Townsend: Beet-Sugar Industry in the U. St. in 1920.

UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 995

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ October 14, 1921

THE BEET-SUGAR INDUSTRY IN THE UNITED STATES IN 1920

By

C. O. TOWNSEND, Pathologist in Charge
Office of Sugar-Plant Investigations

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BEET-SUGAR MILLS IN THE UNITED STATES.

In the United States in 1919, 98 beet-sugar mills were standing and equipped for extracting and refining sugar from beet roots. The oldest one of the mills now standing was built in 1870 at Alvarado, Calif. During the summer of 1919, 4 of the 98 mills had been erected and equipped for the campaign of 1919–20, 6 additional ones were built and equipped for the handling of the 1920–21 crop, and two others are in process of construction, making a total of 106 beet-sugar mills now standing. (Table I.)

TABLE I.—*American beet-sugar mills in 1920.*

No.	Location.		Date of erection.	Name of company.	Capacity.[a]		Date enlarged.
	State.	Town.			Original.	Present.	
					Tons.	*Tons.*	
1	California	Alvarado	1870	Alameda Sugar Co	500	800	[b]1894
2	Nebraska	Grand Island	1890	American Beet Sugar Co	350	500	1916
3	Utah	Lehi	1891	Utah-Idaho Sugar Co	300	1,200	1900
4	California	Chino	1891	American Beet-Sugar Co	400	1,100	1895
5	do	Los Alamitos	1897	Los Alamitos Sugar Co	350	900	1898
6	Wisconsin	Menomonee Falls	1897	Wisconsin Sugar Co	500	600	1901
7	Utah	Ogden	1898	Amalgamated Sugar Co	350	1,000	1912
8	California	Oxnard	1898	American Beet Sugar Co	2,000	3,000	.....
9	do	Betteravia	1899	Union Sugar Co	500	1,200	1908
10	do	Spreckels	1899	Spreckels Sugar Co	3,000	4,500	.....
11	Colorado	Grand Junction	1899	Holly Sugar Corporation	350	700	1906
12	Michigan	Holland	1899	Holland-St. Louis Sugar Co	350	500	.....
13	do	Bay City	1899	Michigan Sugar Co	600	1,400	1912
14	do	Alma	1899	do	600	1,400	1912
15	do	West Bay City	1899	West Bay City Sugar Co	500	900	.....
16	do	Caro	1899	Michigan Sugar Co	600	1,200	1902
17	Colorado	Rocky Ford	1900	American Beet Sugar Co	1,000	1,800	1912
18	do	Sugar City	1900	National Sugar Mfg. Co	500	500	.....
19	Ohio	Fremont	1900	Continental Sugar Co	350	600	.....
20	Michigan	Marine City	1900	Independent Sugar Co	350	600	.....
21	do	Bay City	1901	Columbia Sugar Co	400	1,500	1907
22	do	Lansing	1901	Owosso Sugar Co	600	800	.....
23	Colorado	Loveland	1901	Great Western Sugar Co	1,000	1,950	1912
24	Utah	Logan	1901	Amalgamated Sugar Co	400	700	1912
25	Colorado	Greeley	1902	Great Western Sugar Co	700	1,050	1911
26	do	Eaton	1902	do	600	1,200	1911
27	Michigan	Carrollton	1902	Michigan Sugar Co	800	900	.....
28	do	Mount Clemens	1902	Mount Clemens Sugar Co	600	600	.....
29	do	Croswell	1902	Michigan Sugar Co	600	750	.....
30	do	Sebewaing	1902	do	600	850	.....
31	Utah	Garland	1903	Utah-Idaho Sugar Co	700	900	1912
32	Idaho	Idaho Falls	1903	do	600	900	1905
33	Michigan	St. Louis	1903	Holland-St. Louis Sugar Co	500	600	.....
34	do	Menominee	1903	Menominee River Sugar Co	1,000	1,200	1907
35	do	Owosso	1903	Owosso Sugar Co	1,000	1,300	1907
36	Colorado	Fort Collins	1903	Great Western Sugar Co	1,200	2,150	1911
37	do	Windsor	1903	do	600	1,150	1911
38	do	Longmont	1903	do	600	2,350	1911
39	Wisconsin	Chippewa Falls	1904	Chippewa Sugar Refining Co	600	600	.....
40	do	Janesville	1904	Rock County Sugar Co	600	700	.....
41	Idaho	Blackfoot	1904	Utah-Idaho Sugar Co	600	800	1911
42	do	Sugar City	1904	do	700	900	.....
43	Utah	Lewiston	1905	Amalgamated Sugar Co	600	800	1911
44	Michigan	Blissfield	1905	Continental Sugar Co	600	1,000	.....
45	Illinois	Riverdale	1905	Charles Pope, Chicago	350	500	.....
46	Colorado	Lamar	1905	American Beet Sugar Co	400	500	1907
47	do	Sterling	1905	Great Western Sugar Co	600	1,050	1912
48	Wisconsin	Madison	1905	United States Sugar Co	600	600	.....
49	Colorado	Brush	1906	Great Western Sugar Co	750	1,100	1912
50	do	Fort Morgan	1906	do	600	1,200	1912
51	do	Swink	1906	Holly Sugar Corporation	1,200	1,200	.....
52	Montana	Billings	1906	Great Western Sugar Co	1,200	2,000	1912
53	Kansas	Garden City	1906	Garden City Sugar & Land Co	1,000	1,000	.....
54	California	Hamilton City	1906	Sacramento Valley Sugar Co	600	700	.....
55	Minnesota	Chaska	1906	Minnesota Sugar Co	600	800	.....
56	Colorado	Las Animas	1907	American Beet Sugar Co	700	1,000	.....
57	Iowa	Waverly	1907	Iowa Sugar Co	400	500	1907
58	California	New Delhi (Santa Ana).	1908	Southern California Sugar Co	600	600	[c]
59	Nebraska	Scottsbluff	1910	Great Western Sugar Co	1,200	2,000	1912
60	Ohio	Paulding	1910	Columbia Sugar Co	700	900	.....
61	Nevada	Fallon	1911	Lahontan Valley Sugar Co	500	500	.....
62	Ohio	Findlay	1911	Continental Sugar Co	600	900	.....
63	Utah	Elsinore	1911	Utah-Idaho Sugar Co	500	750	.....
64	California	Anaheim	1911	Anaheim Sugar Co	500	1,200	1911
65	do	Huntington Beach	1911	Holly Sugar Corporation	750	1,200	1912
66	do	Dyer (Santa Ana).	1912	Santa Ana Sugar Co	600	1,200	1914
67	Idaho	Burley	1912	Amalgamated Sugar Co	400	700	1912
68	Ohio	Toledo	1912	Toledo Sugar Co	1,000	1,500	.....
69	do	Ottawa	1912	Ohio Sugar Co	600	700	1917
70	Indiana	Decatur	1912	Holland-St Louis Sugar Co	700	800	.....
71	Utah	Payson	1913	Utah-Idaho Sugar Co	500	750	.....
72	do	Layton	1915	Layton Sugar Co	500	600	.....
73	Wyoming	Sheridan	1915	Sheridan Sugar Co	600	900	.....
74	do	Lovell	1916	Great Western Sugar Co	600	600	.....

[a] Number of tons of beets that may be sliced each 24 hours.
[b] Rebuilt in 1879, 1887, and 1889.
[c] Acquired by the Holly Sugar Corporation.

TABLE I.—*American beet-sugar mills in 1920*—Continued.

No.	Location.		Date of erection.	Name of company.	Capacity.		Date enlarged.
	State.	Town.			Original.	Present.	
					Tons.	*Tons.*	
75	Idaho	Twin Falls	1916	Amalgamated Sugar Co.	600	800	.....
76	Nebraska	Gering	1916	Great Western Sugar Co.	1,000	1,100	.....
77	Utah	Spanish Fork	1916	Utah-Idaho Sugar Co.	750	1,000	1916
78	....do	West Jordan	1916	....do	500	750	.....
79	....do	Brigham	1916	....do	500	750	.....
80	Idaho	Paul	1917	Amalgamated Sugar Co.	500	600	.....
81	Utah	Smithfield	1917	....do	500	700	.....
82	....do	Delta	1917	Utah-Idaho Sugar Co.	1,000	1,000	.....
83	Colorado	Brighton	1917	Great Western Sugar Co.	1,000	1,000	.....
84	Nebraska	Bayard	1917	....do	1,000	1,000	.....
85	Iowa	Mason City	1917	Northern Sugar Corporation	1,200	1,200	.....
86	California	Manteca	1917	Spreckels Sugar Co.	1,000	1,200	.....
87	Utah	Moroni	1917	People's Sugar Corporation	400	400	.....
88	....do	Cornish	1917	Amalgamated Sugar Co.	600	600	.....
89	Idaho	Shelley	1917	Utah-Idaho Sugar Co.	600	750	.....
90	California	Tracy	1917	Alameda Sugar Co.	500	500	.....
91	Wyoming	Worland	1917	Wyoming Sugar Co.	600	600	.....
92	Washington	Yakima	1917	Utah-Idaho Sugar Co.	600	750	.....
93	Utah	Springville	1918	Springville-Mapleton Sugar Co.	350	350	.....
94	....do	Centerfield	1918	Gunnison Valley Sugar Co.	450	450	.....
95	....do	Hooper	1919	Pioneer Sugar Co.	400	400	.....
96	Washington	Sunnyside	1919	Utah-Idaho Sugar Co.	750	750	.....
97	Idaho	Rigby	1919	Beet Growers' Sugar Co.	800	800	.....
98	Washington	Toppenish	1919	Utah-Idaho Sugar Co.	750	750	.....
99	Nebraska	Mitchell	1920	Great Western Sugar Co.	1,000	1,000	.....
100	Idaho	Whitney	1920	Pioneer Sugar Co.	600	600	.....
101	Michigan	Mount Pleasant	1920	Columbia Sugar Co.	1,000	1,000	.....
102	Iowa	Belmond	1920	Iowa Valley Sugar Co.	600	600	.....
103	Wisconsin	Green Bay	1920	Green Bay Sugar Co.	600	600	.....
104	Utah	Honeyville	1920	Utah-Idaho Sugar Co.	600	600	.....
105	Colorado	Delta	1920	Holly Sugar Corporation	600	600	.....
106	....do	Fort Lupton	1920	Industrial Sugar Co.	600	600	.....

During the past 50 years 5 other mills have been built, but 3 of them have burned, 1 has been dismantled, and 1 has been utilized for some purpose other than that of making beet sugar. Of the 106 beet-sugar mills now standing (fig. 1), 26 were erected at some

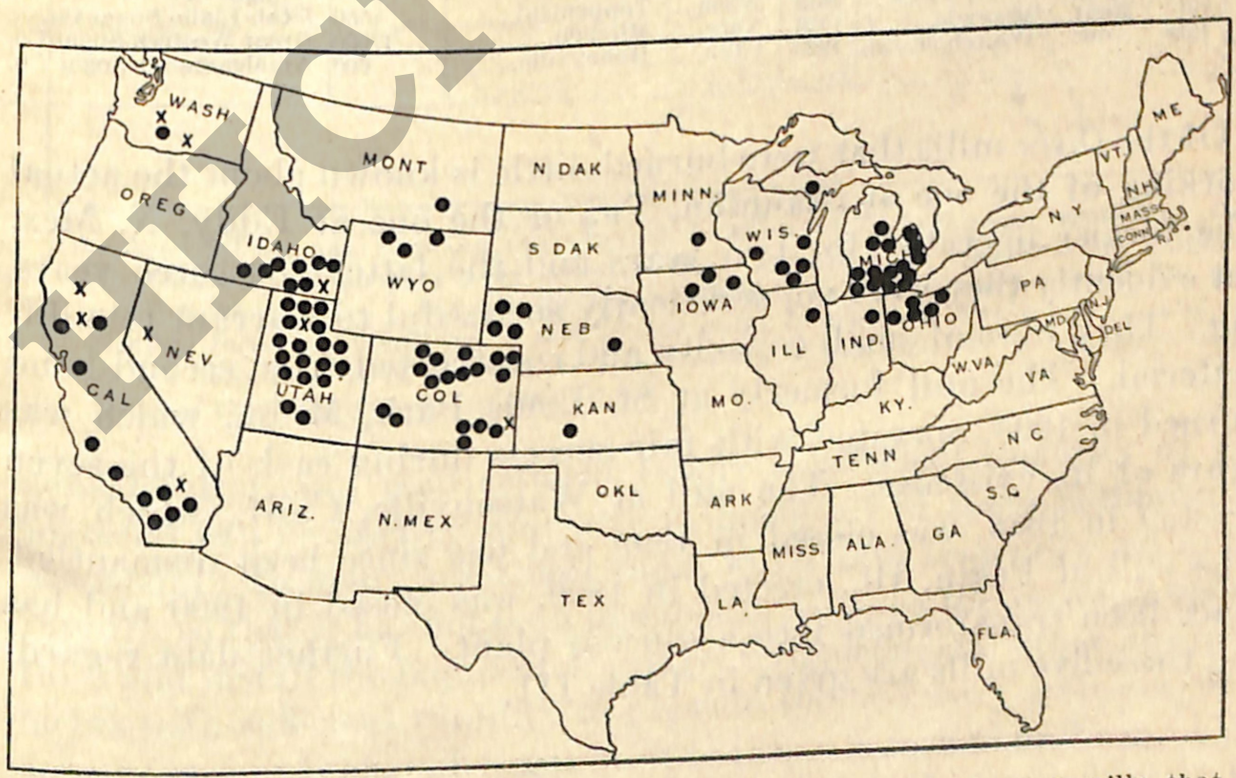

FIG. 1.—Outline map showing by black dots the locations of beet-sugar mills that were in operation during the 1920–21 campaign. Mills that were standing idle during the 1920–21 campaign are indicated by an × mark.

point other than the place where they are now located, but owing to certain limiting factors in beet-sugar production these 26 mills were removed to other locations (fig. 2 and Table II); 2 of these were built in Canada and removed to the United States and 1 was built in this country and removed to Canada.

