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Effect of Root-Rot Upon Sugar-Beet Seed Production

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Due to considerable loss through root-rot of mother beets while in storage during the winter of 1918-1919 the Amalgamated Sugar Company asked advice in regard to planting beets which had decay lesions on them. Would the beets yield seed if planted? How much seed would these beets yield as compared with healthy beets? Would the seed produced be injured by having been grown on decayed beets? It was felt that an experiment carried out with the above questions in view would bring out many facts upon which to base conclusions in answering the questions of the Sugar Company.

A similar trouble of root-rot of mother beets while in storage was reported from Idaho sugar-beet seed growers during the same year.

The experiment was carried out to get data on the following points:

- I. When diseased sugar-beets are planted for seed purpose can they produce seed stalks?
- II. If the diseased sugar-beets can produce seed stalks, how many, and are they as numerous as those on healthy beets?
- III. Will the seed stalks produced on the diseased mother beets be as high as those produced on the healthy mother beets?
- IV. Is the vigor of the seed stalks influenced by the diseased root of the mother beet, and if so how much?
- V. What difference is there in number of seed stalks on the healthy crown area as compared to the diseased crown area of the same diseased beet? Is just the area of the crown cut down by the diseased portion or does it have any influence on the number of stems?
- VI. Is there any difference in height of the seed stalks born on healthy crown area and the diseased crown area of the same diseased beet?

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VII. Would there be any difference in vigor of the seed stalks born on the healthy crown area and the diseased crown area of the same diseased beet?

VIII. The beets varied in regard to the position of the lesion on the beet. What effect would the location of the lesion on the beet have upon its power to produce seed stalks? Would a lesion which destroyed part of the crown retard the formation of seed stalks more or less than a lesion on the side or lower end of the mother beet?

IX. Can beets with lesions on them grow new tissue or isolate the diseased area and grow seed stalks, or can they grow a new crown area upon which to grow seed stalks?

X. What effect will the diseased mother beet exert upon the amount of seed produced?

XI. When the diseased beets could produce seed stalks, would these stalks have as much seed on them as those produced on healthy beets?

XII. Is there any difference in the amount of seed produced upon the diseased crown area and the healthy crown area of the same diseased beet? If so how much?

XIII. When the beets are planted with decay lesions upon them, will the decay continue to spread or can the beet or some other factors check the progress of the disease? To what extent will the mother beet go on rotting after planting?

XIV. Does the disease of the beet have any effect upon the maturity of the beet seed? Will the diseased beet mature the seed as soon as the healthy beet? Would the time of maturing be the determining factor as to the difference in yield?

XV. What effect would the disease of the beet exert on the germination of the seed produced on the diseased beet as compared to the seed produced on the healthy beet?

The experiment on the effect of root-rot upon sugar-beet seed production was begun April 16, 1919. It was laid out as follows: A plot of land sixty-six feet long and forty-five feet wide was used. This was located at the Amalgamated Sugar Company's sugar-beet seed farm at Greenville, Utah.

Fourteen rows were laid off, three feet apart and cross marked every three feet.

making the place for beets three feet apart each way. The entire plat was surrounded by a continuous row of beets spaced the same distance apart as the beets in the plat. Only healthy beets were used in this border row. The rows in the plat were planted with twenty beets to the row. In the first six rows beets Nos. 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, 19, were diseased beets from the Amalgamated Sugar Company's silos. Beets Nos. 5, 10, 15, and 20 were healthy beets used as a check upon the other diseased beets.

The mother beets used in the experiment were obtained from two sources. The diseased beets were from the Amalgamated Sugar Company's silos in Greenville, which had a heavy infestation of root-rot. The infestation was throughout the silos but more pronounced near the air ventilators. The healthy beets were from the Amalgamated Sugar Company's silos at Wellsville, Utah, where very little root-rot occurred in the silos.

The length and diameter of each beet was carefully measured. A drawing was made in the record book of each locating the position of the lesion on the beet. The type of lesion, whether soft-rot, dry-rot, or any peculiarity of the lesion, the space it occupied, its size and position on the beet were all recorded.

The planting was done by hand. Only the top of the crown of the beet was left exposed.

The height of the stems, the number of stems and the condition of the plant were recorded at three different times, May 26, July 7, and Aug. 8. At harvest time the number of stems and their location was recorded on the drawings made in the spring. The height of the stems, any diseased condition of the stem or root, the leafiness of the spike, and the maturity of the seed were also recorded. The seed from each individual plant and stem was placed in an individual envelope and later weighed. All weights and measurements were taken in the metric system. The seed was harvested at three different times: Aug. 6, Sept. 11, and Oct. 6.

The other rows, 7 to 14, were planted the same time as the first six rows but healthy beets were used. In rows 7 and 8 beets 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14, 16, 17, 18, and 19, were inoculated with *Phoma betae* (Oud.) Fr. by removing a triangular

plug with a sterilized knife then inserting some *Phoma* mycelium and spores from tube cultures, then replacing the plug and planting the beet. The exact location of the inoculation was recorded on the drawings. Beets 5, 10, 15, and 20 were healthy beets kept as checks.

