as above	175 GDD	100	100	100	100	100
Standard Rate	Same as above	225 GDD	99	100	100	100	97
Micro-Rate							
Progress + UpBeet + Stinger + MSO	1.3 + 0.08 + 0.5 + 1.5% v/v	5 Day	96	99	100	99	98
Progress + UpBeet + Stinger + MSO	1.3 + 0.08 + 0.5 + 1.5% v/v						
Progress + UpBeet + Stinger + MSO	2.0 + 0.08 + 0.5 + 1.5% v/v						
Progress + UpBeet + Stinger + MSO	2.0 + 0.08 + 0.5 + 1.5% v/v						
Micro-Rate	Same as above	7 Day	96	100	100	100	100
Micro-Rate	Same as above	150 GDD	94	98	100	98	100
Micro-Rate	Same as above	175 GDD	98	99	100	100	100
Micro-Rate	Same as above	225 GDD	86	93	100	98	99
High Rate							
Progress + UpBeet	4.0 + 0.25	7 Day	100	100	100	100	98
Progress + UpBeet + Stinger	6.7 + 0.37 + 1.5						
Progress + UpBeet + Stinger	8.1 + 0.5 + 1.5						
High Rate	Same as above	10 Day	98	100	100	100	98
High Rate	Same as above	150 GDD	100	100	100	100	100
High Rate	Same as above	175 GDD	99	100	100	100	100
High Rate	Same as above	225 GDD	100	100	100	100	100
LSD (P = 0.05)	--	--	4	2	NS	NS	NS

*Standard and high-standard-rate treatments were applied on the same dates.
[†]Application timing based on GDD were determined by calculating the number of GDD beginning the day after the previous application using the equation GDD = [(daily high temperature – daily low temperature)/2] – 34.
[‡]Weed control was evaluated September 3. Pigweed species are a mixture of redroot pigweed and Powell amaranth.

Table 3. Sugar beet injury and yield with standard rate, high-standard-rate, and micro-rate herbicide treatments applied on a calendar day schedule or at different growing degree-day (GDD) intervals, Malheur Experiment Station, Ontario, OR, 2004.

			Sugar beet‡					
			Injury		Yield			
Treatment*	Rate	Timing†	5-24	6-9	Root yield	Extraction	Sucrose	ERS
--	oz ai/acre or % v/v	--	---- % ----		ton/acre	---------- % ----------		lbs/acre
Untreated control	--	--	--	--	6.6	93.7	17.0	2,119
Standard Rate								
Progress + UpBeet	4.0 + 0.25	7 Day	14	11	45.2	93.1	16.6	14,001
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5							
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5							
Standard Rate	Same as above	10 Day	21	14	42.6	93.4	16.9	13,422
Standard Rate	Same as above	150 GDD	11	8	47.7	93.4	16.6	14,822
Standard Rate	Same as above	175 GDD	26	11	46.0	93.4	16.4	14,141
Standard Rate	Same as above	225 GDD	14	10	46.0	93.3	16.8	14,409
Micro-Rate								
Progress + UpBeet + Stinger + MSO	1.3 + 0.08 + 0.5 + 1.5% v/v	5 Day	8	11	46.9	93.2	16.7	14,568
Progress + UpBeet + Stinger + MSO	1.3 + 0.08 + 0.5 + 1.5% v/v							
Progress + UpBeet + Stinger + MSO	2.0 + 0.08 + 0.5 + 1.5% v/v							
Progress + UpBeet + Stinger + MSO	2.0 + 0.08 + 0.5 + 1.5% v/v							
Micro-Rate	Same as above	7 Day	15	13	46.6	93.1	16.8	14,532
Micro-Rate	Same as above	150 GDD	17	11	45.6	93.1	16.7	14,195
Micro-Rate	Same as above	175 GDD	11	9	44.3	93.3	16.7	13,823
Micro-Rate	Same as above	225 GDD	9	10	42.5	93.4	16.9	13,398
High Rate								
Progress + UpBeet	4.0 + 0.25	7 Day	19	6	47.3	93.4	16.3	14,396
Progress + UpBeet + Stinger	6.7 + 0.37 + 1.5							
Progress + UpBeet + Stinger	8.1 + 0.5 + 1.5							
High Rate	Same as above	10 Day	21	10	47.1	93.9	17.2	15,231
High Rate	Same as above	150 GDD	20	13	46.5	93.3	17.1	14,852
High Rate	Same as above	175 GDD	34	19	44.3	93.6	16.9	14,019
High Rate	Same as above	225 GDD	11	3	46.4	93.3	16.6	14,334
LSD (P = 0.05)	--		9	NS	4.4	NS	NS	1,459

*Standard and high standard rate treatments were applied on the same dates.
†Application timing based on GDD were determined by calculating the number of GDD beginning the day after the previous application using the equation GDD = [(daily high temperature – daily low temperature)/2] – 34.
‡Sugar beets were harvested October 8 and 9. ERS = estimated recoverable sucrose.