TABLE II.—*Original and present locations of the removed beet-sugar mills.*

No.	Date of erection.	Where built.		Date removed.	Present location.		Capacity (tons).	Original owners.
		State.	Town.		State.	Town.		
1..	1891	Nebr..	Norfolk.....	1905	Colo....	Lamar.....	350–500	Norfolk Beet Sugar Co.
2..	1897	N. Y..	Rome.....	1906	Calif...	Visalia.....	200	First New York Beet Sugar Co.
3..	1898	...do ..	Binghamton..	1904	Idaho..	Blackfoot.....	350–900	Binghamton Beet Sugar Co.
4..	1898	Oreg..	La Grande....	1912	...do...	Burley.....	350–600	Oregon Sugar Co.
5..	1898	Calif..	Crockett.....	1908	Calif...	Corcoran.....	500–1,000	California Beet Sugar & Refining Co.
6..	1898	Mich..	Bay City.....	1907	Iowa...	Waverly.....	350–500	Michigan Sugar Co.
7..	1899	...do ..	Benton Harbor	1902	Ontario	Berlin.....	350	Wolverine Sugar Co.
8..	1899	...do ..	Rochester.....	1905	Wis....	Madison.....	500–600	Detroit Sugar Co.
9..	1899	...do ..	Kalamazoo....	1904	...do...	Chippewa Falls.	500–600	Kalamazoo Sugar Co.
10..	1899	Nebr..	Leavitt.....	1910	Nebr...	Scotts Bluff....	500–2,000	Standard Beet Sugar Co.
11..	1899	Wash.	Waverly.....	1918	Utah...	Centerfield.....	350–500	Washington State Sugar Co.
12..	1900	N. Y..	Lyons.....	1911	Calif...	Anaheim.....	600–1,200	Empire State Sugar Co.
13..	1901	Mich..	Saginaw.....	1905	Colo....	Sterling.....	600–1,050	Saginaw Sugar Co.
14..	1902	Ont...	Dresden.....	1904	Wis....	Janesville.....	600–700	Dresden Sugar Co.
15..	1902	...do ..	Wiarton.....	1908	Calif...	Santa Ana.....	350–600	Colonial Sugar Co.
16..	1903	Mich..	East Tawas...	1906	Minn ..	Chaska.....	600–800	Tawas Sugar Co.
17..	1905	Colo ..	Holly.....	1915	Wyo...	Sheridan.....	600–900	Holly Sugar Co.
18..	1905	Ariz ..	Glendale.....	1920	Colo....	Delta.....	600	Western Sugar & Land Co.
19..	1906	Idaho.	Nampa.....	1916	Utah...	Spanish Fork...	750–1,000	Western Idaho Sugar Co.
20..	1906	Mich..	Charlevoix....	1912	Ohio...	Ottawa.....	600–700	West Michigan Sugar Co.
21..	1906	Calif..	Visalia.....	1919	Utah...	Hooper.....	400	San Joaquin Valley Sugar Co.
22..	1908	...do ..	Corcoran.....	1920	Idaho..	Whitney.....	600	Pingree Sugar Co.
23..	1911	Colo...	Monte Vista..	1916	Wyo...	Lovell.....	600	San Luis Valley Beet Sugar Co.
24..	1916	Oreg..	Grant's Pass..	1919	Wash..	Toppenish.....	500	Utah-Idaho Sugar Co.
25..	1917	Mont .	Missoula.....	1920	Nebr...	Mitchell.....	1,000	Great Western Sugar Co.
26..	1918	...do ..	Whitehall.....	1920	Utah...	Honeyville.....	600	Amalgamated Sugar Co.

Of the three mills that were burned, little is known about the actual working of the one at Staunton, Va., or the one at Eddy, N. Mex. The former operated for two years and the latter for three years, but evidently they were not sufficiently successful to warrant rebuilding. They were of small capacity and constructed from second-hand material. The mill formerly at St. Louis Park, Minn., which was burned in 1905, operated with fair success during each of the seven years of its existence. The mill at Watsonville, Calif., which was erected in 1888, was closed in 1899 and has since been dismantled. The mill at Pekin, Ill., erected in 1899, was closed in 1900 and has since been transformed into a glucose plant. Further data regarding these five mills are given in Table III.

TABLE III.—*Beet-sugar mills destroyed or used for other purposes than making sugar.*

No.	Location.		Date erected.	Name of company.	Capacity (tons).	Present status.
	State.	Town.				
1	California	Watsonville	1888	Western Beet Sugar Co	1,000	Dismantled.
2	Virginia	Staunton	1892	O. K. Lapham	(a)	Burned, 1894.
3	New Mexico	Eddy	1896	Pecos Valley Beet Sugar Co	200	Burned, 1903.
4	Minnesota	St. Louis Park	1898	Minnesota Sugar Co	350	Burned, 1905.
5	Illinois	Pekin	1899	Illinois Sugar-Refining Co	700	Glucose plant, 1902.

a Not known.

The 106 mills now standing are for the most part favorably situated for extracting and refining beet sugar under present conditions. In many instances certain limiting factors will need careful

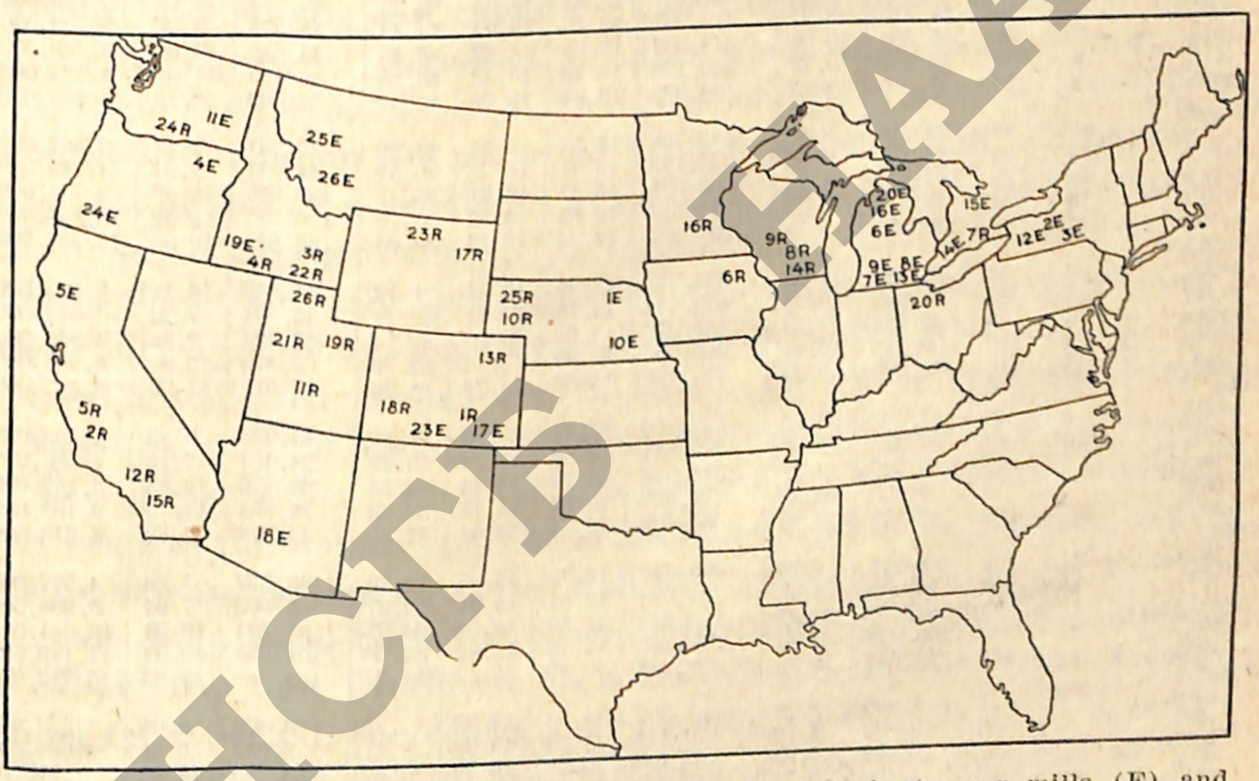

FIG. 2.—Outline map showing the original location of 26 beet-sugar mills (E) and the points to which they were removed (R). For example, 1E shows the original location of mill No. 1 and 1R the point to which that mill was removed; 2E the original location of mill No. 2 and 2R the point to which it was removed; and so on for each mill listed in Table II. Factories 21E and 22E are in the same locations as those designated by 2R and 5R.

consideration and readjustment before a sufficient quantity of raw material can be assured annually to make all of them permanently successful. In many areas beet-sugar mills have been crowded in too rapidly, so that it has not been possible to readjust the farming operations and install the required drainage, irrigation, and other improvements with sufficient rapidity to provide the necessary well-prepared acreage to supply enough sugar beets to insure a normal mill run. Consequently neither the mill owners nor the growers have received under these conditions a maximum return for the money and labor invested.

TABLE IV.—*Beet-sugar production, 1916 to 1920.*

Location and year.	Number of sugar mills.	Days operating.	Beets harvested.	Beets produced.		Average.			Sugar made.	Price paid for beets.	
				Average per acre.	Total.	Extraction.	Sugar in the beets.	Coefficient of purity.		Average per ton.	Total.
California:			*Acres.*	*Tons.*	*Tons.*	*P. ct.*	*P. ct.*		*Tons.*		
1916	11	108	141,097	10.47	1,477,426	16.15	18.35	84.13	236,322	$6.30	$9,311,000
1917	14	92	161,909	8.22	1,331,548	15.84	18.48	82.91	209,325	7.60	10,125,000
1918	13	81	100,684	8.52	858,028	14.52	17.03	81.50	122,795	9.95	8,534,000
1919	10	76	107,174	7.61	815,896	16.30	17.87	82.02	131,172	14.17	11,561,000
1920	10	90	122,813	8.74	1,073,828	15.97	17.66	81.44	167,997	13.13	14,096,000
Colorado:											
1916	14	102	188,568	10.70	2,018,298	13.04	15.00	85.79	252,147	6.06	12,236,000
1917	15	91	161,476	11.50	1,857,649	13.39	15.40	85.16	234,303	7.28	13,526,000
1918	14	76	125,882	11.47	1,443,846	14.07	16.10	85.96	191,880	10.02	14,474,000
1919	15	87	182,616	9.66	1,764,772	11.71	13.62	83.85	193,890	10.85	19,143,000
1920	17	98	219,847	10.58	2,325,003	13.60	15.81	85.15	294,482	11.88	27,627,000
Idaho:											
1916	5	86	42,135	8.48	357,137	13.84	16.95	86.39	45,874	6.16	2,199,000
1917	7	70	37,745	8.27	312,067	13.40	16.74	84.84	38,376	7.06	2,203,000
1918	7	87	32,306	10.66	344,334	13.66	16.57	86.46	44,682	10.00	3,443,000
1919	6	50	30,331	6.70	203,168	13.29	15.48	86.15	26,159	11.00	2,235,000
1920	8	72	45,810	8.82	404,078	13.94	16.26	86.41	57,603	12.10	4,889,000
Michigan:											
1916	15	49	99,619	5.46	543,766	13.79	16.37	85.22	69,341	6.14	3,337,000
1917	14	53	82,151	6.38	524,195	13.91	16.28	86.57	64,247	8.04	4,215,000
1918	16	75	114,976	8.40	966,676	14.37	16.61	85.49	127,979	10.08	9,741,000
1919	16	84	123,375	9.82	1,211,018	12.63	14.57	81.78	130,385	12.52	15,158,000
1920	17	87	149,559	8.78	1,312,883	13.34	15.79	84.04	165,899	10.08	13,236,000
Nebraska:											
1916	3	160	41,083	10.34	424,913	12.86	15.51	81.12	51,945	6.17	2,622,000
1917	4	97	51,337	9.22	473,494	12.16	14.91	80.71	53,893	7.22	3,417,000
1918	4	99	42,746	11.35	485,070	14.01	16.05	86.14	63,494	9.96	4,833,000
1919	4	112	59,113	10.16	600,730	10.99	13.14	82.80	60,870	10.90	6,546,000
1920	5	110	72,296	9.93	717,956	13.37	15.74	83.94	89,518	11.96	8,587,000
Ohio:											
1916	4	45	24,767	5.96	147,718	13.24	15.89	83.36	18,234	6.83	1,008,000
1917	5	70	24,234	9.08	219,931	12.08	16.24	86.25	24,467	7.18	1,586,000
1918	5	91	32,547	9.69	315,371	12.19	15.74	84.23	35,476	10.03	3,162,000
1919	5	79	30,909	10.58	326,962	10.93	14.15	82.73	31,864	12.75	4,168,000
1920	5	100	49,199	8.86	435,928	12.31	15.44	82.45	47,073	9.89	4,313,000
Utah:											
1916	11	95	68,211	11.70	798,119	12.75	16.65	84.79	90,277	5.73	4,577,000
1917	15	82	80,289	7.49	762,028	12.01	15.61	82.27	83,662	7.04	5,368,000
1918	16	98	81,717	12.27	1,003,013	11.69	15.29	84.21	105,794	10.01	10,041,000
1919	18	84	103,247	9.84	1,015,873	11.12	13.87	82.39	101,025	10.97	11,148,000
1920	18	102	112,567	12.35	1,389,843	12.89	15.62	84.27	162,588	12.03	16,713,000
Wisconsin:											
1916	3	48	7,006	8.79	61,500	11.58	14.90	.....	6,800	6.06	373,000
1917	4	53	9,800	8.10	79,372	11.34	15.03	.....	8,032	8.81	699,000
1918	4	61	12,400	8.05	99,777	14.29	16.29	82.40	13,358	10.00	998,000
1919	4	60	12,100	9.71	117,443	10.07	13.16	81.73	10,636	12.02	1,411,000
1920	5	80	20,686	9.19	190,203	12.40	15.86	82.53	20,943	10.20	1,940,000
Other States:											
1916	8	57	52,828	7.56	399,379	13.07	15.69	82.67	49,717	6.20	2,476,000
1917	13	51	55,856	7.52	420,093	12.46	15.17	81.87	48,902	7.28	3,059,000
1918	10	64	50,752	8.53	432,683	13.59	15.95	84.31	55,492	9.86	4,268,000
1919	11	52	43,590	8.39	365,616	11.95	14.27	83.14	40,450	11.08	4,050,000
1920	12	70	79,599	8.75	696,471	13.06	15.46	83.12	83,918	11.52	8,025,000
All States:											
1916	74	80	665,308	9.36	6,228,256	13.86	16.30	84.74	820,657	6.12	38,139,000
1917	91	74	664,797	9.00	5,980,377	13.60	16.28	83.89	765,207	7.39	44,192,000
1918	89	81	594,010	10.01	5,948,798	13.64	16.18	84.70	760,950	10.00	59,494,000
1919	89	78	692,455	9.27	6,421,478	12.34	14.48	82.84	726,451	11.74	75,420,000
1920	97	91	872,376	9.80	8,546,193	13.63	15.99	83.97	1,090,021	11.63	99,426,000