The beets in row 9 were inoculated with *Bacillus betae* in the same way that rows 7 and 8 were inoculated with ~~*Phoma betae*~~ ^{*Bacterium Teutlium Metcal*}. The beets in row 10 were inoculated with material taken from beets showing ~~*Bacillus betae*~~ ^{*Bacterium Teutlium*}. The beets in rows 11 and 12 were inoculated with material taken from beets which were decayed with *Phoma betae*. Rows 13 and 14 were inoculated by spraying the leaves and flowers with *Phoma betae* spores when the beets had come into bloom.

The inoculating materials used in inoculating the beets were obtained from cultures taken from the decaying beets in the silos of the Amalgamated Sugar Company's silos at Greenville. The majority of all the cultures obtained from these diseased beets showed *Phoma betae*.

The plot was in a corner of the Amalgamated Sugar Company's sugar-beet field. It was cultivated, irrigated and taken care of the same as the commercial seed field. The care consisted of weeding, cultivating and irrigating about every eight days.

Table I. Number of Beets Producing Stems of Healthy and Diseased Beets.

Beet	I		II		III		IV		V		VI	
	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy
1	13		0		7		0		6		0	
2	10		6		6		9		2		10	
3	8		10		13		13		11		9	
4	11		12		0		1		5		9	
5		13		8		0		11		4		9
6	0		0		0		7		10		12	
7	0		2		0		3		15		10	
8	6		0		8		18		6		12	
9	0		6		0		8		17		11	
10		6		5		11		9		6		10
11	7		1		0		2		12		1	
12	8		0		8		1		6		7	
13	7		6		11		11		8		6	
14	8		0		5		11		20		6	5
15		6		4		11		4		7		
16	4		8		6		0		5		7	
17	0		1		17		7		4		5	
18	0		5		13		8		1		3	
19	0		0		8		0		3		2	
20		0		5		7		11		14		12
Total:	10	3	10	4	11	3	13	4	16	4	15	4
%	62.5	75	62.5	100	69.3	75	81.1	100	100	100	93.7	100

75 diseased beets; 22 healthy beets

Per cent of diseased beets producing seed stalks -- 78.2

" " " healthy " " " " -- 91.6

From Table No. 2. it is seen that the average number of seed stalks for each diseased beet is 5.93 ~~per cent~~ and 7.73 ~~per cent~~ for healthy beets. There are 1.8 ~~per cent~~ more stalks on the healthy than there are upon the diseased beets.

Table 2. The Number of Seed Stalks Produced by Healthy and by Diseased Sugar-beets.

Beet	I		II		III		IV		V		VI	
	Dis- eased	Healthy	Dis- eased	Healthy	Dis- eased	Healthy	Dis- eased	Healthy	Dis- eased	Healthy	Dis- eased	Healthy
1	13		0		7		0		6		0	
2	10		6		8		9		1		10	
3	8		10		13		13		11		9	
4	11		12		0		1		5		9	
5		13		8		0		11		11		9
6	0		0		0		7		10		12	
7	0		2		0		3		15		10	
8	6		0		8		18		6		12	
9	0		6		0		8		7		11	
10		6		5		11		9		6		10
11	7		1		0		2		12		1	
12	8		0		8		1		6		7	
13	7		6		11		11		8		5	
14	8		0		5		11		20		6	
15		6		4		11		4		7		5
16	4		8		6		0		5		7	
17	0		1		17		7		4		5	
18	0		5		13		8		1		3	
19	0		0		8		0		3		2	
20		0		5		7		12		14		12
Total	82	25	58	22	102	29	99	36	120	38	110	36
Avg.	5.1	6.2	3.5	5.5	6.3	7.2	6.1	9.0	7.7	9.5	6.9	9.0

Avg. No. of stems per diseased beet -- 5.93
 Avg. No. of Stems per healthy beet -- 7.73

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Table 3. Height of Seed Stalks on Diseased Sugar-beets Compared with Healthy Beets.

	Row 1	Row 2	Row 3	Row 4	Row 5	Row 6
Beet:	dis- :eased:	Dis- :eased:	Dis- :eased:	Dis- :eased:	Dis- :eased:	Dis- :eased:
1	80	0	110	0	100	0
2	70	100	18	70	70	70
3	60	70	90	70	60	50
4	80	70	0	70	50	80
5	80	90	0	70	60	90
6	0	0	0	70	70	90
7	0	100	50	80	80	60
8	70	0	100	50	60	100
9	0	70	0	70	60	100
10	70	100	80	70	80	150
11	60	110	40	80	80	70
12	90	0	70	50	50	75
13	90	70	70	70	80	70
14	80	0	90	60	70	80
15	100	60	70	90	70	120
16	60	80	90	0	70	100
17	0	60	60	70	50	80
18	0	70	60	70	100	90
19	0	0	100	0	50	80
20	0	90	80	80	90	70
Total:	740	250	800	340	948	230
Avg.:	74.0	83.3	80.0	85.0	72.9	76.6
II "	42.2	62.5	50.0	85.0	59.2	57.5

Avg. Height of all diseased beet stalks	--	<u>No.1</u>	<u>No.2</u>
" " " " healthy	--	73.8	56.36 centimeters
Difference	--	84.1	78.75 "
	--	11.7	20.39 "

From Table No. 3 the following data was secured. Before giving the results of Table No. 3 the following explanation is essential to a clear idea of the method of computing the height of the seed stalks. Where the plant died or did not produce seed stalks but only leaves they were not figured in the data in average No. 1 but they were in average No. 2.

