Effects of Defoliation and Reduction of Stand on Yield of Sugar Beets in Southern Alberta[1]

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In southern Alberta insect pests often cause serious damage to roots or foliage of sugar beets. Prior to thinning, flea beetles, *Phyllotreta* spp., may cause serious defoliation. After beets are thinned the sugar beet webworm, *Loxostege sticticalis* (L.), the beet leaf miner, *Pegomya betae* Curtis, and the spinach carrion beetle, *Silpha bituberosa* Lec., may cause extensive damage to the leaves. The sugar beet root maggot, *Tetanops myopaeformis* (Röder), the red-backed cutworm, *Euxoa ochrogaster* (Guen.), and the three wireworms *Limonius californicus* (Mann.), *Ctenicera destructor* (Brown), and *Hypolithus bicolor* Esch. attack the root and may kill young beets. There is little information concerning the amount of damage the plants can withstand or the level of protection required, and therefore the value of treating with insecticides cannot be adequately estimated beforehand.

In England, Jones *et al.* (5)[3] found that 50, 75, and 100% defoliation of sugar beets in the 4- and 8-leaf stages reduced yields by 5, 10, and 27%, respectively.

In Montana, Morris (6) found that complete defoliation of sugar beets in late June or early July reduced yield by 1/4 and 50% defoliation reduced yield by 1/6. Afanasiev *et al.* (1), working in the same area, reported that up to 75% defoliation reduced yield of roots by amounts not exceeding 6% and yield of tops by amounts not exceeding 20%. Complete defoliation resulted in reductions in foliage weight of up to 80% and a 23 to 27% reduction in beet yield. The greatest loss of top weight occurred when plants were injured late in the season.

The following experiments were conducted to determine the effects of defoliation and of reduction of stand on the yields of sugar beets grown in southern Alberta so that the economic significance of damage caused by sugar beet insects could be assessed.

Materials and Methods

In 1960 and 1961 experiments were carried out on irrigated land near Lethbridge. The soil was a silty clay loam with a pH of 7.7. Plots had been summer fallowed the previous year and each had received an application of ammonium phosphate (11-48-0) at 100 pounds per acre prior to seeding. The sugar beets

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[3] Numbers in parentheses refer to literature cited.

were seeded in rows spaced 22 inches apart at a rate of 6 to 7 pounds of seed per acre, using a commercial shoe drill. In 1960 seeding was done on May 9 but in 1961 the necessity of irrigating an abnormally dry seedbed followed by inclement weather delayed seeding until May 24. The stands were thinned to 120 beets per 100 feet of row in 1960 and, because of reduced germination, to 100 beets per 100 feet of row in 1961.

After thinning the stand was divided into randomized blocks containing plots 35 feet long and 4-rows wide. In 1960 the treatments were replicated four times and the plots irrigated four times. In 1961 two tests were set out as follows: one, consisting of five replications, was irrigated four times during the growing season; and the other, consisting of four replications, was irrigated twice. In 1960, 8 inches of irrigation water were applied to the plots. In 1961 the experimental area was irrigated with 1 inch of water prior to seeding. During the growing season the plots, irrigated four times, received 9 inches of water while the ones irrigated twice received 4 inches.

To determine the effects of defoliation, treatments were carried out 45, 60, and 75 days after seeding. On each date 25, 50, and 75% of the foliage of every beet in separate plots was removed. Transverse cuts were made through each leaf to remove the appropriate amount of leaf area. The effect of stand density on leaf- and root-yield was determined by removing every second or every fourth beet in other plots 60 days after seeding.

In 1960 flea beetles were controlled with insecticides. In 1961 the sugar beet root maggot was found for the first time in beet plots at the Research Station. Beets that were attacked by this pest were removed together with the adjacent soil and replaced with healthy transplants at the same stage of development.

Each year, harvesting was carried out early in September before the tops were frozen. Immediately before harvest the rows were trimmed to 25 feet and the whole plot harvested. The foliage was weighed immediately in the field. The roots were washed and weighed and then sampled with a multi-saw rasp for sugar determination.

All data were compared at the 5% level of significance by a multiple range test (3).