For several years the Office of Sugar-Plant Investigations, jointly with the Office of Farm Management and Farm Economics and independently, has been studying the agronomic conditions found in each of the existing and in some of the prospective sugar-beet centers. This bulletin discusses the conditions which have been brought out in these studies and points out in a general way the factors that are

favorable and those that are unfavorable for the production of sugar beets. The primary object of this bulletin is to give a general survey of the beet-sugar industry, to encourage the more general application of those principles and practices which make for better returns to the grower, and to discourage those practices which tend to reduce the yields and quality of sugar beets and of other crops and also to unbalance the relation between crop production and the kind, number, and quality of the live stock on the beet farms. The general effect aimed at is the production of more sugar and a more nearly perfect stabilization of the beet-sugar industry in the United States.

The production of sugar from beets in the United States for the five-year period from 1916 to 1920, inclusive, is shown in Table IV.

SOIL.

Almost any fertile soil capable of producing good yields of other crops will, if properly handled, produce good sugar beets. More depends upon the physical condition of the soil and the way in which it is handled than upon the so-called kind or type of soil. Extremely sandy soil or soil of a decidedly gravelly type is not usually satisfactory for sugar-beet growing.

Raw soil.—Generally speaking, raw soil or new soil does not produce as large yields of sugar beets as may be obtained from soil that has been under cultivation for some time. In recent years much new soil has been brought under cultivation through the use of sugar beets; this in a measure has had a tendency to reduce the average yield of sugar beets in this country. The argument in favor of growing sugar beets on new soil is that this crop will bring the raw soil under control and place it in good tilth for other crops more quickly than almost any other crop now produced on a large scale on American farms. It must be expected, therefore, that so long as new sugar-beet territories are being opened in the partially developed sections of the United States this factor, tending to keep down the average yield of beet roots, will be effective. Also in many of the older sugar-beet sections in which the growing of sugar beets is being extended from year to year, whereby new lands are being brought under cultivation, this factor will be more or less effective in holding down the average yield. In those sections where sugar beets have been grown for many years (as, for example, in Utah) and in which a minimum acreage of new soil is being used for sugar-beet culture from year to year, the average yield of beets per acre is strikingly above the average for the entire country. Usually the grower who utilizes new soil for sugar-beet production expects a comparatively low yield and is generally satisfied, for the reason stated above, if the crop pays the cost of production. Though this is one of the causes of the low average yield of beets per acre in this country, it is by no means the only one.

Worn soil.—In those sections where sugar beets have been grown for a number of years without proper attention to the maintenance of soil fertility and an adequate supply of humus, the yield has been reduced. There are few sugar-beet areas in which the soil fertility has been maintained or improved to the limit of possibilities. It is apparent, therefore, that by proper attention to soil conditions from the standpoint of fertility the average yield of beets per acre may be greatly increased. The worn condition of the soil is not peculiar to the growing of sugar beets, but occurs in the growing of other farm crops, when attention is not given to increasing the supply of available plant food in the soil or to maintaining its humus content.

Quality of the soil.—Soils vary widely in their original qualities, both physical and chemical. All agricultural soils are supplied in varying proportions with the necessary plant foods for crop production. Soils that have plant food present in great abundance may be said to be rich. They are not fertile, however, unless these plant foods are in soluble form or unless they are rendered soluble as rapidly as the various materials are required by the plant in the process of growth. The quality of the soil from the standpoint of fertility may be greatly improved by proper cultivation, crop rotation, and the addition of humus, as well as by the application of lime or other material that will improve its physical condition. At times special treatments, such as subsoiling and drainage, are needed to make the soil highly productive.

SUBSOIL.

In the growing of sugar beets the subsoil is often of equal importance with the surface soil.

Hardpan.—Frequently the surface soil is underlain by a hardpan which it is impossible for the beet roots to penetrate. The hardpan may be of natural formation or it may be induced by improper tillage. If it is close to the surface and of such material that it can not be broken up successfully, the profitable growing of sugar beets is impossible. Beets produced under such conditions will be short, with a resulting low tonnage, or they will be pushed out of the ground and consequently will be low in sugar and purity. The nature of the hardpan is of considerable importance in this connection. If it is of rock and near the surface, little can be done to improve its condition for sugar-beet culture, but if it is simply a close and compact form of soil it may be broken up with a subsoil plow. Sometimes local areas of extremely hard subsoil are found in the sugar-beet sections, and this condition constitutes a limiting factor in the production of this crop in those areas as a whole or on certain farms or fields, depending upon the location and distribution of the hard-

pan. If the hardpan is level it may hold too much moisture in the surface soil, thereby rendering the conditions unfavorable for sugar-beet production without artificial drainage. If the hardpan is several feet below the surface and has slope sufficient to carry off the excess water, no unfavorable condition will result from it.

Porous soil.—The reverse of the preceding condition is sometimes found in sugar-beet sections in which the subsoil is of such a nature and of such a depth that it is very difficult to keep the soil supplied with moisture during the growing season. Rain or irrigation water passes rapidly through porous subsoils, and is soon out of reach of the growing plant. If the porous subsoil is very deep and extremely porous the ground is unsuited for sugar-beet culture. Frequently this condition can be relieved somewhat by proper cultivation and by supplying the surface soil with sufficient humus to enable it to retain enough moisture to produce a fair crop. A heavy crop of beets can not be expected on a thin surface soil underlain by an extremely porous subsoil.

TOPOGRAPHY.

The unfavorable topography of an area is frequently the limiting factor in the production of sugar beets. Mountainous areas can not be utilized for the development of the beet-sugar industry unless the valleys are sufficiently large to support a mill or are favorably located with reference to an existing mill and are composed of sufficient fertile, tillable soil so that beets of proper quality and in sufficient quantity can be produced at a reasonable cost. Many small valleys, especially in the western United States, might be utilized in the growing of sugar beets were it not for the fact that they are too small to support a sugar mill and too far from existing mills to permit the beet roots to be transported at a sufficiently low cost. This problem may be solved by utilizing some practical means of drying the beet roots. It is possible to slice and dry the roots, thereby reducing the weight of the beets by about 75 per cent without changing the quality or lessening the quantity of sugar present. If this can be done with sufficient rapidity and at a sufficiently low cost it will be possible to handle to advantage the product of many small valleys and other limited areas. A sugar mill should be able to handle not less than 500 tons of beet roots per day of 24 hours, and it can not be financially successful under normal conditions unless it is supplied with a sufficient quantity of raw material to produce a run of approximately 100 days each year. It is desirable that a considerable part of the supply be within wagon haul of the mill. Any factor which reduces the working capacity or the operating time of a sugar mill increases the cost of production of the sugar. The

small valleys mentioned above are sometimes used to supplement the beet crop produced in other sections provided the hauling distance by wagon or rail is not too great.

Hills.—Generally a hilly country is not satisfactory for sugar-beet culture, especially if the hills are inclined to wash. The nature of the soil of the hills is an important factor in determining whether sugar beets can be grown. Hauling heavy loads in a hilly country is also a matter of serious consideration. Usually from 3 to 5 tons of beets are hauled at each load and if hills must be climbed the loads must necessarily be reduced and the cost of hauling consequently increased. This in itself may be a limiting factor in the production of sugar beets in some otherwise favorable sugar-beet areas.

Level land.—In irrigated countries it is desirable that the surface of the soil be sufficiently level to permit uniform irrigation. A perfectly level area, however, is objectionable because of the difficulty in spreading the water over the entire field with sufficient rapidity. This is especially objectionable in the case of sugar beets, which should be watered between the rows only, as shown in Plate I, figure 2. Again, when the land, especially in irrigated sections, is very level and poorly drained alkali frequently appears on the surface after repeated irrigations. Sugar beets will tolerate a small amount of alkali, but all crops are injured by excessive quantities of alkali in the soil, especially when the plants are young and tender.

Rolling land.—Other things being equal, moderately rolling land is more desirable for sugar-beet culture than either extremely hilly or very level areas. This is especially true in those sections where sugar beets are produced under rainfall conditions. In irrigated sections rolling land is not so desirable unless the topography of the country is such that the area under cultivation can not be irrigated readily. Under irrigation conditions it is desirable that the land have an even surface with a gentle slope of at least 7 feet to the mile. If the slope is too marked the irrigation water passes over it too rapidly unless special care is taken in applying the water.

CLIMATE.

One of the most important factors in determining the suitability of a given area for sugar-beet culture is the climate. Frequently all other conditions are favorable, but some climatic factor renders sugar-beet growing unprofitable.

Temperature.—Successful sugar-beet growing has been confined to the temperate region in practically all beet-sugar producing countries. Frequently sugar beets will produce a satisfactory tonnage of roots in warmer areas, but for some reason they generally are not sufficiently rich in sugar to make them profitable in sugar making.

FIG. 1.—PLANTING SUGAR-BEET SEED WITH 4-ROW DRILLS, WHEREBY THE SEED SHOULD BE PLACED AT A UNIFORM DEPTH, IN STRAIGHT ROWS, AND IN A FIRM SEED BED.

FIG. 2.—A FIELD OF SUGAR BEETS, SHOWING FURROW IRRIGATION; EACH ALTERNATE ROW FURROWED.

FIG. 1.—THE SMOOTH ROLLER, A USEFUL IMPLEMENT IN PACKING THE SEED BED BEFORE AND AFTER PLANTING.

FIG. 2.—THE CORRUGATED ROLLER, AN IMPLEMENT WHICH BREAKS THE CRUST AND RIDGES THE GROUND AGAINST WIND EFFECT.

This is notably the case in nearly all parts of the southern United States. Occasionally areas are found in these warmer zones where sugar beets may be grown successfully. This is true in southern California and in some parts of Arizona and New Mexico, where the adverse condition of temperature is overcome by growing the beets during the so-called winter months, or at least by getting the plants started in the winter or early spring. In some sections the elevation and the temperature of the prevailing wind are sufficient to modify the climate so that sugar beets may be produced with profit. If the winter months are too cold for the production of beets and the summers too warm for the proper storage of sugar in the roots, a limiting factor is established which renders profitable sugar-beet growing impossible with any known varieties. Should it become desirable to extend the culture of sugar beets into the warmer sections of the country, it is possible that suitable varieties could be developed that would be profitable from the standpoint of both tonnage and quality.

Another important consideration is the fact that high temperatures tend to increase spoilage. This may be overcome by passing the beets through the mill as rapidly as they are harvested and by harvesting the roots as soon as they are matured. Regarding the lower temperatures, sugar beets have been successfully grown in practically all of our Northern States, and several beet-sugar mills are operated successfully in Canada. It is apparent, therefore, that the lower temperatures do not constitute a limiting factor in sugar-beet growing in any of our agricultural sections. It would seem that a short growing season would render sugar-beet production unprofitable in many northern areas, but the sugar beet readily adapts itself to many adverse conditions, and usually in those sections where the growing season is short the sugar beet grows rapidly and stores sugar in great abundance. In fact, some of our most satisfactory sugar-beet sections are to be found in the more northern States.

During the period just preceding the beet harvest the difference in temperature between day and night is one of the important conditions in the development and storage of sugar in the beet root. The young beet plant begins very early to store sugar, but its maximum activity along this line is reached in the fall, when in most of the beet-growing areas the difference in temperature between night and day is most apparent. This difference is apparently one of the conditions necessary for the proper elaboration and storage of sugar and is a limiting factor in the production of sugar-beet roots sufficiently rich in sugar to make them profitable for sugar-making purposes. It is probable that the absence of cool nights at the end of the growing season permits the continued growth and development of the beets, thereby using up the sugar in plant growth instead of storing it.

Moisture.—Moisture is necessary for the production of profitable crops of sugar beets. This reaches the soil in the form of rain or snow, or it may be applied artificially. Our present sugar-beet area extends over a portion of the humid and the irrigated sections of the country, as shown in figure 1.

