Defoliation of Sugarbeet: Effect on Root Yield and Quality[1]

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ABSTRACT

A three-year study was conducted to evaluate the effect of defoliation on the yield and quality of sugarbeet grown in south central Montana. Sugarbeet (*Beta vulgaris* L.) plants were subjected to a single defoliation of 30, 60, or 100% on six dates from July 1 through September 16 in 1991, and seven dates from June 12 and 15 through September 12 and 10 in 1992 and 1993 respectively. Root yield, sucrose content (with the exception of 60% defoliation on July 29, 1993), and sucrose yield (with the exception of 60% defoliation on July 9,1992) were not significantly reduced by 30 or 60% defoliation over the three year study or by 100% defoliation at the mid-June dates in 1992 and 1993. One hundred percent defoliation in late June or early July, mid-July, in mid-August, or in mid-September reduced sugarbeet root yield by an average of 23, 27, 20 and 10%, respectively, averaged over the three-year period. Sucrose content was significantly reduced by 100% defoliation later in the season, from mid-August through mid-September in each year of the study. Sucrose yield as affected by root yield, sucrose content or both, was significantly reduced by 100% defoliation from late June or July through mid-September in 1991 and 1993, and from late June through August 28 in 1992. Defoliation did not affect sucrose loss to molasses or percent root tare.

Additional Key Words: simulated hail, root yield, percent sucrose content, sucrose yield, Beta vulgaris L.

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Scattered or widespread hailstorms of various intensities can occur at any time during the growing season in south central Montana. While hailed sugarbeet fields can appear devastated, the actual effect of hail injury on the yield and quality of sugarbeet is often less serious than visual observation would suggest.

Data from simulated hail studies conducted in the United States, Canada, England, India, and Spain, suggest that yield and quality loss in sugarbeet resulting from hail is dependent upon the severity of defoliation, date of defoliation, and plant growth stage at defoliation.

The effect of defoliation on sugarbeet was previously evaluated in the late 1940s and early 1960s, at the Southern Agricultural Research Center, Huntley, Montana. Sugarbeet yield was reduced 5, 10, and 33% by late June defoliation; 10, 15 and 35% by late July defoliation; and 13, 18, and 28% by late August defoliation from defoliation levels of 25, 50, and 100%, respectively (Morris, 1948; 1950). Root sucrose content was reduced by 2 to 4% from 25, 50 and 100% defoliation at the late June and late July dates, and 13%, from 100% defoliation in late August (Morris, 1948). Results of the 1960s research showed that defoliation of 25, 50, and 75% reduced root yield less than 10% and did not affect sucrose content. One hundred percent defoliation reduced root yield by 20 to 30% with mid-June to mid-August defoliation and root yield was reduced less than 5% by mid-September defoliation. Sugar content was reduced 6% due to defoliation in early August, 16% from mid to late August defoliation, and 5% by mid-September (Afanasiev et al., 1960; Afanasiev, 1964,1966).

Sugarbeet yields in Minnesota were reduced 7, 13, 14, and 28% by a 25, 50, 75, and 100% August defoliation, respectively. Sucrose content was not affected by 25, 50, or 75% defoliation but was reduced by 9 to 12% when sugarbeet were defoliated 100% during August (Soine, 1967).

Carter et al. (1978) reported that sugarbeet suffering a 75% leaf loss in early August due to a hail storm in Idaho yielded an estimated 17% less than non-hailed beets, while sucrose content was unaffected by the hail.

In a two year Canadian study, sugarbeet root yields were reduced by 25, 50, and 75% defoliation; however, the yield reductions did not relate to growth stage or percent defoliation. Sugar content was not affected by the defoliation treatments (Lilley and Harper, 1962).

Sugarbeet root yield in England was not affected by defoliation of 12 to 75% at the 4- to 8-leaf stage of growth. One hundred percent defoliation reduced yields 25 to 30%, while sugar content was not affected by the defoliation treatments (Jones et al., 1955). Partial defoliation of sugarbeet resulted in an increase in photosynthetic activity by the remaining leaves,

which compensated for the lost leaves (French and Humphries, 1977). Results also indicated that new leaves produced after defoliation were less efficient than old leaves in photosynthetic activity.

Results of artificial defoliation 120 and 144 days after planting in India indicated that a single defoliation of 25, 50, or 75% did not reduce sugarbeet root yield, but 100% defoliation at 120 days after planting significantly reduced root yield (Singh et al, 1980). Sucrose yield was significantly reduced due to a single 75% defoliation 120 days after planting and due to a single 100% defoliation 120 or 144 days after planting. Singh and Sethi (1993) described a statistical model, that predicted the influence of extent and duration of defoliation on root sugar content, root yield, and sugar yield.

Sugarbeet in Spain were defoliated 33, 66, and 100% by shears, and to various degrees of severity using a water-jet spray(Muro et al, 1998). Sugarbeet root yield was reduced most by defoliation during mid-season at the time of maximum root growth, while sugar content was reduced most by defoliation later in the season.