Results

When plots were irrigated four times during the growing season defoliation did not cause significant differences in foliage yields (Tables 1 and 2). A significant reduction in yield of foliage occurred only where the stand was reduced by 50%.

In 1960, 75% defoliation 60 days after seeding resulted in a yield of roots significantly lower than those of the check plots.

Table 1.—Effect of defoliation or stand reduction on yield of foliage, roots, and sugar of sugar beets, Lethbridge, Alberta, 1960.

Treatment	No. of beets (100 row-ft)	Treatment	Foliage (lb/plot)	Treatment	Roots (lb/plot)	Treatment	Sugar (lb/plot)
25% defoliation (45 days)	119	25% defoliation (45 days)	262.1 [1]	25% stand reduction	195.8	25% stand reduction	25.8
50% defoliation (45 days)	123	75% defoliation (75 days)	257.8	25% defoliation (45 days)	190.6	25% defoliation (45 days)	25.3
75% defoliation (45 days)	119	50% defoliation (45 days)	257.3	50% stand reduction	185.5	25% defoliation (75 days)	25.1
25% defoliation (60 days)	121	50% defoliation (60 days)	249.1	50% defoliation (45 days)	184.8	Check	24.4
50% defoliation (60 days)	119	25% defoliation (75 days)	248.3	25% defoliation (75 days)	182.0	50% defoliation (45 days)	24.0
75% defoliation (60 days)	122	75% defoliation (60 days)	244.8	Check	180.8	50% stand reduction	23.5
25% stand reduction	94	75% defoliation (45 days)	240.9	50% defoliation (60 days)	178.5	50% defoliation (75 days)	23.2
50% stand reduction	61	Check	239.2	75% defoliation (75 days)	173.4	75% defoliation (45 days)	23.0
25% defoliation (75 days)	121	25% defoliation (60 days)	222.8	50% defoliation (75 days)	170.9	50% defoliation (60 days)	23.0
50% defoliation (75 days)	121	50% defoliation (75 days)	221.3	25% defoliation (60 days)	170.6	25% defoliation (60 days)	22.5
75% defoliation (75 days)	123	25% stand reduction	217.1	75% defoliation (45 days)	168.5	75% defoliation (75 days)	22.5
Check	120	50% stand reduction	176.0	75% defoliation (60 days)	159.3	75% defoliation (60 days)	21.6

[1] Means connected by the same vertical line are not significantly different at $P = .05$.

However, the yields of roots from plots where the number of beets had been reduced from 120 to 94 were significantly higher than where the plants had been defoliated 25% at 60 days, 50% at 60 and 75 days, and 75% at all dates after seeding. It appears that under the growing conditions encountered, 94 beets per plot more closely approached an optimum stand than 120.

In 1961 at the higher level of irrigation a 50% reduction in stand resulted in a significant decrease in root yield. Root yields from plots in which beets had been defoliated 25% at 60 days, 50% at 45 days, and 75% at 45, 60, and 75 days after seeding were also lower than those from the check plots (Table 2). It should be noted that the check plots contained an average of 93 beets in 1961, which was almost the same as that of the stand that had been reduced by 25% in 1960.

A comparison of the total numbers of heat units[3] between the various dates of defoliation and harvest in 1960 and 1961 is shown below:

Year	Total no. of heat units/ growing season	No. of heat units between each defoliation and harvest		
		First (45 days)	Second (60 days)	Third (75 days)
1960	1637	1335	1128	793
1961	1830	1037	767	512

The shorter growing periods available to plants for recovery from defoliation in 1961 may account in part for the enhanced effect of defoliation on yield of roots.

At the lower level of irrigation there were no significant differences in yields of roots regardless of treatments. Beets irrigated four times, however, produced greater yields of roots than did those irrigated twice. With the two additional applications of water, yields in the check plots were increased by 60.7 pounds per plot (54.9%).

There were no significant differences in percentage sugar among treatments at any level of irrigation. In 1961, however, percentages of sugar were higher at the lower level of irrigation.

In 1960 yields of sugar from check plots (120 beets per plot) were significantly higher than those from plots defoliated 75%, 60 days after seeding. Yields of sugar from plots in which beet stands had been thinned by 25% (94 beets per plot), however, were significantly higher than yields from stands subjected to

[3] One heat unit is one degree above 50° F for 24 hours and is based on the mean of 24 hourly temperature readings.