In the humid sections the moisture falls largely during the winter months, although rains usually are frequent during the spring and summer. Occasionally some parts of the humid portion of our sugar-beet area are visited by heavy rains in the early spring, which greatly delay the planting of the beets as well as of other crops. This is sometimes followed about midsummer by a severe drought, which greatly retards crop growth. If these conditions were of frequent occurrence over wide areas, they would constitute a limiting factor in sugar-beet growing in the humid sections; but they have occurred in this country only in limited areas and at long intervals. Occasionally rainfall is large at harvesting time, and sometimes injures the sugar-beet crop by producing a second growth of the plants, which greatly reduces the sugar content. The extent of this injury depends upon the condition of the beets and the duration of the rainy period. If this is followed by a period of favorable weather, the sugar content will be restored wholly or in part, depending upon the duration and nature of the weather. It sometimes happens that the beets must be harvested before the lost sugar is fully restored, either to prevent the roots from freezing in the ground or to avoid a temporary shutdown of the mill. Consequently a second growth due to late rains may cause serious losses to the grower and to the sugar company. A season in the humid region in which the rainfall is just sufficient to maintain a steady growth until near harvesting time, followed by continuous fair weather accompanied by cool nights and warm days, makes conditions most favorable for the production of sugar beets so far as the humid area is concerned. These conditions prevail generally in the humid sections where sugar beets are grown.

In the irrigated sugar-beet areas usually less than 20 inches of moisture falls during the entire year, and frequently many of the showers are so light that they are of no practical benefit in crop production. Sugar-beet growers in those sections depend largely upon irrigation. Frequently the showers that fall in irrigated areas are detrimental rather than helpful in the production of sugar beets, since they frequently cause the soil to crust. If this crusting occurs shortly after the seed is sown the young plants have great difficulty in breaking through to the light, with the result that the stands are very seriously injured and replantings are necessary. If the showers occur soon after the beets are up and the ground crusts around the young plants the air is cut off from the roots and growth is inter-

fered with. This may sometimes be remedied by prompt cultivation, although the plants are often so firmly embedded in the crust that cultivation is difficult without serious injury to the plants. Sometimes a moderately heavy roller of one of the types shown in Plate II will produce the desired result in breaking the crust. In irrigated sections every effort should be made to retain the fall or winter moisture in the soil, and if the ground is dry in the fall, irrigation is generally desirable. The soil should be sufficiently moist when the seed is planted to produce prompt and complete germination, and there should be sufficient moisture in the soil to maintain a steady growth for several weeks. As soon as the plants indicate that they are suffering from lack of moisture they should be irrigated. When beets wilt during the day and fail to revive at night they should be watered without delay. Usually from one to three irrigations during the growing season are sufficient to produce a crop in most of the irrigated sections where sugar beets are grown. When beets are irrigated the soil should be thoroughly wet, and every effort should then be made to retain the moisture as long as possible by frequent cultivation.

Sunshine.—The third element of climate which has a marked effect on the quality of sugar beets is light, over which man has little control except in the selection of locality. It is generally believed that direct sunshine is an important factor in the production and storage of sugar in the beet; observation indicates, however, that diffused light is almost, if not quite, as effective in producing and storing sugar. The importance of light should not be overlooked, however, since without it the leaves could not manufacture sugar. Beet sugar is all made in the beet leaves by the action of light upon the leaf green when moisture and carbonic-acid gas are present. Without light this action in the leaf can not take place, no matter how favorable may be all other conditions for growth and sugar production.

SUGAR-BEET STAND.

One of the most important factors in sugar-beet production is the stand at harvest time. A perfect stand of beets with the usual width of row and the proper distance of spacing would consist of 25,000 to 40,000 plants to the acre. If each of the beet roots harvested weighed 1 pound, which is below the average in most fields, there should be 12½ to 20 tons of roots per acre. As a matter of fact the sugar-beet stands are only from 50 per cent to 80 per cent perfect, and the average yield of beets in the United States is about 10 tons. Absolutely perfect stands are not to be expected, considering the many factors influencing the stand and the large area annually in sugar beets, now approximately 1,000,000 acres. However, there should be no difficulty in greatly raising the percentage of stand,

thereby increasing the yield per acre. Careful attention has been given to the factor of stand during the last few years, and by actual count in many fields in all parts of the sugar-beet area it has been found that the stand at harvest time very frequently is as low as 50 or 60 per cent of a possible 100. It is very seldom that a field has more than 80 per cent of a perfect stand at harvest time. Many factors influence the stand, some of the most important of which have been carefully studied and are discussed below.

Seed.—The quality of the seed is one of the primary factors in producing a stand of sugar beets. All beet seed imported from foreign countries must be up to a certain standard of germination and purity; otherwise it need not be accepted. As a rule sugar-beet seed stored under proper conditions will retain its vitality six or seven years. Usually we have no means of knowing the age of the seed that is shipped to this country, and it is entirely possible that seed imported is sometimes near the limit of its vitality and if held over for one or two years may deteriorate in germinating power. It is customary for sugar companies to retain a part of their seed from year to year to provide for replanting or to take care of belated contracts. All reserved seed, as well as new lots, should be carefully tested for germination before it is given to the growers. If the germination of the seed is too low to produce a good stand of beets at the usual rate of planting, either the seed should be discarded entirely or a sufficient quantity of seed should be planted to insure a good stand.

With American grown sugar-beet seed no difficulty should be met in ascertaining its age; in fact, all American grown sugar-beet seed is utilized within a year or two following its production, so that at present there is no danger of the home-grown seed losing its germinating power before it is planted. In general, domestic sugar-beet seed shows a higher germinability than is shown by the imported seed. All American seed, however, should be tested carefully for germination, because certain conditions during the process of growth, development, and storage of the seed may render it weak or nongerminable. One of the most important factors affecting beet seed adversely during its development is the false chinch bug, which occasionally appears in some beet-seed growing localities. This insect infests the beet-seed balls and the tender leaves and stalks and by sucking the juice from the plant may prevent the seed from developing and maturing.[1] The health and vitality of the beet root when planted for seed is another important factor influencing the quality of the seed. Beet roots that have been weakened by Phoma rot or other diseases of the root will sometimes produce seed stalks, and fre-

[1] For control measures, see p. 49.

quently the seed balls will begin to form; but the plants often die before the seed is mature. If the seed stalks bearing the nonmatured seed are harvested and the seed balls from these stalks are mixed with the matured seed, it is evident that the percentage of germination will be materially reduced. Hot dry winds at the time the seed is forming interfere with pollination and tend to prevent the seed balls from filling and producing viable seed.

The water supply during the growing season has also a marked effect upon the quality of the seed. If the supply of moisture in the soil is too low, especially at the time when the seed is forming, the seed balls will not fill, and the yield of viable seed will be reduced. In the humid sections where seed is grown we have no direct control over the moisture supply except in so far as we are able to retain the moisture in the soil by proper methods of cultivation. In the irrigated sections, wherever water is constantly available, the moisture supply is under the control of the grower. It is not advisable to undertake the growing of sugar-beet seed in those irrigated sections where an abundant supply of water is not available for irrigation when needed.

The seed bed.—The condition of the seed bed as a factor influencing sugar-beet stands is of an importance equal to the quality of the seed. In general, the seed bed should be firm and moist and capable of retaining its moisture under all conditions for a considerable period. To produce such a seed bed the soil should be thoroughly supplied with humus. The ground should be plowed in the fall, in order that it may catch the winter rain and snow, and the surface should be harrowed as early as possible in the spring, so as to retain as fully as possible the moisture in the soil at that time. The seed bed should be worked from time to time to destroy the weeds that may appear, as they rob the soil of moisture as well as of fertility. Just before planting, the seed bed should be thoroughly worked down and firmed, so that the surface will be uniform in texture and in firmness. If the bed is not uniformly firmed, the drill wheels will sink deeper in some places in the field than in others, with the result that some of the seed will be so deeply covered that the plants will not reach the light, or they will be more or less retarded, producing a spotted or uneven stand. The seed should be drilled into the firm seed bed, so that it will be constantly in contact with the moist soil. (Pl. I, fig. 1.) Poor stands are probably produced oftener by too deep and uneven planting, due to a poorly prepared seed bed, than by any other cause.

Date of planting.—No specific date for planting beet seed can be given, since much depends upon local soil and weather conditions. In general, however, it has been found that the soil should be warm

and uniformly moist before the seed is planted, as beet seed will not germinate satisfactorily in a cold or unevenly moistened bed. A few of the stronger plants may come up in the moist spots if the seed bed is not too cold, but the stand will be uneven and far from perfect. It is advisable, therefore, to see that the soil conditions are right before planting. Generally there is a planting period of several weeks during which the seed may be placed in the ground with good results. It has been observed that late plantings will frequently give better results than very early plantings. It is not advisable to plant in soil that is too dry or too wet. If the soil is too dry and irrigating water is available it is best to irrigate before planting; if irrigating water is not available and the indications are favorable for rain it will usually be advisable to wait until rain has fallen. If the ground is too wet when the seed is planted, there is danger of the seed rotting and thereby failing to produce a stand.

Winds.—In some localities wind is an important factor affecting the stand of sugar beets. Aside from the effect of wind upon seed formation, as previously noted, wind is effective in two ways in injuring the stand of beets. If the soil is sandy, strong winds may shift the sand so that the seed is covered too deeply and the young plants can not get through to the light, and if the beet seedlings are up the wind may carry the fine particles of sand against the tender plants with such force that they are destroyed or severely injured. This frequently occurs in level areas where strong winds prevail in early spring. The destructive effect of winds may be overcome, in part at least, by drilling in the seed at right angles to the direction of the prevailing winds and by ridging the ground slightly between the rows.

Crust.—In many sugar-beet localities the soil has a strong tendency to crust if it is moistened and then quickly dried. Showers sometimes fall shortly after the seed is planted, followed by sunshine and drying winds, and in cases where the soil has a tendency to bake a very hard crust will frequently form, which will either prevent the young plants from coming through to the light or will cause a very uneven stand. The crust formed will vary in thickness, depending upon the nature of the soil and the conditions of the weather. If the crust is thin and the young plants have not been caught in it, a light harrow or a roller will sometimes put the surface in shape so that the plants will break through. If the crust is thick and the plants are embedded in it, there is frequently no remedy except to harrow the ground and replant. A crust may be prevented or greatly retarded by an application of lime before or immediately after plowing and by keeping the ground well supplied with humus.

FIG. 1.—BLOCKING AND THINNING SUGAR BEETS, AN OPERATION THAT MUST BE PERFORMED BY HAND AS SOON AS THE BEETS ARE LARGE ENOUGH.

FIG. 2.—FLOODING A FIELD OF SUGAR BEETS, A POOR METHOD OF IRRIGATION, SINCE IT REDUCES THE STAND OF BEETS, WASTES THE WATER, AND INJURES THE SOIL.

FIG. 1.—A 4-ROW CULTIVATOR, WHICH IF NOT CAREFULLY USED MAY DESTROY A GOOD STAND OF BEETS.

FIG. 2.—A FIELD OF SUGAR BEETS WHOSE TOPS COMPLETELY COVER THE GROUND, AT WHICH STAGE THE CROP MAY BE LAID BY.

Blocking and thinning.—A good stand of beets very largely depends upon careful blocking and thinning. Blocking consists in cutting out a portion of the beets by means of a hoe or other suitable implement (Pl. III, fig. 1), usually operated at right angles to the row, leaving the remaining beets in tufts from 8 to 10 inches apart. This should be done while the beets are very small. It is very easy for the careless workman to strike the row at an angle, making the distance between the tufts very much greater. Frequently the tufts themselves are destroyed by careless use of the blocking implement. When the plants have been destroyed, practically nothing can be done to replace them. Transplanting sugar beets to the vacant spaces has not been found practicable on a commercial scale.

The thinning is done by hand and consists in pulling out from each tuft all the plants but one. Careless workers will often destroy or pull out all the plants from the tuft, thereby reducing the stand. Frequently in thinning the dirt is removed so that the young plants are left with their tender stems subject to the influence of the rays of the sun, the heat of which sometimes destroys them. The dirt should be brought close around the plant that is left so as to protect it from injury.

Cultivating.—Many otherwise good stands of beets are seriously injured by the cultivators either covering the young plants with dirt or tearing them out. This injury is frequently due to carelessness and sometimes to accident. Sugar beets are usually cultivated by means of a 4-row cultivator (Pl. IV, fig. 1). If by accident or otherwise the cultivator is permitted to shift so that several plants are injured or destroyed in one row, the same number of plants will be injured or removed from each of the four rows. This is a common cause of poor stands in many fields. A few beets cut out of four rows here and there in the field each time the beets are cultivated will have a marked effect upon the final stand and will greatly reduce the yield of beets harvested. Success in operating the cultivator depends upon the condition of the seed bed, upon the animals, the driver, and the adjustment of the implement. By careful attention on the part of the driver, nearly all the injury due to cultivation may be avoided, provided the seed bed is in good condition and the drill rows are straight. When the beet leaves cover the ground, as shown in Plate IV, figure 2, the crop is laid by, and no further work is done until the harvest begins.

Diseases affecting the stand.—One of the common agencies affecting the stand of sugar beets is disease. Nearly all sugar-beet diseases are due to parasitic organisms. One of the most serious affecting the stand is the damping-off of the young beets. Later in the season root-rot does considerable damage in some localities. Leaf-

spot frequently injures the beets and reduces the tonnage, but does not often destroy the stand. All fungous diseases may be greatly reduced or entirely controlled by proper cultural methods, including the proper rotation of crops.

There are several diseases which sometimes destroy entire fields. The disease known as curly-top belongs to this group. This is an obscure disease, the cause of which is not definitely known. The Office of Sugar-Plant Investigations in cooperation with the Bureau of Entomology is making an earnest effort to determine the cause of this disease and to find a practical means for its control. Another serious pest affecting the stand of beets is the sugar-beet nematode. The nematode first appears in a field here and there, destroying a few beets. From year to year this area becomes more marked if beets are grown continuously in the infested fields, and eventually the whole field is affected and the crop is worthless. The Office of Sugar-Plant Investigations in cooperation with the Office of Agricultural Technology is carrying on extensive experiments in all areas infested with the sugar-beet nematode, with a view to controlling this pest in a practical way, so that profitable crops of beets may be grown in spite of the nematode. For a further discussion of sugar-beet diseases, see pages 45 to 48.