The objective of this three year study was to evaluate the effect of hand or mechanical defoliation on the yield and quality of sugar beet varieties which have greater root yield and sucrose content potential than varieties grown in south central Montana 25 to 30 years ago when previous defoliation studies were conducted.

MATERIALS AND METHODS

The study was conducted under irrigation from 1991 through 1993 at the Southern Agricultural Research Center, Huntley, MT, on Lohmiller silty clay soil, with pH 7.9, and 2.5 % organic matter. The soil was fertilized for a yield goal of 58 Mg/ha, based on 3.3 kg N/t expected yield response; phosphorus was maintained above 25 ppm and potassium was well above the adequate range. Cycloate at 3.4 kg ai/ha was broadcast and incorporated 10 cm deep prior to planting, by operating a Triple-K cultivator with attached roller baskets.

Aldicarb was band applied at 1.1kg ai/ha at planting for flea beetle control. 'ACH-184' sugarbeet was planted May 12, 1991 and April 17, 1992, while 'ACH-203' sugarbeet was planted April 22, 1993. Sugarbeet were over- planted at an 8.1 cm seed spacing, with a 61cm row width, and were thinned to an average in- row spacing of 20.3 cm. The crop was irrigated as required. The experimental design was a randomized complete block with five replicates. Plots had three rows 10.6 m long. The center row was harvested using a single row sugarbeet harvester that was modified with a load cell scale system for yield determination. Yield and quality

data were analyzed statistically using MSUSTAT program (Lund, 1991).

Sugarbeet plants were defoliated on six dates beginning July 1, 1991, and on seven dates beginning mid-June in the 1992 and 1993 growing seasons. Thirty and 60% defoliation was accomplished by hand removal of the appropriate leaf area of all plants. Thirty percent defoliation was accomplished by hand, removing a third of the total leaf area from one side of each leaf exposed on the plant. Sixty percent defoliation was accomplished by hand removing one-half of the leaves plus ten percent from the remaining half leaf from each exposed leaf of the plant. One hundred percent defoliation was accomplished by using a hand held gas powered string trimmer so that a five cm petiole stubble height was left on the beet root.

Sucrose loss to molasses (Western Sugar laboratories), was calculated using a modified procedure of Carruthers and Oldfield (1960), based on amino-N, potassium, and sodium values.

RESULTS AND DISCUSSION

The changes in root yield, sucrose content, and sucrose yield due to 30, 60 and 100% defoliation in 1991, 1992, and 1993 are described in Tables 1, 2, and 3: respectively. One hundred percent defoliation from July 1 through August 29, 1991 and from June 25 through August 28, 1992 significantly reduced sugarbeet root yield. In 1993, 100% defoliation on June 29 and August 11, and on September 10, reduced root yield by over 10 Mg/ha; however, yield reductions were statistically significant only with the July 29, August 11, and September 10 defoliations. Root yield reductions due to 100% defoliation, averaged over the three year study, were 26% during July, 17% during August, and 10% at the mid-September date. Thirty and 60% defoliation from late June through mid-September reduced root yields by 4% averaged over the three years. Sugarbeet root yield was not affected by defoliation of 30, 60, or 100% (data not shown) in mid-June 1992 or in mid-June 1993.

Sucrose content was significantly reduced by 100% defoliation on August 29, 1991, August 13, 1992, and August 11, 1993 or later. One hundred percent defoliation prior to mid-or late August did not affect the sucrose content of the sugarbeet roots. Defoliation of 30 and 60% did not significantly reduce sucrose content (with the exception of 60% defoliation on July 29, 1993) throughout the three-year study.

Sucrose yield was significantly reduced by 100% defoliation on July 1, 1991, and June 29, 1993 and all dates through mid-September, and from June 25 through August 28, 1992. Sucrose yield was reduced by an average of 25% by the 100% defoliation on July 1 through September 16,

Table 1. The effect of defoliation on sugarbeet root yield, sucrose content, and sucrose yield, 1991.

Defoliation	Date of Defoliation					
Percent	7/1	7/17	7/31	8/14	8/29	9/16
			YIELD (Mg/ha)			
100	40.4	39.0	41.5	38.6	42.7	47.2
60	48.8	50.9	51.1	49.6	49.0	49.3
30	50.9	49.1	50.1	47.9	57.4	49.5
0	52.8	53.9	54.2	51.0	50.3	53.1
LSD (0.05)	5.9	8.5	6.3	6.2	6.1	7.1
			SUCROSE CONTENT, %			
100	17.03	16.70	16.63	16.42	15.17	14.76
60	17.10	16.62	16.90	16.90	17.10	16.60
30	16.94	16.94	17.01	16.80	17.02	16.70
0	7.07	16.91	17.08	16.63	17.01	16.83
LSD (0.05)	0.58	0.61	0.52	0.57	0.34	0.52
			SUCROSE YIELD (kg/ha)			
100	6869	6505	6901	6338	6481	6970
60	8343	8464	8625	8396	8378	8236
30	8627	8305	8664	8055	9770	8277
0	9014	9119	9258	8505	8553	8951
LSD (0.05)	1038	1379	1145	1186	954	1244

Planted 5-12-91 Harvested 10-10-91

Table 2. The effect of defoliation on sugarbeet root yield, sucrose content, and sucrose yield, 1992.

