The Effect of Simulated Hail Damage on Sugar Beets

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The sugar beet producing area of the Red River Valley of the North in Minnesota and North Dakota is subject to hailstorms. Information on the effect of hail damage to sugar beets for this area has been needed for some time. This study was undertaken to gather data on the effect of simulated hail damage on the yield of beets, percent sucrose, weight of tops and the percent purity. The data presented in this paper covers a four-year period.

Review of Literature

There is no published information for the Red River Valley area of Minnesota and North Dakota on the effect of simulated hail damage to sugar beets, but there is some information for other areas in the United States, Canada and England. Afanasiev et.al. (1,2)[2] working with sugar beets in Montana reported that yields of roots were reduced less than 6% by defoliation as great as 75% and the yields of tops were reduced as much as 20%. With 100% defoliation, yields of beets were reduced 23 to 27%. There was very little reduction in the sugar content except on the 100% defoliation. Jones et.al. (6) working with sugar beets in England reported that 50, 75 and 100% defoliation in the 4- and 8-leaf stage caused a reduction in yield of roots of 5, 10 and 27% respectively. In Southern Alberta, Lilly et.al. (8) stated that yields of sugar beet foliage were the same for all treatments irrigated twice, and only the 50% defoliated plot was lower than plots irrigated four times. In 1961, yields of roots from plots irrigated four times were significantly reduced when the beets were defoliated 25% at 60 days, 50% at 45 days, or 75% at 45, 60, and 75 days after seeding. Morris (9,10) in Montana reported that 100% defoliation of sugar beets in late June or July reduced yields by one-fourth, and 50% defoliation reduced yields by one-sixth.

In other crops, Hella and Stoa (5) in North Dakota working with spring wheat and flax reported that the recovery of wheat plants from beating or whipping was related inversely to the severity of the beating and the stage of growth. Young flax plants recovered quickly when their stems were cut, but the degree

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and percent of recovery decreased rapidly from such injury as the plants became older. Woodbury and LeBaron (11) working with Pinto beans in Idaho report that the most serious losses were sustained when defoliation occurred at about the full-bloom stage or later. In soybeans, Fuellema (4) working in Illinois found that all degrees of defoliation at the time of pod and seed formation resulted in the most severe yield reduction. Kalton et al. (7) in Iowa reported that the yield was reduced most by plant injury as the soybeans began to develop in the lower pods. Beresford (3) working with potatoes in Minnesota reported that the reduction in yield from simulated hail damage applied at the 50% past full bloom stage was greater than at either the 50% bloom or full bloom stage, and that all yields were significantly lower than the check plot.

Methods and Procedure

The soils of the Red River Valley are alkaline (pH 7.5 - 8.2), high in organic matter, exchangeable potassium, and low in extractable phosphorus. The annual precipitation is 20.20 inches, and the crops are not irrigated. A four-year rotation of beets, wheat, barley, and sweet clover-fallow is most commonly used. The beet crop receives 200 - 350 pounds of 0-46-0 as a broadcast treatment with a starter application of 100 pounds of 6-42-0 at planting time.

In this study, the simulated hail "damage" was accomplished by cutting off 0, 25, 50, 75, and 100% of each individual leaf from each plant. Only one damage treatment was applied per plot during the entire season. The first damage was applied when the beet plant reached the "eight-leaf" stage, which time occurred between June 28-30. After this first date, the damage was applied to subplots at approximately 15-day intervals. The last treatment was applied August 31.

A split-plot design with four replicates and with dates of treatments as main plots and percent damage as sub-plots was used in this experiment. Plots consisted of four rows, 22 inches apart and 23.5 feet long. The two center rows were harvested for yield determinations, and duplicate samples from each plot were taken for sucrose and purity. The plots were harvested during the last part of September and early October.

Results and Discussion

Yield of Sugar Beets: The effect of simulated hail on the yield of sugar beets in tons per acre is given in Table 1 and expressed as a percentage of the check in Figure 1. These data are an average of four years, and each yield figure represents an average of 16 plots.

Table 1.—The effect of simulated hail damage on the yield of sugar beets in tons per acre, average 1962-65.