The diseased beets have an average seed stalk height of 73.8 centimeters. The healthy beets have an average seed stalk height of 84.1 centimeters, from average No. 1 where only the plants which produced seed stalks were considered. The seed stalks produced upon the healthy beets average 11.7 centimeters higher than the seed stalks produced upon the diseased beets, showing that even though the diseased beets do produce seed stalks they are not as high as those produced upon the healthy beets.

When all the beets are considered, whether they bore seed stalks or not the average for diseased beets is 58.36 centimeters and 78.75 centimeters for healthy beets seed stalks, making a difference of 20.39 centimeters.

Table 4. The Vigor of the Stems on Diseased Plants compared with the Vigor of Stems Upon Healthy Plants.

Beets:	I		II		III		IV		V		VI	
	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:
1	100		0		80		0		100		0	
2	100		100		50		100		0		75	
3	50		50		100		100		55		50	
4	70		80		0		25		50		30	
5		100		100		0		90		100		80
6	0		0		0		100		30		60	
7	0		50		0		95		95		80	
8	70		0		50		75		40			
9	0		50		0		80		50		95	
10		100		100		80		100		90		95
11	80		100		50		100		75		50	
12	100		0		70		80		60		15	
13	100		50		0		50		40		60	
14	80		0		100		65		95		80	
15		100		100		90		80		70		100
16	100		100		100		0		60		70	
17	0		100		80		80		20		20	
18	0		100		50		90		70		80	
19	0		0		100		0		30		100	
20		0		100		90		95		75		70
Total:	850	300	780	400	830	260	1130	365	870	335	845	345
Avg.:	53.1	75	48.8	100	51.8	65	90.8	91.2	54.5	83.7	63	86.2

Average vigor for diseased beet stems -- 60.3
 " " " healthy " " -- 83.5
 Difference -- 23.2

The vigor was obtained from data taken at three different times, May 29, July 15, and Aug. 8, during the growing season. The condition of leaves, such as color, blotches, leaf spots, tip burn, and chlorosis, were considered in the rating. The condition of the seed stalks, the amount of brown dying on end of branches, was rated. One hundred per cent meant that a plant had good green color, was healthy and vigorous, and free from leaf and stem discoloration.

It will be seen from Table No. 4 that the vigor of the diseased beets was 60.3 per cent. The check beets showed 83.5 per cent of vigor, a difference of 23.2 per cent in favor of the check beets. This brings out the fact that healthy beet is more vigorous and is capable of producing a stronger plant than the diseased beet.

Table 5. No. stems on lesion of healthy area and diseased area of same beet.

Beet	I		II		III		IV		V		VI	
	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased
1	7	6			5	2						
2							9	0			8	2
3					13	0	13	0				
4												
5												
6												
7			2	0			3	0			3	7
8	6	0			6	2	18	0				
9												
10												
11	7	0										
12	8	0			7	1						
13	7	0	6	0								
14	8	0			5	0	11	0			6	0
15												
16	3	1	8	0	5	1			5	0		
17			1	0	15	2						
18					13	0						
19					8	0						
20												
Total: 46	7	17	0	0	69	8	54	0	5	0	17	9
Ave. : 6.58	1	4.2	0	0	8.5	.88	10.8	0	5	0	5.6	3

Average number of stems for healthy area 6.76
 " " " " " lesion " .61
 Average 7.58

Is the number of stems the limiting factor? If it is some light ought to be thrown on it by a comparison of the number of stems grown upon the healthy and lesion area of the same beet.

In table No. 5 twenty-nine beets are shown having crown lesions. The average number of stems on the healthy area was 6.76 while the average for the lesion area was .61. A comparison of these figures alone would not be ^{justifiable} ~~fair~~ but when we consider that 6.63 stems were on *77 per cent of the crown area and that .77 stems were on 23 per cent of the crown area, or in other words 89.59 per cent of all the stems were grown on 77 per cent, the crown area, while only 10.41 per cent were grown on 23.0 per cent, the crown area. The above figures show that the lesion cut down the number of stems considerably.

* See Table No. 10.

Table 6. Height of Seed Stalks produced on Diseased and Healthy Crown Areas of Diseased Sugar-Beets.