Table 2.—Effects of defoliation or stand reduction at two levels of irrigation on yield of foliage, roots, and sugar of sugar beets, Lethbridge, Alberta, 1961.

Treatment	No. of beets (100 row-ft)	Treatment	Foliage (lb/ plot)	Treatment	Roots (lb/ plot)	Treatment	Sugar (lb/ plot)
			Four Applications of Water				
25% defoliation (45 days)	90	Check	281.8	[1] Check	171.2	Check	19.6
50% defoliation (45 days)	90	25% defoliation (45 days)	280.9	25% defoliation (75 days)	168.1	25% defoliation (75 days)	19.2
75% defoliation (45 days)	95	25% defoliation (75 days)	278.1	25% defoliation (45 days)	165.3	25% defoliation (45 days)	18.8
25% defoliation (60 days)	90	50% defoliation (60 days)	271.8	25% stand reduction	159.4	25% defoliation (60 days)	17.7
50% defoliation (60 days)	93	25% defoliation (60 days)	268.8	50% defoliation (60 days)	159.0	25% stand reduction	17.2
75% defoliation (60 days)	98	50% defoliation (45 days)	268.7	50% defoliation (75 days)	158.8	50% defoliation (60 days)	17.1
25% stand reduction	73	75% defoliation (45 days)	264.0	25% defoliation (60 days)	157.2	50% stand reduction	16.9
50% stand reduction	52	75% defoliation (75 days)	262.6	50% defoliation (45 days)	154.5	50% defoliation (75 days)	16.9
25% defoliation (75 days)	96	50% defoliation (75 days)	254.9	75% defoliation (45 days)	149.6	50% defoliation (45 days)	16.5
50% defoliation (75 days)	96	75% defoliation (60 days)	248.0	50% stand reduction	149.5	75% defoliation (75 days)	16.0
75% defoliation (75 days)	95	25% stand reduction	247.2	75% defoliation (60 days)	145.0	75% defoliation (45 days)	15.7
Check	93	50% stand reduction	202.0	75% defoliation (75 days)	142.8	75% defoliation (60 days)	15.4
			Two Applications of Water				
25% defoliation (45 days)	97	Check	204.4	25% defoliation (60 days)	120.5	25% defoliation (45 days)	16.4
50% defoliation (45 days)	99	25% defoliation (60 days)	203.0	25% defoliation (45 days)	115.5	25% defoliation (60 days)	15.7
75% defoliation (45 days)	98	25% defoliation (75 days)	196.1	Check	110.5	75% defoliation (45 days)	14.9
25% defoliation (60 days)	98	50% defoliation (45 days)	183.9	75% defoliation (45 days)	108.5	Check	14.1
50% defoliation (60 days)	100	25% defoliation (45 days)	182.7	25% defoliation (75 days)	106.0	25% defoliation (75 days)	13.8
75% defoliation (60 days)	101	75% defoliation (60 days)	178.5	75% defoliation (60 days)	100.0	50% defoliation (75 days)	13.1
25% stand reduction	78	25% stand reduction	175.3	50% defoliation (60 days)	99.3	50% stand reduction	13.1
50% stand reduction	54	50% defoliation (60 days)	172.8	50% stand reduction	97.8	50% defoliation (45 days)	13.0
25% defoliation (75 days)	97	50% defoliation (75 days)	168.4	75% defoliation (75 days)	97.3	50% defoliation (60 days)	12.9
50% defoliation (75 days)	95	75% defoliation (45 days)	167.8	50% defoliation (45 days)	97.1	75% defoliation (60 days)	12.9
75% defoliation (75 days)	96	75% defoliation (75 days)	161.1	25% stand reduction	96.8	75% defoliation (75 days)	12.2
Check	96	50% stand reduction	127.0	50% defoliation (75 days)	96.8	25% stand reduction	12.0

[1] Means connected by the same vertical line are not significantly different at P = .05.

25% defoliation at 60 days, 50% defoliation at 60 and 75 days, 75% defoliation at 45, 60, and 75 days, and 50% reduction at 60 days after seeding.