Insects affecting stand.—There are several insects affecting the stand of sugar beets. The most common during the early stages of the beet are wireworms and cutworms. The latter usually cut off the root at some distance below the ground. As a result the plant dies or produces a very short root. Sometimes the cutworms destroy beets here and there in the field, but when the pests are numerous the entire stand may be destroyed, necessitating replanting in order to produce a crop. White grubs also are serious pests. They are the larvæ of the May and June beetles. They occur frequently in sod ground and are to be expected in beet fields where beets follow sod. Later in the season army worms and related pests frequently do considerable damage. Even if the stand is not seriously injured by the pests the tonnage is greatly reduced. For a further discussion of insect pests affecting sugar beets, see pages 48 and 49. For a list of publications relating to sugar-beet diseases and insects, see pages 57 and 58.

Rodents affecting stand.—In some localities ground squirrels and other rodents are a serious menace to the sugar-beet crop. They feed upon the beets from the seedling to the mature stage, but do most of their damage when the beets are about half grown. They sometimes make serious inroads upon the stand of beets. These pests may be destroyed by the use of poison or by trapping.

WATER.

Excess or deficiency of water may be a limiting factor in sugar-beet production.

Precipitation.—In the humid sections of the sugar-beet area beet growers depend upon rainfall and snow for the necessary supply of soil moisture. Usually the snow and the spring rains put the soil in good condition for planting, and the summer rains keep the crops growing until the end of the season. Whether the precipitation will furnish an excessive amount of moisture for the soil will depend upon soil conditions, as well as upon the amount of precipitation. For uniform soil conditions, however, the right amount of precipitation is of vital importance in the growing of sugar beets. Excessive precipitation may be detrimental in two ways: (1) By preventing a proper preparation of the seed bed, and (2) by saturating the soil to such an extent that the air is excluded from the plant roots and the proper growth of the plants thereby prevented. A deficiency of precipitation may make a proper preparation of the seed bed impossible, or it may put the seed bed in such condition that the germination of the seed or the subsequent growth of the plants may be impaired. Excessive precipitation may be remedied under certain conditions by a proper system of drainage. (See pages 22 to 24.) The lack of moisture may be remedied in part (1) by putting the proposed seed bed in a proper condition to catch and hold the fall and winter moisture; (2) by subsequent cultivation whereby a mulch is formed on the surface of the field, thereby retarding evaporation; and (3) by supplying the soil with a suitable amount of humus.

Irrigation.—The use of irrigating water is theoretically simple, but its practical application is very complex, calling for a knowledge of plant growth and soil requirements based upon experience and good judgment. It is one of the most important factors in sugar-beet production in the semiarid regions. Good crops are sometimes ruined by a lack of knowledge of the water requirements of plants and by want of experience in applying the water.

There are four sources from which irrigating water may be obtained, namely, from reservoirs, direct from streams, from flowing wells, and by pumping. A reservoir is a storage place in which an excess of water due to melting snows or from other sources may be stored for future use. Stream irrigation implies either a continuous or an intermittent flow of water in a river bed which may be drawn upon when needed. Pump irrigation is practicable when the subsurface water is present in sufficient quantity and at a depth shallow enough to supply the necessary water for crop production at a reasonable cost.

Reservoirs are either individual storage places which supply moisture for a single farm or part of a farm or they may be community enterprises operated by the landowners or by an irrigating company. Community reservoirs are sometimes filled directly from permanent streams and sometimes they are filled during freshets, while individual reservoirs are frequently supplied with water by pumping; in this manner pump irrigation may be direct or indirect. By direct irrigation the water is pumped into the ditches or laterals and spread at once upon the fields; by indirect irrigation the water is pumped into a reservoir, from which it is distributed upon the field when needed. There are difficulties to overcome in each of the methods of irrigation mentioned. In utilizing water from a community reservoir it is necessary for all farmers under the ditch from this reservoir to use the water at a time agreed upon by the majority of users, regardless of the requirements of all the crops to be watered. In case the water is not used by one or more farmers when the reservoir is open, they must await the next opening of the reservoir, which may be several weeks later, regardless of the injury that the lack of water may cause to their crops. The reservoir can not be opened at the will and pleasure of each water user. To do so would cause a great waste of water, which is often of greater value than the land itself.

Water from a community reservoir is usually prorated and measured to each farmer so that he is able to obtain only his share; likewise, in using water from a stream in which the supply is limited it is prorated and measured, and irrigation must cease when the allotted number of acre-feet have passed through the gate, regardless of the crop requirements. If the pumping plant is a community plant, practically the same regulations obtain as in the case of the community reservoir; that is, each farmer entitled to water must use it at a definite time agreed upon by a majority of the users or forfeit his right to the use of the water until the next irrigating period arrives. It would, of course, be too expensive to operate the pumping plant for a limited number of farmers whose crops were not in need of water at the regular irrigating period. The individual plant is usually more satisfactory from the standpoint that water may be available when needed. The expense, however, of installing and operating an individual pumping plant has frequently been beyond the farmer's means. It is apparent, therefore, that the water supply for irrigating a sufficiently large area to insure the growing of the necessary acreage of beets to enable a sugar mill to operate successfully is frequently the deciding factor in the growing of sugar beets. The problem of water supply should be considered carefully before any large sum of money is expended in the erection of a sugar mill

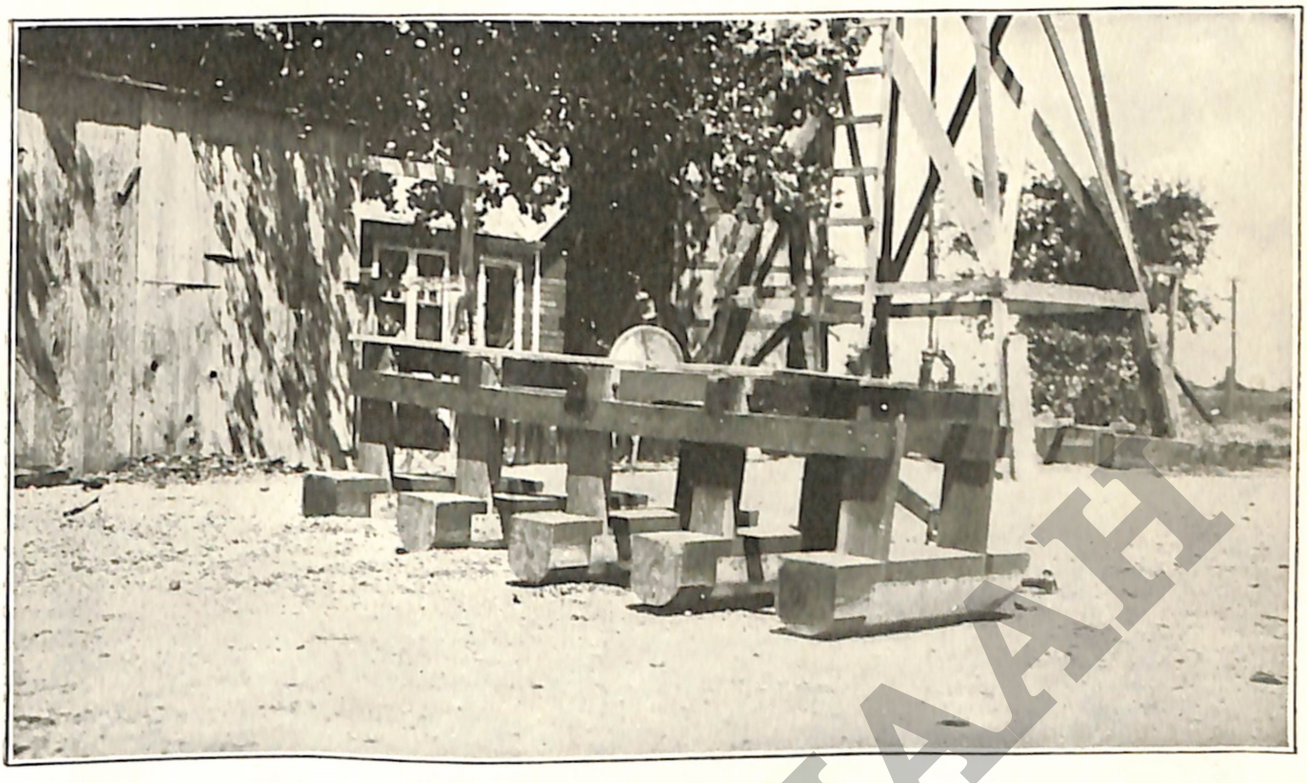

FIG. 1.—A SLEDDING IMPLEMENT USED IN SMOOTHING IRRIGATING FURROWS IN SUGAR-BEET FIELDS, BEING SOMETIMES HELPFUL IN DISTRIBUTING THE WATER.

FIG. 2.—A FLOAT USED IN LEVELING THE SEED BED FOR SUGAR BEETS.

FIG. 1.—PREPARING LAND FOR SUGAR BEETS BY PLOWING UNDER A CROP OF ALFALFA, ONE OF THE BEST GREEN FERTILIZERS WHEN THUS TREATED IN THE FALL.

FIG. 2.—HAULING SUGAR BEETS TO THE MILL, THE COST BEING GREATLY REDUCED BY GOOD ROADS.

in any locality in which irrigation is necessary to grow satisfactory crops of beets.

If the water supply in a given area will insure the growing of only 5,000 acres of sugar beets annually under proper crop rotation and under other conditions favorable to sugar-beet culture, it would not be advisable to build a mill having a capacity greater than 500 tons per day. It frequently happens that a large part of the water used for irrigating purposes is wasted either by badly constructed ditches or by improper methods of irrigating. Ditches are improperly constructed when they allow an excessive amount of seepage or when they are so easily clogged that they overflow. Under the methods in practice it is sometimes impossible to avoid using water on certain fields when it is really not needed. Occasionally the water is turned on from the reservoir, or the community pumping plant is put in operation before the water is actually needed by any of the growers. Much can be done to delay the first irrigation and to extend the time between irrigations by proper preparation of the seed bed and by proper cultivation. In most irrigated areas the actual water supply is limited, and in order to meet the crop requirements as nearly as practicable there should be no waste of water beyond the unavoidable losses due to seepage and evaporation.

Methods of irrigation.—There are two general methods of irrigating sugar beets, namely, by flooding, as shown in Plate III, figure 2, and by the furrow method, as shown in Plate I, figure 2. The first method is generally detrimental to sugar-beet production and is wasteful of water. In flooding the entire surface of the field more water is used than would be used by the furrow method. There is a much larger surface for evaporation. The air supply is cut off from the beet roots, and frequently as the ground begins to dry after a flood irrigation the surface forms a crust which further cuts off the air supply, promotes evaporation, and incases the beet plants in such a way that it is very difficult to cultivate or otherwise work the plants without doing some damage. It is argued that flood irrigation is necessary in certain sections where the slope of the land is slight, but it is seldom the case that the slope is not sufficient to enable the careful irrigator to use the furrow method, especially if proper laterals and cross ditches are used. In using the furrow method of irrigation a furrow is made between the rows of beets or between each alternate row and the next, as shown in Plate I, figure 2, and frequently this furrow is smooth or sledded out by an implement, as shown in Plate V, figure 1, which is drawn lengthwise through the furrow, leaving its surface smooth and well adapted to carrying the water. The water should be turned into these furrows, should be confined to them entirely without flooding the surface around the

beets, and should be allowed to flow until the soil is thoroughly wet. The head of water which is used in furrow irrigation must not be too large, as shown in Plate III, figure 2. The size of the head must be governed by the slope of the land, by the nature of the soil, and by the number of furrows that can be irrigated at one time.

Leveling.—In order that irrigation may be properly done the field must be carefully leveled, as shown in Plate V, figure 2. This is frequently a limiting factor on many fields and occasionally in an entire community. The lack of success in at least one sugar-beet area is due primarily to the failure of the growers to level the ground properly. It usually requires several years to level a field properly for furrow irrigation, for the reason that the depressions that are filled during the first effort to level the field will usually settle and still leave slight depressions, while the higher points from which the soil was removed to make the fills do not settle, and an unevenness results. If the leveling process is repeated for two or three years the ground generally becomes sufficiently level to admit of furrow irrigation. If the ground is very uneven the Fresno scraper may often be used to good advantage. In some localities the surface of the soil is by nature sufficiently level to admit of proper irrigation. In other sections the slopes are sufficiently long and the source of the water supply so high that it can be carried to the highest point and distributed over large areas without the expense of leveling the ground. In the process of leveling, the better surface soil is removed from the high point and carried to the depression. It is then necessary to improve the areas from which the better soil has been removed, either by the use of stable manure or a leguminous crop. Sometimes several years are required to make a leveled field uniform in fertility as well as in firmness of surface.

A very coarse soil, especially if it has a porous subsoil, is irrigated with great difficulty, and frequently much time and money are wasted in leveling such lands, as they are not adapted to the growing of sugar beets or other intensively cultivated crops.

DRAINAGE.

Drainage has an important bearing upon sugar-beet growing in general, as well as upon the production of other farm crops. Large areas of land that are now too wet to be cultivated could be put under tillage and would produce good crops if properly drained. Other large areas now under cultivation are in many instances becoming water-logged, especially in the irrigated sections, and will soon be unfit for crop production unless they are drained. In some instances the further expansion of the sugar-beet acreage is limited to the bringing in of areas through drainage.

Natural drainage.—Fortunately a large part of the tillable area now devoted to sugar-beet culture has a natural drainage. This may be due to one of several conditions.