Defoliation	Date of Defoliation					
Percent	6/25	7/9	7/27	8/13	8/28	9/12
			YIELD (Mg/ha)			
100	44.9	43.2	46.5	50.1	49.7	59.8
60	58.4	53.4	61.7	58.2	63.5	60.9
30	62.2	60.2	64.6	54.3	59.9	62.9
0	62.7	60.8	60.2	60.3	59.8	61.9
LSD (0.05)	8.9	7.0	10.0	7.6	8.1	7.9
			SUCROSE CONTENT, %			
100	18.89	18.89	18.18	17.29	16.64	17.65
60	18.61	18.74	18.64	18.82	18.25	18.41
30	18.01	18.99	18.48	18.91	18.90	18.84
0	18.76	18.62	18.77	18.73	18.86	18.90
LSD (0.05)	0.82	0.30	0.71	0.60	0.67	0.66
			SUCROSE YIELD (kg/ha)			
100	8473	8160	8474	8653	8279	10,624
60	10,867	10,024	11,491	10,946	11,592	11,184
30	11,222	11,413	11,939	10,302	11,323	11,816
0	11,470	11,312	11,290	11,245	11,245	11,682
LSD (0.05)	1613	1262	1952	1401	1466	1428

Planted 4-17-92 Harvested 10-12-92

Table 3. The effect of defoliation on sugarbeet root yield, sucrose content, and sucrose yield, 1993.

Defoliation	Date of Defoliation					
Percent	6/29	7/14	7/29	8/11	8/24	9/10
			YIELD (Mg/ha)			
100	48.1	47.4	43.8	50.8	54.7	57.6
60	57.6	54.5	66.9	61.0	60.2	66.6
30	53.2	62.7	59.7	59.9	56.8	65.2
0	58.4	61.7	67.5	62.2	62.3	68.5
LSD (0.05)	12.5	14.8	9.0	10.0	15.1	10.1
			SUCROSE CONTENT, %			
100	17.96	18.43	18.30	17.67	17.28	16.85
60	18.31	18.68	17.91	18.58	18.36	17.90
30	18.60	18.06	18.38	18.50	18.31	18.37
0	18.03	18.42	18.47	18.38	18.43	18.44
LSD (0.05)	0.97	1.10	0.73	0.49	1.40	1.10
			SUCROSE YIELD (kg/ha)			
100	8,687	8,727	8,073	9,078	9,383	9,882
60	10,370	10,276	11,928	11,458	11,058	11,850
30	9,838	11,301	10,840	11,125	10,422	11,995
0	10,653	11,356	12,443	11,334	11,502	12,759
LSD (0.05)	1220	2265	1747	1896	1835	2061

Planted 4-22-93 Harvested 10-22-93

1991; by an average of 26% by defoliation from June 25 through August 28 1992: by 9% by defoliation on September 12, 1992, and by an average of 24% by defoliation from June 29 through September 10, 1993. Thirty and 60% defoliation reduced sucrose yields (averaged for the three years) from 0 to 10%; however, the reduction in sucrose yield was not significant, with the exception of the reduction from 60% defoliation on July 9, 1992.

Percent defoliation or date of defoliation in each of the three years did not affect sucrose loss to molasses or percent root tare (data not shown)

Results of the present study suggest that date and severity of defoliation, rather than the sugarbeet stage of growth, are primary factors influencing the reduction of root yield and sucrose content of sugarbeet. One hundred percent defoliation of sugarbeet at the 8- to 13-leaf stage of growth did not affect root yield when defoliation was in mid-June in 1992 and 1993, but did reduce root yield when applied at the 5- to 8-leaf stage of growth on July 1, 1991.

The timing patterns of reduced root yield and reduction in sucrose content due to 100% defoliation in this study were similar to the Minnesota and Montana studies published in the 1960s, and the results of studies conducted in India and Spain in the 1990s. Root yields were reduced by defoliation throughout the time of maximum root growth and sucrose content was reduced by defoliation later in the growing season, during the time of increased sucrose accumulation. The significant reduction in sucrose yield caused by 100% defoliation was due to reduced root yield from defoliation in late June to mid-August; due to a combination of reduced root yield and sucrose content from defoliation in mid- to late-August; and due primarily to the reduced sucrose content with the mid-September defoliation.

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