Beet:	I		II		III		IV		V		VI	
	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:
1	45	60			110	102			80	90		
2		72	100	106				73			71	73
3					70	75		71	50	57		
4										63		
5	100	103										
6										75		
7								93	71	71		
8		76			100	103		46		66		
9									46	56		
10												
11		81							81	69		
12	50	55			80	70						
13		75		75					70	71		70
14		79				94		55				
15												
16	90	82		75	90	86				59		83
17				120	46	58		70	20	50		74
18				86		64		64				110
19						84						
20												
Total:	285	683	100	462	496	736	0	472	418	717	71	410
Avg.:	71.2	75.9	100	92.5	82.6	81.9	0	76.4	59.7	65.1	71.0	82.0

Avg. for six rows of diseased -- 76.9 cm.
 " " " " " healthy -- 78.96 "

The seed stalks do not get as high when they grow out from the lesion area as when they grow out from the healthy crown area. Table 6 shows lesion area stem height to be 76.9 cm. and the height of stems on the healthy area of the same beet to be 78.96 cm., a difference of 2.06 cm.

Table 7. Height of Seed Stalks on Healthy Area of Diseased Beets Compared to the Height of Stems on Healthy Plants.

Beets	I		II		III		IV		V		VI	
	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy
1	60				102				90			
2	72		106		75		73				73	
3							71		57			
4									63			
5		80		90				70		60		90
6									75			
7							93		71			
8	76				103		46		66			
9									56			
10		70		100		80		70		80		150
11	81								69			
12	55				70							
13	57		75						71		70	
14	59				94		55					
15		100		60		70		90		70		120
16	82		75		86				59		83	
17			120		58		76		50		74	
18			86		64		64				110	
19					84							
20				90		80		80		90		70
Total	580	170	462	340	756	320	472	310	717	300	410	430
Ave.	72.5	83.3	92.5	85.	81.9	76.3	76.4	77.5	65.1	75.	82.	107.5

The average height of stems grown upon healthy area of the diseased beets, Table No. 7, is 78.96 cm. as compared with 90.1 cm. on healthy beets used as checks; a difference of 11.14 cm. The stems grown upon the healthy beets average 11.14 cm. higher than the stems grown on the healthy area of the diseased beet.

Table No. 8. Vigor of Seed Stalks Produced on Lesion Against Those on Healthy Area.

Beet:	I		II		III		IV		V		VI	
	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:	Dis- eased:	Healthy:
1	100	100			100	100						1
2			100	100							80	80
3					100	100			25	25		
4												
5	100	100										
6												
7									100	100	25	25
8					50	50			100	25		
9												
10												
11									70	50		
12	100	0			70	100						
13											100	100
14											80	80
15												
16	100	0			100	100						
17					25	25						
18									70	0		
19												
20												
Total:	400	200	100	100	445	475			365	200	285	285
Avg.:	100	50	100	75.5	79.1				75.	40.0	71.2	71.2

Avg. for healthy beets of 6 rows -- 83.5

Avg. " diseased " " 6 " -- 56.7

Difference -- 26.8

100 -- healthy stems

0 -- dead

The average vigor for the healthy area is 83.5 per cent as shown in Table No. 8, while it is 56.7 per cent for the diseased area; a difference of 26.8 per cent. From these figures it is shown that the stems grown on the lesion area are not as vigorous as the stems grown on the healthy area.

Table No. 9. The Effect That Location of the Lesion Upon the Diseased Beet has Upon the Number of Seed Stalks per Beet.

Beet:	I			II			III			IV			V			VI		
	C*	CR*	R*	C	CR	R	C	CR	R	C	CR	R	C	CR	R	C	CR	R
1	13							7					6					
2	10			6				6			9					10		
3			8				10	13				13	11					9
4			11				12					1	5			12		
5																		
6												7	10				12	
7				2							3		15				10	
8		6						8	11			6						13
9					6				8				17					11
10																		
11	7					1						2	12					1
12	8							6				1		6				7
13		7		6					11			8			6			
14	8						5		11					20		6		
15																		
16		4			8			5						5			7	
17					1			17	7					4		5		
18					5	13			8				3				3	
19								8							3			2
20																		
Total	46	17	19	14	20	23	24	66	0	75	0	24	70	37	29	33	34	43
Avg.	8.1	5.6	9.5	4.6	5.	7.6	8.	9.3	0	9.3	0	4.8	8.7	9.2	9.6	8.2	6.8	7.1
Beets	5	3	2	3	4	3	3	7	0	8	0	5	8	4	3	4	5	6

* C -- lesion on crown; CR -- lesion on crown and root; R -- lesion on root below crown.

Avg. for six rows crown	7.8
Avg. " " " " and root	5.98
Avg. " " " root	6.4

Those beets which were completely decayed were not taken into consideration in this table.

The effect of location of lesion on the diseased mother beet to the production of seed stalks is shown in Table 9. The beets are divided into three classes -- those which had lesions only on the crown, those with lesions on the crown and root, and those which had lesions on the root.

The crown lesions gave an average of 7.8 stalks; the crown and root lesions gave an average of 5.98 stalks; and the root lesions gave an average of 6.4 stalks.

The data show that the crown and root lesions on the same beet will reduce the number of stems considerably. This is due no doubt to the decay coming from two sources, that which weakens the plant and that which reduces the number of stems.