(1) The surface of the ground may be sufficiently rolling to drain naturally. In some instances the slope is so great that the water passes off too quickly, and consequently the land is unproductive because of excessive surface drainage.

(2) Certain areas have a natural drainage due to a sloping subsoil. As previously noted, some areas have a subsoil that is more or less impervious to water. If the impervious subsoil is sloping, the water falling upon the surface soil will pass through to the subsoil and gradually disappear along the sloping subsoil. In this case natural drainage is satisfactory and needs no particular attention, provided the impervious subsoil is not too near or too far from the surface, and provided further that there is a natural outlet, so that the water will not eventually back up along the slope or incline of the subsoil.

(3) The natural drainage accomplished by means of a porous subsoil has been already noted. There are localities in which the subsoil is so porous that it is almost impossible to hold sufficient water in the seed and root beds to produce a crop of beets. There are therefore localities in which the natural drainage is of such a nature, either through a lack of moisture or through an excess of water, that natural drainage constitutes a limiting factor in sugar-beet production.

(4) On the other hand, there are areas and fields in which artificial drainage must be practiced in order to put the soil in condition for sugar-beet production. Several systems of artificial drainage are in general use.

The open ditch.—An open ditch constitutes one of the methods by which this limiting factor of excessive moisture is removed. It is the least expensive method of providing artificial drainage, especially from the standpoint of labor and material involved. However, considerable tillable ground is lost through the construction of open ditches. This loss is due to the space occupied by the ditch and by the ditch bank. In constructing an open ditch these points should be kept in mind, so that the least possible loss of tillable area will result. The open ditch constitutes a barrier which can not readily be crossed in the usual farming operations. It is advisable, wherever practicable, to construct these ditches along the edges of the field, along roadsides, and in places where they will interfere least with the farming operations. Sometimes it is necessary to cross the fields with ditches in order to drain the soil properly; in such cases the fields and ditches should be so laid out that the

ditches will run lengthwise of the field, thereby avoiding the crossing of the ditch in the usual farming operations. The size and depth of the open ditch will depend upon the length and fall of the ditch, the location of the subsoil, the amount of water to be carried, and the position of the outlet. The drainage ditch should always be deep enough to prevent any interference of the water table with the crop to be grown.

The blind ditch.—The most satisfactory method of artificial drainage is the blind ditch. In the construction of this ditch tile is used most commonly. Many fields that otherwise would not yield profitable crops have been reclaimed by the blind ditch. These ditches should be laid out very carefully with reference to direction, depth, and slope, so that the entire area under consideration will be drained thoroughly. The size of the tile is very important. Tiles that are too small must never be used. This is false economy, and it frequently results in added expense in that the small tiles must be taken up and replaced with larger ones. The tile should be large enough to carry off the water quickly in times of excessive rainfall, deep enough not to be disturbed by the plow or other implements, and laid so carefully that the ends will fit against each other evenly and a gentle and continuous fall should be provided, without depression or elevation. The outlet of the blind ditch should be kept open, that the water may flow freely.

SEEPAGE.

Seepage is closely related to drainage. Many fields or areas that otherwise might be profitable for crop production are rendered useless by seepage. This is especially noticeable in those areas where irrigation is practiced. Seepage is detrimental to the soil in several ways: (1) As a loss of water, especially in cases where water has been stored for irrigating purposes, and (2) through a loss of the use of the land, either because the soil is too wet for crop production or because of the accumulation of soluble minerals which are brought to the surface through seepage. The injurious soluble minerals usually are known as alkali.

Seepage from streams.—Some streams are so located naturally that a portion of the water seeps into the adjacent soil, forming marshes or waste places due to excessive moisture; this is especially true where the fields adjacent to the stream are low, level, or underlain with an impervious subsoil. The nature of the bank of the stream is of importance in this connection. If the overflow at flood time is prevented by the construction of dikes the land may be made productive by drainage. Usually these marshlands when drained are very fertile and produce good crops, though they are not always the best for sugar-beet production, since they sometimes produce large roots low in sugar.

Seepage from ditches.—It is sometimes necessary to construct irrigating ditches higher than the surrounding area, to carry the water across low places or to carry it long distances. It is very common for the water to seep through the ditch bank in such cases and to saturate the surrounding fields, especially if the soil in those fields has a high water-holding capacity. Ditches constructed of clay or other close-textured material allow less seepage than ditches constructed of sandy or other porous material. In the case of sandy ditches the holding capacity may be increased very greatly by oiling the surface of the ditch with crude oil; this can be applied economically only in those localities not far removed from the source of oil supply. Where the oil is available it may be spread over the inner surface of the ditch when the ditch is empty and should be allowed to soak into the soil before the water is turned into the ditch. A second or even a third application of the oil will improve the condition of the ditch. Ditches treated in this manner will carry water with almost no seepage, and when the work is done properly the oiled surface will frequently last for several years. If the oil is spread over the ditch bank, weed growth will be prevented, or at least decidedly retarded. There is always some seepage from the ordinary untreated earth ditch, and the amount of damage done by this seepage will depend upon the nature of the ditch and the soil of the adjacent fields. The seeped areas may sometimes be rendered tillable by drainage.

Seepage from earth reservoirs.—The area of land damaged by seepage from earth reservoirs is less than that from ditches, but the total is considerable and is usually progressive; that is, a small area first appears to be water-logged and this gradually increases from year to year until large areas involving fields and sometimes entire farms are destroyed. Seepage from reservoirs depends upon the construction of the reservoir and upon the nature of the surrounding country. Reservoirs are sometimes constructed in mountainous areas for the purpose of catching and storing flood waters due to melting snows. Generally the location of these reservoirs is such that no tillable soil is injured through seepage; the only loss in such cases is caused by the quantity of water which seeps away and becomes unavailable for irrigation purposes. In other instances reservoirs are constructed of cement, which is nearly impervious to water, and consequently little or no loss from seepage results. The serious injury due to seepage from reservoirs takes place in those localities in which the reservoirs are constructed entirely or in part of earth and in which the surrounding country is composed of tillable land; in such cases the loss due to seepage is sometimes of considerable importance.

Alkali.—As already indicated, one of the serious results of seepage is the accumulation of alkali in the surface soil. In such cases

there must be more or less alkali dissolved in the water. As this water rises to the surface of the soil it brings with it the salts held in solution. After the water evaporates from the surface of the soil the alkali remains, and it may eventually accumulate to such an extent that crop production is greatly reduced or rendered entirely impossible. This condition is a limiting factor in the production of sugar beets as well as other crops in certain portions of the sugar-beet area. The sugar beet is one of the most alkali resistant of our farm crops, but even with this plant the limit of endurance is sometimes reached or exceeded, and beet growing becomes unprofitable. Alkali in the seed bed is especially troublesome, since the young plants are very tender and therefore susceptible to this and other adverse conditions. If the beet plants are well started before the alkali accumulates in the surface soil, much less damage will be done, as the subsequent growth of the plants is less affected by the same amount of alkali. The alkalinity of a soil may be reduced by the use of irrigation water, provided the irrigating water is comparatively free from alkali and a satisfactory drainage system has been established.

SOIL FERTILITY.

Elements of plant growth.—By fertility is meant the ability of the soil to produce a good crop. The difference between a rich soil and a fertile soil should be kept in mind—that is, a soil is rich if it contains a considerable quantity of each of the elements required by the plant in the process of growth. Unless, however, these elements are available to the plant and the physical conditions of the soil are such as to promote plant growth, the soil cannot be said to be fertile. If a single element required by the plant, though present, is not soluble, this condition will render the soil infertile. In order that an element may be available to the plant, it must be soluble, and it must dissolve rapidly enough to supply the plant with that particular element as rapidly as the plant requires it. Certain elements are always available when present; other elements must be acted upon by certain substances under certain conditions in order to become available or soluble. It is apparent, therefore, that fertility is one of the limiting factors in the production of sugar beets as well as of other crops.

The sugar beet requires the same elements of plant food that are required by other field crops, but in slightly different proportions; for example, a 10-ton crop of sugar beets (which is approximately the average yield for the United States) will require about 30 pounds of nitrogen, 14 pounds of phosphoric acid, and 71 pounds of potash; a wheat crop, yielding 20 bushels per acre, will require 41 pounds of nitrogen, about 13 pounds of phosphoric acid, and 17 pounds of

potash; a corn crop, yielding 40 bushels of ears to the acre, will require 56 pounds of nitrogen, 21 pounds of phosphoric acid, and 23 pounds of potash; clover yielding 2 tons of hay per acre requires 83 pounds of nitrogen, 18 pounds of phosphoric acid, and 88 pounds of potash. These elements are required by all field crops, and, in addition to these, seven other elements are required in much smaller quantities. These elements are always present in agricultural soils in larger or smaller quantities. The two questions, therefore, with regard to soil fertility, so far as the composition of the soil is concerned, are whether the required elements are present in sufficient quantity to produce the desired crop and whether the elements are available or soluble in such quantity and at such time during the growing season as the plant requires. In addition to the presence of these elements, as indicated above, the soil must be in proper physical condition to promote plant growth in order to be fertile. In the production of sugar beets a moderately fertile soil is required. If the soil is lacking in fertility the roots may be too small to produce sufficient tonnage to make the crop profitable to the grower.

Under ordinary farm conditions there is little danger of the soil being too fertile for satisfactory beet growing. Occasionally spots are so fertile that large roots low in sugar are produced, as, for example, an old feed lot, a barnyard which has been turned into a portion of the field, or a spot where an old straw stack has been left to decay. These areas are small and insignificant when compared with the total sugar-beet acreage in the United States, but they sometimes have an important bearing upon the results on an individual farm, especially where the sugar-beet acreage on that particular farm is small. The greatest danger from the standpoint of fertility arises from the lack of those physical conditions or the absence of available plant foods to produce large yields. The principal problem, therefore, in this connection lies in the improvement of the fertility of the soil. Soils may be rendered infertile through natural causes, such as leaching, and through artificial causes, such as single cropping, improper crop rotation, and the improper proportion of live stock to crop production. One of the principal methods that may be employed to increase soil fertility is the addition of humus to the soil, either in the form of stable manure or of green crops plowed under.

Stable manure.—One of the most satisfactory methods of supplying humus to the soil is the proper use of stable manure. A close relation should exist between the number of live stock on the sugar-beet farm and the acreage under cultivation. Studies in practically all parts of the sugar-beet area indicate that the number of live stock on most farms is too small for the most profitable production of crops and is usually below the possibilities in both live stock

and crop production when we consider the number of acres under cultivation and the satisfactory crops that the tillable area is capable of producing when properly fertilized and tilled. Furthermore, a considerable portion of the stable manure produced on most sugar-beet farms is wasted or rendered only partially effective either by not giving it proper care or by the method in which it is handled in connection with crop production. In addition to the humus contained in stable manure, considerable quantities of plant food are present, which, if properly handled, add to the fertility of the soil. This plant food is largely soluble; consequently the leaching process to which the stable manure is in most cases subjected, owing to the fact that it is usually exposed to rains and snows, frequently causes much of the fertility to be lost. Again, stable manure is often spread upon the fields and left exposed to the weather, until a large part of the volatile plant foods has passed off into the atmosphere. Much of the nitrogen is often lost in this manner. The best results in utilizing stable manure in connection with sugar-beet production are obtained by applying the manure to the crop preceding the beet crop; this allows the manure to be thoroughly worked into the soil. It is a common practice in many localities where manure spreaders are not used to haul the manure from the feed yard or stable at times when there is no urgent work to be done and to dump it in piles, to be spread at some convenient time before the ground is plowed. This is a wasteful method, especially if the piles are left for some days or weeks without spreading, often resulting in much loss of valuable material through leaching. However, this method is preferable to spreading the manure and leaving it on the surface of the ground exposed to the action of the sun and wind. If the manure is spread and the ground can not be plowed immediately, it should be disked whenever practicable; that is, if the ground is not frozen. Fortunately, the manure spreader is becoming more and more common, and where the number of live stock on the farm warrants it there is probably no other implement of greater value to the farmer. The full value of the spreader is not realized, however, unless the manure is plowed under or worked into the soil immediately after spreading.

Green crops.—Green crops plowed under provide another source of humus for soil improvement. Any vegetable matter plowed under and worked into the soil will add humus, though certain crops are more valuable for this purpose than others, because of the plant food as well as the vegetable matter which they contain. Such crops as peas, beans, clover, and alfalfa, are among the best for supplying humus to the soil. These crops should be plowed under in the fall so that they will have abundant opportunity to decay before the growing season begins the following year. In irrigated sections

the ground should be irrigated thoroughly, if necessary, before plowing, so that there will be sufficient moisture in the soil to bring about the desired change in the crop plowed under. In the case of such crops as clover and alfalfa, usually one or more cuttings are made for hay, and the later growth is plowed under when it has attained the height of 1 to 1½ feet, as shown in Plate VI, figure 1. If cowpeas are used for green manure they are usually planted in midsummer and plowed under when they have attained their normal growth in the fall. All crops when used for this purpose should be plowed under while they are still green.

If for any reason a leguminous crop can not be grown for green manure, other crops, such as oats, rye, barley, or even sorghum, may be used. Maintaining the humus in the soil is more difficult in the irrigated than in the humid sections of the country. The climatic conditions, especially the hot winds, seem to have a decidedly reducing effect upon the quantity of humus in the soil. Humus in irrigated sections is doubly important, since it is necessary not only in maintaining and improving soil fertility, but it also has a decided advantage in increasing the water-holding capacity of the soil.

The green crops will add little material not already in the soil. They may, however, bring up the elements required for plant growth from considerable depths and when plowed under deposit them in soluble form in the surface soil. For this reason deep-rooted crops are to be preferred for soil improvement to those more shallow rooted. At any rate some deep-rooted crops should be included in each rotation system. The legumes may increase to some extent the nitrogen content of the soil, and stable manure, if applied in sufficient quantity, will supply at least a part of the necessary plant foods besides adding some humus to the soil.