Treat-ment	Dates of damage					Average
	June 30	July 15	July 31	Aug. 15	Aug. 31	
Check	14.49	14.67	14.31	11.96	14.36	14.56
25%	14.70	13.86	14.32	13.90	14.22	14.20
50%	13.99	13.10	13.00	12.95	13.55	13.31
75%	13.22	12.69	12.51	12.83	13.61	12.97
100%	10.73	10.80	10.48	10.85	12.34	11.04
Average	13.42	13.02	12.92	13.10	13.61	

L. S. D.   5%   .37
           1%   .48

L. S. D.   5%   .57
           1%   .76

Difference between 2 treatment means for same date   N.S.
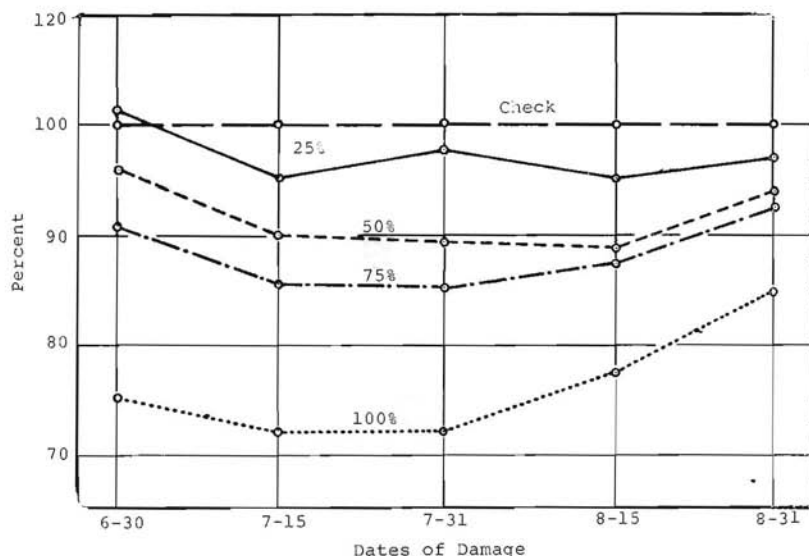Difference between 2 date means for same treatment   N.S.

Figure 1.—The effect of simulated hail on the yield of sugar beets in tons per acre given in percent of check, avg. 1962-65.

The reduction in the yield of sugar beets on the 25% damage plots was very slight. In fact, the yield on June 30 was slightly higher than the corresponding check plot and on July 31 the yields on the damage and check plots were identical. The greatest reduction, 1.06 tons per acre, occurred on the damage date of August 15. The average yield for the five damage dates was only 0.36 tons below the average of check plots. This represents an average reduction of 2.5% in yield.

The yields of the plots with 50% damage were all below the corresponding check plots. The greatest reduction, which was 2 tons per acre, occurred on the damage date of August 15 and the least reduction of 0.50 tons was on June 30. The plots on the five damage dates showed an average reduction of 1.25 tons per acre as compared to the average of the check plots. This is an average reduction of 9%. The most critical dates of damage were on July 15, 31 and August 1.

In the 75% damage class, (Figure 2) the average reduction for the five damage dates was 1.59 tons per acre when compared to the average of the check plots. This is equivalent to an average reduction of 11%. The lowest yields were obtained on the damage dates of July 15, 31 and August 15.

Figure 2.—Plots showing 75% damage on July 15.

The most severe reduction in yield took place on the 100% damage plots (Figure 3). These plots varied from 2.02 to 4.11 tons below the corresponding check plots. The average yield for the five different damage dates was 11.04 tons per acre as compared to 14.56 tons for the average check plot. This is

Figure 3.—Field plot with 100% damage.

equivalent to a 24% reduction. The most critical dates of damage were June 30, July 15 and 31, and August 15 (Figure 4).

Figure 4.—Plots showing 100% damage on August 16.

Percent Sucrose. The percent sucrose is given in Table 2 for the various treatments and dates of damage for the four-year period. The percent sucrose for the 25, 50 and 75% damage plots followed the check plots closely throughout the growing season and the percent of reduction was small for each degree of damage. The largest reduction in sugar content for the 25% damage treatment was on the damage date of July 15, but the average sucrose content for the five damage dates was 14.2% as compared to 14.4% for the check plots—a reduction of 0.2%.

Table 2.—Effect of simulated hail damage on the percent of sucrose average 1962-65.

Treat-ment	Date of damage					Average			
	June 30	July 15	July 31	Aug. 15	Aug. 31				
Check	14.63	14.50	14.12	14.54	14.07	14.37		-	
25%	14.31	14.09	13.86	14.54	14.14	14.19			
50%	14.46	14.39	14.32	13.99	13.87	14.21	L. S. D.	5%	.23
75%	14.31	14.31	14.04	13.99	14.08	14.15		1%	.30
100%	14.20	13.89	12.91	12.40	12.39	13.16			
Average	14.38	14.23	13.85	13.89	13.71				

L. S. D. 5% .27
1% .37

Difference between 2 treatment means for same date   5% - .51
1% - .67
Difference between 2 date means for same treatment   5% - .53
1% - .70

Both the 50 and 75% damage plots showed an identical reduction of .55% in sugar content for the damage date of August

15 when compared to the corresponding check plot. The average reduction for the five damage dates for the 50% and 75% damage plots was 1 and 2% when compared to percent sucrose of the check plots.