In 1961, at the higher level of irrigation, yields of sugar from check plots (93 beets per plot) were significantly higher than yields from stands reduced by 25 and 50% or from beets subjected to 50% defoliation at 45, 60, and 75 days and 75% defoliation at 45, 60, and 75 days after planting. Yields from beets defoliated 25% at 45, 60, and 75 days after planting were not significantly lower than those of the check plots.

At the lower level of irrigation there were no significant differences in yields of sugar.

Discussion

It is evident that at higher levels of irrigation, defoliation may have an effect on yield of beets. Its importance will vary with extent of injury, stage of plant development at time of injury, growing conditions immediately following injury, and length of growing season.

Results in 1961 indicated that at the lower level of irrigation defoliation or stand reduction seemed to have no adverse effect on plant growth. During the hot weather that prevailed at times the defoliated plants probably benefited from reduced transpiration while each beet in the thinned stands would have access to more moisture and nutrients and increased light intensity.

Swanson (7) found that less leaf area was required to produce a bushel of sorghum in a dry year than in a wet year but that the highest yields were obtained in seasons of abundant rainfall because there was greater leaf area even though it was less efficient. Eldredge (4) reported that loss of leaves was less detrimental under drought conditions and that a moderate degree of defoliation could even increase yields of corn.

Watson (8) reported that the rate of dry-matter production by sugar beets apparently increases as the leaf-area index (leaf area per unit area of land) increases until an optimum value is reached. As the index increases further the rate of dry matter production will decline, probably because the lowermost leaves become so heavily shaded at high leaf-index that their photosynthetic contribution is less than their respiration.

Chester (2) stated that the full complement of leaves functions at a relatively low efficiency and he used the results of other workers to prove that the first leaves lost are dispensable, their removal causing less damage to the plant than further equal increments of defoliation. As more leaves are lost those remaining function more efficiently and their loss is more detrimental to the plant. He also reported that losses in yield are greatest when plants are defoliated in midseason. At this critical stage the foliage has not yet served its photosynthetic function, yet it is too late for a new set of leaves to be produced to compensate for those lost.

The results of the present experiments indicate that sugar beets are able to recover from light to moderate defoliation or stand reduction with no decrease in weight of tops and with little or no decrease in yields of roots and sugar. It appears that an insect infestation causing 25% or less defoliation of beets generally will prove to be of no economic importance. During late June, July, and early August an infestation should be controlled if the beets are defoliated 50% or more. Even when the leaves have been subjected to 75% defoliation it is still possible to obtain a reasonably good crop.

The results of stand reduction indicated that in the Lethbridge area 90 to 100 beets per 100 feet of row were probably closer to an optimum stand than 120. A relatively uniform reduction of stand to as low as 61 beets per 100 feet of row gave a yield as high as that from 110 to 120 beets. Thus, where stands are lowered due to insect feeding or other factors such as poor seed germination or phytotoxicity from the use of insecticides or fertilizers, it would seem advisable to leave any reasonably uniform stand containing at least 60 to 65 beets per 100 feet of row rather than reseed the field.

The results also indicate that there would probably be no increase in yield from controlling insect infestations if moisture were a limiting factor in the development of the sugar beet crop.

Summary

To simulate insect injury sugar beets were defoliated 25, 50, and 75% at 45, 60, and 75 days after planting. Yields of roots and tops of defoliated plants were compared with those of undefoliated plants grown at the same stand density and also with those of uninjured plants from stands thinned by 25 and 50%.

Yields of foliage were the same for all treatments in plots irrigated twice during the growing season and were lower only where stands had been reduced by 50% in plots irrigated four times.

In 1960 in plots irrigated four times 75% defoliation 60 days after seeding resulted in reduced yields of roots. In 1961 yields of roots from plots irrigated four times were significantly reduced

when beets were defoliated 25% at 60 days, 50% at 45 days, or 75% at 45, 60, and 75 days after seeding. Decreasing stand by 50% in 1961 also reduced yield of roots. At a lower level of irrigation the defoliation and thinning treatment had no effect on root yields. Root yields from check plots irrigated four times during the growing season were higher by 60.7 pounds per 100 feet of row than those from check plots irrigated twice.

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