Table No. 10. The Extent to Which Beets Can *grow* New Crown Areas When the old Crown Has Been Partially or All Decayed. (4)

Beet	I		II		III		IV		V		VI	
	Lesion	Not	Lesion	Not	Lesion	Not	Lesion	Not	Lesion	Not	Lesion	Not
1		0		0	1			0	1	0		
2		0	1			0	1			0	1	
3		0		0	1			0		0		0
4		0		0		0		0		0		0
5												
6		0		0		0	1			0		0
7		0		0		0		0	1			0
8	1			0		0		0		0	1	
9		0		0		0		0				0
10												
11	1			0		0		0	1		1	
12	1			0		0		0		0		0
13	1			0		0		0		0	1	
14	1			0		0		0			1	
15												
16		0		0		0		0	1		1	
17		0	1			0		0		0		0
18		0	1		1		1		1			
19		0		0	1					0	1	
20												
Total:	5		3		4		3		6		7	

Grand total -- 28 out of 96 beets, or 29.1 per cent.

(4) Reference is made to bibliography or literature cited last page of paper.

At harvesting time it was seen that some of the beets grew new growths cut away from the lesion area. In some cases these new growths were as large as the original mother beet. The growth would tend to cut off or isolate the diseased area. In Table 10. is given the record of twenty-eight beets, or 29.1 per cent of all the diseased beets which showed regeneration of one type or other of new growths.

Table 11. WEIGHT OF SEED GROWN ON HEALTHY AND DISEASED SUGAR BEETS.

Beet	I		II		III		IV		V		VI	
	Dis- eased	Healthy	Dis- eased	Healthy	Dis- eased	Healthy	Dis- eased	Healthy	Dis- eased	Healthy	Dis- eased	Healthy
1	49.6				63.9				64.8			
2	130.9				11.0		98.3				23.4	
3	5.3		58.9		11.8		86.3		40.2		19.5	
4	38.7		76.0				.6		4.9		8.0	
5		268.9		25.4				69.7		73.3		53.0
6									6.7		52.3	
7			70.4				27.1		105.9		89.5	
8	28.4				226.0		37.7		17.4			
9			14.4				14.4		8.6		40.6	
10		80.1		43.4		94.3		58.0		50.2		73.6
11	13.6		49.5				21.5		46.8		16.8	
	55.7				56.7		27.5		11.0		1.8	
13	80.2		19.7		22.9		13.9		12.4		22.7	
14	52.7				19.7		43.9		95.1		25.4	
15		232.3		28.5		64.1		21.9		28.1		58.2
16	24.8		33.7		12.8				8.2		28.7	
17			8.5		38.0		54.0				6.0	
18			3.4		39.9		27.9					
19					49.2				3.7		59.0	
20				13.7		3.4		79.8		82.2		10.8
Total	457.9	561.3	343.5	111.0	658.2	161.8	453.1	229.4	425.7	233.8	393.7	175.6
Avg.	45.7	193.7	37.16	25.5	39.83	53.93	37.75	57.3	32.7	56.9	30.28	43.9

Avg. grams of seed per beet diseased -- 37.23
 " " " " " " " healthy -- 55.54

Healthy beets producing no seed -- 6.3%
 Diseased " " " " -- 29.0%

The diseased beets produced 67.5% as much seed as did the healthy beets.

One of the main problems of diseased mother beets is the question of their being able to produce as great a yield of seed as healthy beets. From Table 11 is obtained an average of 37.23 grams of seed per diseased beet and 55.54 grams from the healthy beets, which is 32.5 per cent less yield of seed for diseased beets. In other words the diseased beets produced only 67.5 per cent as much seed as did the healthy beets.

From the same table it can be seen that twenty-eight diseased beets produced no seed at all, or 29 per cent, while only two healthy beets, or 3.3 per cent, produced no seed. These later data again substantiate the fact that diseased mother beets cut down the yield of sugar-beet seed.

Table 12. Percent of Healthy and Diseased Crown Area of Each Beet.

Beet	I		II		III		IV		V		VI	
	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased	Healthy	Diseased
1	32	68			75	25						
2							90	10			88	12
3					88	12	92	8				
4												
5												
6												
7			92	8			92	8			40	60
8	50	50			90	10	88	12				
9												
10												
11	86	14										
12	86	14			88	12						
13	50	50	86	14								
14	92	8			80	20	90	10			70	30
15												
16	70	30	67	33	60	40			88	12		
17			25	75	86	14						
18					95	5						
19					90	10						
20												
Total	466	234	270	130	752	148	452	48	88	12	198	102
Ave.	66.5	33.4	67.5	32.5	63.5	16.4	90.5	9.6	88	12	66	34

Average Healthy Area 77%
 Average Diseased " 23%

In order to properly interpret some of the other tables it is desirable to determine the percent of crown area actually covered by the lesion. Table No. 12 shows that the average healthy area is 77 per cent and the average lesion area is 23 per cent of the crown area.

Twenty-nine beets were used in these calculations; all being beets which had crown lesions where the area could be computed.

Table 13. Weight of Seed On Healthy Area and Lesion Area of Same Beets.