All the plots which received 100% damage were below the check plots and there was a gradual reduction in sugar content from June 30 to August 31. The largest reduction was 16% for the damage date of August 15, but the average reduction for the five damage dates was 8% when compared to the check.

Weight of Beet Tops. The average weight of beet tops in tons per acre is given in Table 3 for 1962, 1963 and 1965. No data for 1964 were taken because a hail storm in early September destroyed the foliage.

Table 3.—The effect of simulated hail damage on the yield of beet tops in tons per acre, average 1962-63-65.

| Treat-ment | Dates of damage | | | | | Average | | | |
	June 30	July 15	July 31	Aug. 15	Aug. 31				
Check	13.96	13.96	13.32	14.04	13.84	13.83			
25%	13.98	13.94	13.24	12.26	12.52	13.19			
50%	12.90	13.19	11.43	11.47	11.65	12.13			
75%	13.71	13.33	11.29	12.34	10.20	12.18	L. S. D.	5%	.72
100%	11.04	11.19	9.67	7.51	6.06	9.10		1%	.96
Average	13.12	13.13	11.79	11.53	10.86				

L. S. D. 5% 1.15
1% 1.54

Difference between 2 treatment means for same date 5% - 1.87
1% - N.S.
Difference between 2 date means for same treatment 5% 2.02
1% - N.S.

It is interesting to note that the weights of tops for the 25% damage plots were the same as the corresponding check for the dates of June 30, July 15 and 31. After this date, the weights were less than those of the check plots. The average reduction for all the 25% damage plots was 5% when compared to the average check plots.

The data for the 50 and 75% damage plots were similar, and the reduction in the weight of tops was greatest for the last three damage dates. The average reduction for all dates of damage for the 50% and 75% damage plots were the same; namely, 12% and 12% respectively.

On the 100% damage plots, the reduction in weight of tops followed a definite pattern. Starting on June 30, the reduction

was 21% and by September 15 it was 56%. The average re-
duction for all dates of damage was 34% compared to the average
of the check plots.

Purity. The data in Table 4 give the effect of simulated hail
damage on the purity for the different treatments and dates of
damage. In the processing of sugar beets, the purity of the raw
juice is very important and directly effects the amount of ex-
tractable sugar. There was little effect on the purity as a result
of the 25, 50, and 75% damage treatments. On four different
damage dates for each of these treatments the percent purity was
the same or higher than that of the corresponding check plots.
The average percent purity for the 25 and 75% damage plots
for the five dates was higher than the average for the check
plots while the 50% damage plots showed a 0.10% reduction
when compared to the check plots.

Table 4.—The effect of simulated hail damage on purity in percent, average 1962-65.

Treat- ment	Dates of damage					Average			
	June 30	July 15	July 31	Aug. 15	Aug. 31				
Check	84.82	84.90	83.58	85.56	84.33	84.64			
25%	84.65	85.18	84.13	85.54	84.64	84.83			
50%	84.91	84.59	85.24	83.76	84.32	84.56		L. S. D.	5% .59
75%	85.21	85.52	83.78	83.99	84.97	84.70			1% .78
100%	83.89	83.62	84.06	82.91	83.73	83.64			
Average	84.69	84.76	84.16	84.34	84.39				

L. S. D.   N.S.

Difference between 2 treatment means for same date   5% - 1.33
                                                     1% - N.S.
Difference between 2 date means for same treatment   5% - 1.42
                                                     1% - N.S.

The plots on four of the five damage dates with 100% dam-
age were below the check plots in purity, but the differences were
small. The average reduction in purity for these five damage
dates was only 1.2%.

Summary

This paper gives the effect of simulated hail damage on the
yield, percent sucrose, weight of beet tops and the purity of
sugar beets over a four-year period.

The greatest reduction in the yield of sugar beets for all
treatments occurred on the damage date of August 15, and was

7, 13, 14 and 28% for the 25, 50, 75 and 100% damage, respectively. However, the average reduction for all five damage dates was 3, 8, 11, and 24% for the 25, 50, 75 and 100% damage treatments, respectively, when compared to the average of the check plots. The reduction in yield for the 25% damage treatment was not significant.

There was little effect on the percent of sucrose by the 25, 50 and 75% damage treatments. The 100% damage treatments caused a gradual decline in the sucrose content throughout the growing season, and the average reduction for the five damage dates was 8%.

The weight of beet tops for the first three damage dates on the 25% damage plots was the same as the corresponding check plots; however, the damage in August caused a significant loss. The average reduction in weight of the beet tops for the 50 and 75% damage treatment was the same, namely; 12% for all dates. The 100% damage treatment reduced the average weight of tops 34% for all damage dates.

There was no significant difference in the purity for the 25, 50 and 75% damage treatment means for the five damage dates, but the 100% damage treatment mean did show a significant difference.

Acknowledgment

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