Commercial fertilizers.—If the required elements are not present in the soil, or if present are not readily available, they should be supplied in the form of so-called commercial fertilizers. The composition of the fertilizer used will depend upon the requirements of the crop to be grown and upon the condition of the soil which is to be used for crop production. From the figures given above it is apparent that a sugar-beet or clover crop should have an abundant supply of potash, while for a wheat or corn crop special attention should be given to the nitrogen supply. A complete fertilizer consists of nitrogen, phosphoric acid, and potash. Compounds containing these elements are mixed in different proportions for different crops and for different soil requirements. It frequently appears that a complete fertilizer is not required. For example, there may be present in the soil an abundant supply of available potash, but the supply of nitrogen and phosphoric acid may be deficient. In that case a fertilizer containing the required amount of nitrogen and phosphoric acid only

should be applied. Under certain conditions commercial fertilizers do not seem to be effective. This may be due to the fact that the fertilizer elements are not used in the proper proportions, or it may be due to the physical condition of the soil. The greatest benefits are obtained from commercial fertilizers when the soil is well supplied with humus. There should, of course, be a sufficient supply of moisture in the soil to dissolve and hold in solution the plant foods that are already present or that may be supplied in the form of a commercial fertilizer. The benefits arising from the use of fertilizers, whether stable manure, green crops, or mineral compounds, are frequently noticeable over a period of several years; hence, in estimating the value of a fertilizer the results of several seasons' crops should be taken into account.

CROP ROTATION.

Occasionally a farm is found on which beets are grown on the same field year after year. While this seems to give satisfactory results for a time in some instances, it is in general a poor method and one that can not be recommended, since it tends to encourage the development of certain sugar-beet pests which eventually render the crop unprofitable. The rotation practiced in the various sugar-beet areas must necessarily depend upon the crops that do best or are most profitable in these several localities, as well as upon the crop and live-stock requirements of the farm. In some areas, for example, the Irish potato is a profitable crop and forms an important link in a system of rotation with sugar beets. In other areas the Irish potato is not successful, and in such sections it would be a waste of time and money to undertake to utilize it in rotation with sugar beets. Again, there are areas in which the muskmelon is very satisfactory and rotates well with sugar beets or other crops; in other parts of the sugar-beet territory the muskmelon can not be grown with success. In planning the rotation, therefore, one must have in mind not only the crops that will rotate well with sugar beets, but also the success of those crops independently. The grower must also consider the practicability of handling such crops from the standpoint of his returns; for example, in some sugar-beet areas alfalfa gives good yields, but because the hauls are so long the value of the alfalfa under normal conditions is not sufficient to pay the transportation charges and leave a reasonable profit. Therefore, unless there is an abundance of live stock to utilize the alfalfa locally or unless it is needed as a soil improver, it is not a satisfactory rotation crop in certain localities in spite of the fact that it produces satisfactory yields. Our studies of the various sugar-beet sections indicate that live stock is an important factor in crop rotation on the sugar-beet farms. As already indicated, certain crops can be grown

to advantage if there is an abundance of live stock to utilize them. Even if certain crops could be sold from the farm at a reasonable return above the cost of production, it would be poor policy to sell them, for the reason that by so doing a large amount of plant food would be shipped away. Live stock, if properly handled, enable the farmer to keep a larger proportion of the plant foods on the farm than could be done if the crops themselves were removed. Feeding the crops on the farm is the best practice and will generally yield the largest returns per unit of land and per unit of labor, especially if the proper relations between crops, live stock, land area, and labor are established. It is apparent, therefore, that several objects may be accomplished by proper crop rotation, all of which must be kept in mind in order to reap the greatest returns from the sugar-beet farm.

Effect on the soil.—As has been previously noted, all plants require certain plant foods, and these elements are utilized by different plants in different proportions. The rotation of crops insures a better utilization of these plant foods than can be obtained by growing a single crop. Certain crops are deep rooted, while others are more shallow. The deep-rooted crops tend to stir the soil to a greater depth and in this way make the plant foods more readily available for the shallow-feeding crops. Certain crops aid in the production of certain plant foods, as, for example, the leguminous crops store nitrogen, which is rendered available to the other crops grown in rotation with the legumes. Again, certain crops require more or less cultivation, as is the case with sugar beets. This stirring of the soil tends to expose the plant foods to the action of the elements, thereby rendering the mineral material available for the use of the beet plants and the plants of succeeding crops.

Relation of pests to crop rotation.—The rotation of crops tends to reduce or to destroy those pests which depend upon certain plants for their existence. As is well known, some plant pests live and thrive only on certain plants. If these plants are grown year after year in the same field, they furnish favorable breeding conditions for the propagation and increase of these pests. By changing to other crops, plants upon which the pests can not live or upon which they do not thrive may be grown and the pests thereby destroyed or reduced to a minimum. Frequently the pests have resistant forms or stages in which they can exist in a dormant condition for several years, as is notably true of the brown-cyst stage of the sugar-beet nematode and the resting-spore stage of certain fungi. In such cases it is necessary to plan the rotations with a view to starving out these pests. To do this the rotations must be of such a length that crops upon which these pests can not thrive may be grown for several years in succession. In some cases other methods must be resorted

to in order to control the destructive pests, but a large number of the sugar-beet pests, including some of the fungi and bacteria as well as insect pests, may be controlled by crop rotation.

Effect of sugar beets upon other crops.—As a rule, the effect of sugar beets upon succeeding crops is beneficial. This is especially true of the small grains; that is, small grains grown after sugar beets will almost invariably produce larger yields than when these grains follow other crops. The sugar beet does not gather nitrogen from the air and transform it into plant food, but, owing to its long main root and its uneven feeding rootlets, it gathers a considerable quantity of several soluble mineral salts and stores them in the beet crown, and when the beet tops are fed to live stock and the manure returned to the soil considerable fertility is added. In addition to this improved fertility of the soil the methods of cultivation employed in growing and harvesting the beet crop put the soil in splendid tilth, thereby forming good seed and root beds for the crops that follow the beets. Although sugar beets are grown primarily for the cash value of the roots as a source of sugar, the feeds obtained from the beet tops, molasses, and pulp, and the increased fertility and improved tilth of the soil are recognized as indirect benefits to the beet growers, and are important factors in considering the advisability of growing sugar beets. These indirect benefits due to sugar-beet growing have only a remote bearing upon the price paid for beets and upon the price of sugar. They should, however, be considered in figuring the profits derived from sugar-beet culture.

COMPETING CROPS.

Crops grown in competition with sugar beets may or may not be suitable for rotation with sugar beets. By competing crops is meant those crops grown in sugar-beet areas which appear to be more profitable or more easily produced, or for some reason are so favored by the farmer that he may possibly prefer them to sugar beets. Some of the competing crops do not lend themselves readily to a rotation with sugar beets. In such cases the competing crops may be a limiting factor in sugar-beet production on an individual farm, or if the crop is a general one it may be a limiting factor in sugar-beet production in a given community. A crop may compete with sugar beets because of its market price, because of the small amount of labor involved in its production, because of the peculiar fitness of the soil for the growing of that crop, because of local market conditions, or because it fits more closely the requirements of the individual farms than any other crop. The competing crops in the sugar-beet sections are beans, tobacco, potatoes, muskmelons, alfalfa, and grains. Other crops may temporarily be competing with sugar beets, and some of those mentioned may for local or other reasons temporarily cease to be compet-

ing crops. Most of the competing crops may form a satisfactory crop-rotation system with sugar beets in one or more of the recognized sugar-beet areas.

Beans.—In the farm-to-farm survey of the Office of Sugar-Plant Investigations beans have been found as a competing crop in several localities, and under certain conditions it is one of the strongest competitors. This crop is easily produced and brings a fair return to the farmer for the labor and money invested. In some of the areas studied beans have ceased to be a competing crop because of local conditions, chief of which is the presence of certain bean diseases. It was believed that beans could follow beans profitably in the same field for a number of years, but this, like all other crops, is more satisfactory in the long run when grown in proper rotation with other crops. As in the case of sugar beets, continuous cropping with beans has enabled certain diseases of the bean to be propagated from year to year, thereby becoming more widespread and more destructive, until bean production in certain areas is no longer profitable. If properly handled, beans should be a good crop to rotate with sugar beets. They should not compete with the sugar beet to the exclusion of the latter, for the reasons above stated. The diseases affecting sugar beets and beans are for the most part very different, and for this reason these crops rotate well together. Again, the sugar beet leaves the ground in good condition for the production of the bean crop. If the beet crop has been properly handled the weeds are eliminated, and in this respect the field is left in a good condition for beans. Furthermore, sugar beets leave the ground in good physical condition for a bean crop; on the other hand, if beans precede beets they will leave the ground in good condition for the sugar beets. The order of rotation, therefore, with these crops is not particularly important.

Tobacco.—Tobacco is not generally grown in the sugar-beet areas, but there are a few localities in which both tobacco and sugar beets are produced. Though the tobacco crop is expensive to handle, the returns under favorable conditions make it a strong competitor. The methods used in growing tobacco do not usually lend themselves well to crop rotation; for example, tobacco fields are usually heavily fertilized with commercial fertilizer. Part of the results to be expected from these fertilizers should be apparent during the second or even the third year after they are applied. Owing to this large expense growers usually expect to use the same field for the tobacco crop for a series of years, consequently it does not admit of ordinary crop rotation. Again, the tobacco crop requires a large amount of labor, some of which conflicts with the labor necessary for sugar-beet production. If, however, a farmer can obtain sufficient labor

to handle both crops there should be no serious difficulty in producing both sugar beets and tobacco, especially if these crops are produced on comparatively small areas on the individual farm. It may be found, also, that these crops will rotate one with the other to the advantage of both.

Potatoes.—In certain areas studied, the potato under present conditions is one of the strongest competing crops with sugar beets. Where these crops are grown in rotation, however, the results, from the standpoint of yield, are satisfactory. Unfortunately, certain diseases affecting potatoes attack sugar beets also; this is notably true of the scab. When the price of potatoes is high the tendency in the especially good potato areas is to increase the potato acreage and to diminish the sugar-beet acreage correspondingly. The chief danger is that when an extra-large potato crop is harvested the price usually drops, and the results are somewhat disappointing. It should be noted in this connection that the prices paid for sugar beets are fixed in practically all cases before the seed is planted. The returns from this crop depend not only upon the yield, but upon the quality of the beets produced and upon the wholesale price of sugar. As already indicated, sugar beets and potatoes form a part of a satisfactory rotation, but neither of these crops should immediately succeed or follow the other, because of the diseases that are common to both plants. There should be one or two years of intervening crops, such as small grains or alfalfa.

Alfalfa.—In some localities studied, alfalfa has appeared to be a strong competing crop with sugar beets. This is true in part because of the tendency to leave alfalfa sod without breaking for a number of years, thereby making a very long rotation or, in some cases, what amounts to no rotation; for example, certain areas have been found in which alfalfa has remained undisturbed in some fields for upward of 20 years. Alfalfa is an inexpensive crop to produce, provided a good stand is obtained. This is not difficult if the ground is well prepared and properly handled at seeding time. After the alfalfa has become established the expense of maintaining the crop is slight, and the chief expense in connection with alfalfa production consists in irrigating in certain sections and in harvesting and marketing the crop.

In some sections where alfalfa grows well it is not a competing crop with sugar beets, because of the remoteness of these areas from the market or because it is not fed locally to advantage; but in cases where the alfalfa is used locally to advantage or where the markets are accessible it may compete strongly with the sugar beet and may exclude the latter to such an extent that the beet acreage will be so small that the profitable operation of a sugar mill is not possible; for a sugar mill should have a sufficient quantity of beets to

insure a run of at least 100 days each year, though the average run for 1920 was only 91 days. (Table IV, p. 6.)

Sugar beets may be grown in rotation with alfalfa to good advantage under certain conditions, and our studies have shown the advantage of these conditions in several instances. This is especially true if the farmer looks upon the alfalfa crop as a soil-improving crop as well as a crop from which direct satisfactory returns may be expected. In such cases alfalfa may be grown two or three years, and at the end of this period the last crop of alfalfa is plowed under for the improvement of the soil, thus putting it in good condition for one or two crops of sugar beets. It is not desirable to grow sugar beets immediately after old alfalfa, because the old alfalfa roots are large and woody and interfere seriously with cultivation. It is better to follow old alfalfa with a noncultivated crop, such as small grain, which in turn may be followed by sugar beets.

Fruit.—In several sugar-beet areas fruit has been found to be a competing crop. In several instances the sugar beet has been eliminated or shifted to other areas, or reduced in area below the point of a profitable mill run. It is sometimes possible to grow considerable areas of beets in orchards when the trees are small, but as the orchards get older and the trees increase in spread of branches and roots the vacant space between them must necessarily become smaller and smaller until finally the sugar beet is excluded. When fruit growing has become general in a sugar-beet area, as has been the case in several instances in certain localities, sugar-beet growing and diversified farming in general have been practically eliminated. Occasionally some misfortune overtakes the fruit industry, and the area again returns to general farming, including sugar beets. In one locality studied the entire cycle has been passed through, and the fruit growers are now removing their trees and returning to general farm practice, including the growing of sugar beets.

FARM EQUIPMENT.

The equipment on the sugar-beet farm is a matter of vital importance. It covers a wide range but may be grouped under four general heads, namely, soil and water, implements, live stock, and labor. If a farm is lacking in any of the essential parts of the equipment, and if these parts can not be supplied, successful sugar-beet growing is not possible. The equipment differs to some extent in different localities, especially between the humid and irrigated sections. Soil and water are not usually listed as a part of the farm equipment, but are included here in order to emphasize their importance in crop production.