Beets	I		II		III		IV		V		VI	
	Healthy	Dis-eased	Healthy	Dis-eased	Healthy	Dis-eased	Healthy	Dis-eased	Healthy	Dis-eased	Healthy	Dis-eased
1	21.3	28.9			42.3	21.6						
2							98.3	0			20.6	2.8
3					98.0	0	86.3	0				
4												
5												
6												
7			70.4	0			22.1	0			16.5	70.3
8	26.4	0			173.	52.	37.7	0				
9												
10												
11	13.6	0										
12	55.7	0			27.5	29.2						
13	80.2	0	19.7	0								
14	32.7	0			19.7		43.9	0			24.4	0
15												
16	15.9	8.9	36.2	0	12.8				8.2	0		
17			38.5	0	35.5	29.2						
18					39.9							
19					49.2							
20												
Total	247.8	37.8	134.8	0	498.9	132.	293.3	0	8.2	0	61.5	73.1
Avg.	35.4	5.4	33.7	0	55.4	14.6	58.6	0	8.2	0	20.5	24.3

Avg. for healthy area -- 35.28 grams per beet
 " " lesion " -- 7.38 " " "

What effect would the lesion area have upon the yield of seed of the beets having crown lesions?

Table No. 13 shows that 35.28 grams or 82.7 per cent of seed for each beet from the healthy area and 7.38 grams or 17.3 per cent for each beet from the lesion area. From Table No. 5 we find that the healthy area is 77 per cent of the crown area and the lesion ^{is} ~~was~~ 23 per cent of the crown. From these figures we conclude that the healthy area 77 per cent gave 82.7 per cent of the seed while the lesion area 23 per cent gave only 17.3 per cent of the seed: but for the unit area the healthy gives 70 per cent of the seed and the diseased area 30 per cent of the seed.

This data points to the fact that a lesion area on the crown cuts down the amount of seed per beet.

Table 14. Shows to What Extent Mother Beets Go On Rotting After Being Planted.

Beet	I		II		III		IV		V		VI	
	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy	Dis-	Healthy
1	0		100		40		100		0		0	
2	100		0		100		0		100		0	
3	100		100		10		25		100		80	
4	50		50		100		30		80		80	
5		50		50		0		0		15		80
6	100		0		0		10		50		100	
7	100		80		0		80		0		80	
8	50		100		95		0		100		0	
9	100		100		100		80		0		0	
10		0		0		0		0		0		0
11	25		100		100		50		0		0	
12	70		90		80		100		100		80	
13	25		80		100		100		50		0	
14	30		100		80		100		0		0	
15		0		0		100		100		80		0
16	80		30		40		100		0		0	
17	100		30		100		80		50		60	
18	0		0		5		0		0		0	
19	100		100		5		100		100		0	
20		0		0		100		20		0		0
Total:	1020	50	1060	50	955	200	955	120	730	95	480	80
Avg.:	163.7	12.5	170.6	12.5	159.7	50	159.7	30	145.6	23.2	30	20

Avg. for all six rows diseased beets -- 54.88%
 " " " " " healthy " -- 24.66%

0 -- good beets
 100 -- totally rotted

The extent to which mother beets go on rotting after planting is shown in Table 14. One hundred per cent is taken as complete decay of the beet root and zero as the beet which did not increase in size of lesion or form new lesions on the root.

The data showed 54.88 per cent of the diseased beets continue rotting after planting. The healthy beets showed 24.66 per cent that had lesions on at harvest time. There was 30.22 per cent more rotting going on in the diseased beets than in the healthy beets. This shows that rotting does continue and to a greater extent in diseased mother beets than in healthy beets.

Table 15. The Effect of Root Rots upon the Time of Maturity of the Seed of Diseased and Healthy Mother Beets.

Row	Diseased Beets				Healthy Beets			
	August	September	October	Immature or No Seed	August	September	October	Immature or No Seed
1	11	0	0	5	3	0	0	1
2	4	0	6	6	1	0	3	0
3	5	1	6	4	2	0	0	2
4	2	9	2	3	1	3	0	0
5	0	9	3	4	1	2	1	0
6	0	6	7	3	0	2	1	1
Total	22	25	24	25	8	7	5	4
%	22.9	25.9	24.9	25.9	33.3	29.1	20.8	16.6

Table 15 shows the effect of root rots upon the time of maturity of the beet seed. The seed was harvested at three different times -- August 30, September 11, and October 6.

The healthy beets show 33.3 per cent to be mature on August 30, while only 22.9 per cent of the diseased beets had mature seed on that date. On September 11 it was found that 29.1 per cent of the healthy beets and 25.9 per cent of the diseased beets showed maturity. On October 6 it was found that 20.8 per cent of the healthy beets were mature and 24.9 per cent of the diseased beets were mature. On this date there was 16.6 per cent of the healthy beets with either immature seed or none at all, while the diseased beets showed 25.9 per cent in this condition.

If we should take September 11 as about the latest date for practical harvesting beet seed it would show 62.4 per cent of the healthy beets to have matured seed, while the diseased beets produced 48.8 per cent, a difference of 13.6 per cent.

Table 16. Condition of roots at harvest time of the inoculated beets.

Row	Check Beets Y				Inoculated Beets			
	Healthy		Diseased		* Healthy		Diseased	
	No. of:	Percent	No. of:	Percent:	No. of:	Percent of:	No. of:	Percent
	Beets :	of beets:	Beets :	of beets:	Beets :	Beets :	Beets :	of beets
7 :	1 :	33 :	2 :	66 :	9 :	75 :	3 :	25
8 :	4 :	100 :	0 :	0 :	12 :	80 :	3 :	20
Av.:	2.5 :	66.5 :	1 :	33 :	10.5 :	77.5 :	3 :	22.5
9 :	3 :	75 :	1 :	25 :	2 :	19 :	9 :	81
10 :	4 :	100 :	0 :	0 :	4 :	33 :	8 :	66
Av.:	3.5 :	87.5 :	.5 :	12.5 :	3 :	26 :	8.5 :	73.5
11 :	2 :	50 :	2 :	50 :	5 :	39 :	8 :	61
12 :	1 :	25 :	3 :	75 :	4 :	33 :	8 :	66
Av.:	1.5 :	37.5 :	2.5 :	62.5 :	4.5 :	36 :	8 :	63.5
13 :	3 :	75 :	1 :	25 :	4 :	33 :	8 :	66
14 :	4 :	100 :	0 :	0 :	2 :	17 :	10 :	84
Av.:	3.5 :	87.5 :	.5 :	12.5 :	3 :	25 :	9 :	74.5

* Healthy represents beets in which the inoculation lesion was grown over that is entirely healed and no discoloration or infection showing upon the place of inoculation at time of harvesting.

Table No. 16 shows the condition of the root of the beets planted in rows 7, 8, 9, 10, 11, 12, 13, and 14, at the time of harvesting. The only data ^{obtained} ~~observed~~ at this time was the condition of the root. Most all of the seed from the plants was knocked off the plants by an early snow storm.

Rows 7 and 8 which had been inoculated with *Phoma batae* from culture stocks gave the following figures. The ^{average per cent of} ~~percent average~~ healthy beets among the check beets ^{was} 66.5 while in the inoculated beets it was 77.5, a slight increase ~~where~~ of disease in the inoculated beets. The difference does not seem to be conclusive enough to warrant any positive statement as to whether or not the inoculation was a very large factor in producing the disease, especially if the rows be taken separate ^{ly}. Row No. 7 shows 66 per cent of diseased beets among the checks and 25 per cent among the inoculated. The results are very variable.

Rows 9 and 10 which were inoculated with *Bacterium teutlicum* ^{Metc} ~~Phoma~~ showed 12.5 per cent diseased and 73.5 per cent of inoculated diseased. Out of the diseased beets 50 percent showed characteristic phoma lesions. No culture tests were made of the roots due to lack of time.

Rows 11 and 12 were inoculated with decaying portions taken from decaying sugar beets and inoculated. The check beets showed 62.5 percent of disease while the inoculated beets showed 63.5 percent. The difference is so small that there seems to be no effects from inoculation.

Rows 13 and 14 which were used for spray inoculation showed 12.5 per cent of diseased beets in the checks and 74.5 per cent in the beets to be inoculated. Only four beets were inoculated by spraying with phoma culture at time of blooming, the rest of the plants were not inoculated. The high percentage of diseased roots can not be accounted for other than that they were not free from disease at time of planting. Yet only beets which appeared healthy were used. The checks were planted whole while the inoculated ones were split in half.

Table 17. Germination Power of Seed Produced by Diseased Sugar-beets and Healthy Sugar-beets.

Row	Large		Small		Large Treated		Small Treated	
	Dis- eased	Healthy	Dis- eased	Healthy	Diseased	Healthy	Diseased	Healthy
1	69.8	65.0	12.9	6.0	72.0	61.0	9.3	10.6
2	64.6	70.5	24.5	24.3	---	---	---	---
3	57.6	71.3	15.8	29.3	---	---	---	---
4	72.0	85.5	15.0	31.2	---	---	---	---
5	60.3	65.5	16.8	13.0	---	---	---	---
6	50.0	43.0	11.3	26.0	---	---	---	---
Total	374.3	402.1	96.3	129.8	72.0	61.0	9.3	10.6
Avg.	62.4	67.0	16.0	21.6	72.0	61.0	9.3	10.6

Avg. for diseased large and small -- 39.2%
 Avg. " healthy " " " " -- 44.3%

Avg. for diseased large and small treated -- 40.6%
 " " healthy " " " " " -- 35.8%

Avg. for all seed not treated -- 40.6%
 " " " " treated -- 38.2%

Avg. for diseased, large, small, and treated -- 39.9%
 " " healthy, " , " , " " -- 40.5%

Avg. germination of all small seed @- 14.37%
 " " " " large " -- 65.6%

Seed germination of diseased and healthy sugar-beets is shown in Table 16. After finding out the effect of disease upon the yield of seed and stalk production of mother beets, the effect of the diseased condition upon the germinating power of the seed was determined.

After many preliminary experiments upon methods of germination of beet seed, the following method was adopted:

The rag-doll tester was used.⁽²⁾ It was made of one layer of gauze about twelve feet long and six inches wide. It was marked off into squares of six inches each and numbered from 1 to 20. Fourteen testers were used. The testers were sterilized in the steam autoclave for fifteen minutes at fifteen pounds' pressure. The seeds were divided into two sizes⁽⁷⁾ by passing them thru a sieve of three-sixteenth-inch mesh. Those that would not go thru were called large and those that went thru were called small. The dirt passed on thru a one-sixteenth-inch sieve.

The seed from each beet was kept separate. One hundred of the large seeds were placed on a square of the rag-doll tester, the large seeds from the one row on one rag doll tester and the small seeds on another rag doll tester. From Row No. 1 two sets were germinated, one treated with mercuric chloride and the other not treated⁽¹⁾, before placing in the rag doll tester to germinate. This was done as a check on method of work.

One hundred seeds were placed in each six-inch space. The rag dolls were placed in a germinating chamber which had been previously cleansed by washing with corrosive sublimate (1-1000 solution). The incubating chamber was kept at a constant temperature of 28°C (5 & 6). The rag dolls testers were kept moist by using sterilized water. If a seed germinated it was removed and counted as complete germination⁽⁸⁾. The date of germination and count of each seed was recorded, making an individual record for each beet. This was con-

(1) ("The Presoaked Method of Treatment" by Harry Barun)

REVIEW OF LITERATURE

After a very thoro examination of literature on the subject the author did not find ^{that} the problem as presented in the paper had been covered by any worker. Parts of the problem have been covered by other workers. This is especially true in regard to the germination of sugar-beet seed and inoculation of beets in the field with Phoma betae.

Stone(8) states that in methods of testing beet seed whenever a seed ball showed germination of one seed the entire ball was removed and called a complete germination. This method is adopted by the Official Seed Analysts of North America.

Flahn(7) graded the sugar-beet seed balls into four grades by means of sieves of 2-, 3-, 4-, and 5-mm. meshes. He also used 100 seed balls in germination lot.

Edson(3) working on the seedling diseases of sugar-beets and their relation to root-rot found that inoculation of the beets was not effective. In some cases they were able to recover Phoma betae from dark streaks in the beets.

Edson(4) also found that a change of ^{environmental} conditions will cause Phoma betae to discontinue the attack and that the sugar-beet may grow new tissue and isolate the disease. This seems to substantiate the author's work(See Table 10).

Kling(6) working with the germination of grass seed found that from 20° to 30° C. was the temperature most favorable to germination of those seeds. The author in preliminary experiments worked with several different temperatures and obtained best results with a temperature of 28° C.

Burns(2) found that the rag-doll method was a very satisfactory method for testing the germination of seeds.

SUMMARY OF RESULTS

1. Diseased beets can produce seed stalks. (Table 1)
2. Diseased beets do not produce as many seed stalks as do healthy beets. There is one stalk less on each diseased beet than there is on the healthy beets. (Table 2)
3. The diseased beets produce seed stalks 11.7 cm. or about one-eighth shorter than the seed stalks the healthy beets produce. (Table 3)
4. The vigor of the healthy beets is 23.2 per cent higher than it is for the diseased beets. (Table 4)
5. The lesion area of a beet grows ^{fewer} ~~less~~ stems than the healthy area. The healthy area, 77 per cent of the crown area, grew 89.59 per cent of the stems, while the lesion area, 23 per cent of the crown area, grew 10.41 per cent of the stems. (Table 5)
6. The seed stalks on the healthy area were one-fifth higher than on the lesion area. (Table 6)
7. The vigor of seed stalks on the healthy area^s was 26.8 per cent greater than those produced on the lesion area. (Table 8)
8. The location of the lesion has very little effect upon the power to produce seed stalks. Where it is on both crown and root there are fewer stems. When the lesion is on the crown there is an average of 7.8 stems, when it is on the crown and root there is an average of 5.98 stems, when it is on the root there is an average of 6.4 stems. (Table 9).
9. The experiment shows that 29.1 per cent of the beets were able to regenerate. (Table 10)
10. Diseased sugar beets produce only 67.5 per cent as much seed as do healthy sugar beets. (Table 11)

12. The lesion area cuts down the yield of seed on the same beet, taken per unit area. The healthy unit area produces 70 per cent of the seed while the diseased area produces 30 per cent of the seed. (Table 13)

13. There is more seed produced on the stems grown on the lesion area than on the stems grown on the healthy area of the beet; 9.68 grams per stem of diseased area and 5.32 grams for stems on the healthy area. (Tables 5 & 13)

14. The diseased beets rot twice as fast as the healthy beets. The diseased beets show 54.8 per cent rot and the healthy beets 24.6 per cent of rot. (Table 14)

15. Disease lengthens the time of maturity of the seed. If Sept. 11, is taken as the time when sugar-beet seed should be mature, there is 13.6 per cent more mature on the healthy beets than on the diseased beets. (Table 15)

16. The seed that is produced on the diseased beets has almost as high a germination power as that produced on the healthy beets. The laboratory test of germination gave 39.9 per cent for diseased beets and 40.05 per cent for healthy beets. (Table 17)

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