SUITABLE SOIL.

As previously noted, a suitable soil, together with a satisfactory subsoil, is one of the first requisites in the production of sugar beets. Although soil is not usually classed as a part of the farming equipment, it is in fact a very essential part. If the soil is very sandy or extremely rocky, it is not probable that it would pay to undertake the growing of sugar beets. Certain conditions of soil may be changed or modified by proper cultural methods, so that an otherwise unfavorable soil condition may be changed to a sufficiently favorable condition to enable the farmer to produce a satisfactory crop of beets; for example, a hard subsoil may sometimes be broken up in such a manner that a sufficiently deep soil for the production of beets is produced. Again, an infertile soil due to lack of humus, to a scarcity of lime, or to improper crop rotation, may be remedied at a small cost and an otherwise unproductive soil rendered productive. As already noted, a soil containing an excess of moisture or one in which the water table is too near the surface may be made productive by proper drainage. It is apparent, therefore, that soil, from the standpoint of equipment, may be a permanent limiting factor, which in some cases can not be overcome sufficiently to enable the farmer to produce a satisfactory crop of beets, while, on the other hand, this part of the farmer's equipment may be modified in many cases by proper treatment and the barrier to sugar-beet production removed. This part of the farm equipment, however, like work stock, implements, and labor, is just as essential for the production of other crops as for the production of sugar beets.

IMPLEMENTS.

Many of the implements used in sugar-beet growing are the same as those used in the production of other crops, though some special implements are necessary in order to grow sugar beets successfully; this is especially true of the drill shown in Plate I, figure 1, and the cultivator, Plate IV, figure 1.

Drills and cultivators.—Sugar beets are grown in rows about 20 inches apart, and there is a special drill for the planting of sugar-beet seed. There are several sugar-beet drills on the market which seem to be fairly satisfactory. In some localities the farmers own their beet drills, and in others they are owned by the sugar companies and rented to the farmers at a small charge per acre. Most of the drills made for planting sugar-beet seed are so constructed that they will plant four rows at a time, as shown in Plate I, figure 1. Likewise, the cultivator is especially adapted to sugar-beet work, and will cultivate four rows corresponding to the drill. This is very important, as will be noted by those who have had experience in using a cultivator in such narrow rows. In planting four

rows at a time many deviations from a straight line will occur in each of the four rows, which can, therefore, be followed more readily with a 4-row cultivator with less damage to the plants. The beet cultivators are usually equipped with various implements for stirring the soil, destroying weeds, and forming a mulch, depending upon the soil conditions and the size of the beets.

Plows.—The ordinary walking or riding plow can be used in turning the soil in the preparation of the seed bed. The 2-way plow is well adapted to the sugar-beet crop, for the reason that it produces neither back furrow nor dead furrows. This is especially important in the irrigated areas. In some localities the disk plow is frequently used, although the ordinary moldboard plow is in most common use in sugar-beet areas. The advantage of the disk plow for deep plowing is that it enables one to stir the soil to a good depth if the plow is properly constructed and adjusted, without bringing too much raw soil to the surface. The plows in use vary from the walking moldboard plow through various types of sulky plows to the disk plow with its numerous variations. In some types of soil it is especially desirable to give an occasional deep plowing.

Best results are generally obtained by fall plowing for sugar beets. The farm-to-farm survey as well as the experience and observation of the Office of Sugar-Plant Investigations indicates that fair results may be obtained by spring plowing, provided the soil has been previously in good tilth.

Harrows.—In preparing a seed bed for any crop the disk harrow is a valuable implement. It is frequently used to advantage before the ground is plowed. When so used it puts the surface of the ground in such condition that holes or spaces are nowhere left when the ground is turned with the plow. The disk harrow is used sometimes in breaking up lumps or clods after the plowing has been done; however, if the ground has been plowed when in good condition and has been properly treated after plowing there will be no large lumps or clods for the disk harrow to break. In case weeds start before the time for planting the sugar-beet seed the disk harrow is sometimes useful in destroying them. In some instances in which beets have been followed by beets good results have been obtained by omitting the plowing and simply disking and harrowing in the preparation of the seed bed in the early spring. The proper preparation after the ground is plowed consists in harrowing, preferably with a spike-tooth harrow or other form of this implement, which simply stirs the surface of the ground and makes a moderately fine mulch. It is a more or less common practice to harrow at the end of each half day or, at the latest, at the end of each day the ground just plowed. This is a practice to be especially recommended in cases of spring plowing, since it has a tendency to hold the moisture in

the soil, thereby leaving it in good condition to form a satisfactory seed bed. In case of fall or winter plowing it is better to leave the ground rough, in order that it may catch or hold the winter snows and rains.

The scraper and float.—In the irrigated sections leveling is sometimes necessary to put the ground in condition to be irrigated. As pointed out on page 10, ground which is not level or nearly so can not be satisfactorily irrigated. This is especially true with a crop like sugar beets, which must be irrigated by the furrow method. If the ground is leveled before the plowing is done, a scraper is commonly used. If the leveling is left until after the ground is plowed, an implement called a float is frequently used; this consists of two planks placed on edge and so framed together, about 6 or 8 feet apart, that they can be dragged sideways over the field as shown in Plate V, figure 2. This has the advantage of not only leveling the ground, but it tends to break up the small clods and puts the ground in good condition for further preparation of the seed bed. Frequently the Fresno scraper is used before plowing if the surface is very uneven, and the float is used after plowing in the same field. The two operations are quite distinct; the former is usually called scraping and the latter leveling. The scraping is necessary only when inequalities in the surface of the field are very marked. The time and labor spent in leveling will be repaid in the production of sugar beets, both from the standpoint of yield and from that of labor saved in irrigating.

The roller.—Another implement of considerable importance in sugar-beet growing is the roller. There are two types of this implement, as shown in Plate II, figures 1 and 2, namely, the smooth roller and the so-called corrugated roller. The latter is desirable in those localities where there are high winds, since the corrugations tend to prevent the soil from shifting under the influence of the wind. The chief advantage of the roller is its surface-packing effect. If the root bed is inclined to be loose the subsurface packer should be used immediately after plowing. As previously noted, the seed bed for sugar beets should be decidedly firm, for the two reasons, at least, that the firmness of the seed bed tends to hold the moisture, and at the same time prevents the sinking of the drill wheels, which would frequently result in planting the seed too deep. The seed bed that is unevenly firm or in which there are soft spots or areas is always unsatisfactory, as it results in an uneven start of the beet plants, which interferes with the handling of the crop.

Harvesting tools.—At harvest time the beet lifter, a special implement not required in harvesting other crops, is necessary. (Pl. VII, fig. 1.) There are two forms of this implement, namely, the double-pointed lifter and the side lifter. In the former, one point

passes along each side of the beet root at a depth of several inches below the surface and is so constructed that the beets are loosened and slightly lifted. (Pl. VII, fig. 2.) The side lifter passes along one side of the beet row and loosens the beet, usually without lifting it; in either case the roots, after they have been loosened, can readily be pulled and thrown into piles. Care should be taken in using these lifters to see that the beet roots are not broken, as considerable loss frequently results to the grower from the breaking of the roots, causing the lower part of the beet to be left in the ground.

In topping beets by hand, heavy knives closely resembling large butcher knives are used; in some localities sickles are used for the purpose. This work, now done by hand, as shown in Plate VIII, figure 1, may be done by machinery. (Pl. IX.) In loading the beets on the wagons, forks specially constructed with a knob of metal on the end of each tine should be used, so that the beets may not be punctured when they are forked onto the wagon. Special beet racks, as shown in Plate VI, figure 2, and Plate VIII, figure 2, are commonly used in hauling the beets to the factory or dump. These special racks are necessary in facilitating the unloading of the beets at the dumps, where the beets are emptied from the wagons onto the cars. (Pl. VIII, fig. 2.) If the beets are forked from the wagon the ordinary wagon box may be used, but generally the beets are dumped, in which case racks with hinged sides are necessary. Furthermore, the special rack holds more roots than the ordinary wagon bed, thereby reducing the cost of delivering the crop.

Sugar-beet harvester.—Heretofore the most laborious operation connected with beet culture has been the harvesting. This operation consists of three parts, lifting, pulling, and topping, as described above. The pulling and topping have been done entirely by hand at a cost of $7 to $9 per acre. Many attempts have been made in this country and in Europe to construct a mechanical harvester. Recently several types of this implement have been improved, and it is expected that they will be available to harvest at least a part of the 1921 acreage. One type of harvester, as shown in Plate IX, figure 1, is a motor-driven device which lifts the beets entirely out of the ground and tops and piles the roots. Another type of harvester, as shown in Plate IX, figure 2, is a horse-drawn implement which tops the beet and then lifts the root. Each implement is operated by one man; hence, the saving in labor and in labor cost are considerations that appeal to the beet grower.

LIVE STOCK.

The live stock on the sugar-beet farm should consist of work stock and other animals. One of the most important parts of the necessary

equipment on a beet farm is the work stock, which should be sufficient in number, size, and quality to handle the work readily. For the heavy work, such as deep plowing, lifting, and hauling the beets, heavy work animals, similar to those shown in Plates II, V, and VI, are desirable. Work stock of proper size and quality, therefore, are an essential part of the equipment. The horses should be trained to follow rows when cultivating. Large animals, properly trained and handled, will do this work without injury to the beets and may be used unless small animals are available for this purpose.

Apparently the tractor is taking the place of work animals in some localities for many of the operations on sugar-beet farms. A farm tractor should be of simple and durable construction, moderate in price, easily and cheaply operated, and capable of making fair speed when required.

Animals, in addition to work stock, are essential on the sugar-beet farm in order to utilize to the best advantage the beet tops and pulp, as well as the feeds grown in rotation with the beets, and also to furnish the necessary farmyard manure required to keep up and improve the fertility of the soil. The particular kind of stock, whether dairy cows, beef cattle, sheep, hogs, or poultry, will depend upon the locality, especially with reference to the markets, upon the kind of labor obtainable for handling the stock, and upon the other farm crops adapted to that particular locality.

LABOR.

The question of labor on a beet farm is of vital importance, and the lack of labor to handle beets at the proper time will constitute a limiting factor in sugar-beet production. Other things being equal, the beet grower with sufficient dependable labor of good quality at his command will handle the crop to the best advantage. For those growers who have not a sufficient amount of labor available for the production of sugar beets in addition to the other farm work, the sugar companies will usually undertake to obtain laborers. These laborers usually are transient, coming into an area at the beginning of the growing season, caring for a given acreage of beets during that season, and returning to their homes after the beets are harvested. In some instances they go out year after year to work in the same locality and for the same farmers. Frequently they rent land after a few years of experience and remain in the community throughout the year; such workers sometimes purchase land, thereby becoming landowners and employers of labor. The labor imported into an area for work in connection with sugar beets is handled under contract at a fixed price per acre. Before he leaves his home the laborer demands a contract stipulating the acreage that he will be

FIG. 1.—LIFTING THE BEETS, THE FIRST OPERATION IN HARVESTING THE CROP BY HAND.

The lifter is sometimes provided with a riding attachment.

FIG. 2.—ONE TYPE OF SUGAR-BEET LIFTER USED IN SOME LOCALITIES.

This illustration shows the construction of the lifting parts, which are raised out of the ground in turning at the end of the row.

FIG. 1.—PASTURING BEET TOPS AFTER THE ROOTS HAVE BEEN HAULED AWAY

FIG. 2.—FEEDING BEET TOPS AND BEET-TOP SILAGE IN RACKS.

This is the most economical method of handling this class of feeds.

allowed to handle and the price per acre that he will receive for the labor. Labor problems are more fully treated on pages 42 to 44.

BEET BY-PRODUCTS AND LIVE STOCK.

Live stock constitutes an important factor in the success of beet growing from two standpoints: (1) The utilization of beet tops and pulp and (2) the production of stable or barnyard manure.

Kind of live stock to feed.—Sugar-beet tops and pulp are good feed for all kinds of live stock, including chickens, hogs, sheep, cattle, and, to some extent, horses. Generally the tops and pulp are fed to sheep and cattle. There are several methods by which the beet tops may be utilized for feed. They may be pastured off, a process which consists in turning the live stock into the beet field after the beets have been harvested and the roots removed, as shown in Plate X, figure 1. The tops are left scattered over the ground, and this method of feeding results in the ground being more or less trampled. Sheep especially are inclined to travel more generally in paths, thereby trampling the ground unevenly. In no case should the pasturing of the tops be permitted when the ground is wet, since the ground itself would be seriously injured by trampling in that condition and many of the tops would be wasted by being trampled into the ground. While live stock thrives on beet tops and pulp, other feed must be used in finishing the animals for the market. Beet tops, especially the crowns, contain considerable mineral matter which is beneficial to live stock, but it should not be fed in too large quantities.

The tops are sometimes allowed to cure partly and are then gathered into piles, hauled to the feed yard, and fed in racks, one form of which is shown in Plate X, figure 2. This is a much more economical method of utilizing the tops, but it involves the additional expense of gathering and hauling. The tops may also be used as ensilage. When chopped with straw, cornstalks, or other roughage excellent silage is produced. Both the tops and the pulp are excellent for dairy cows, since they act as a tonic upon the animals as well as a food and increase the flow of milk. Pulp is used either fresh or dried. It is dried artificially, either by itself or in combination with molasses. When dried by itself it contains the same substances as when fresh; when dried with molasses it, of course, contains the added sugar and mineral matter. The object in drying the pulp is to make it easier to handle. About 80 per cent of the weight is lost in drying and when dried it can be shipped long distances. It should be soaked for several hours before it is fed to stock.

Number of live stock to keep.—It is apparent that there should be a suitable ratio between the number of live stock and the available tops, pulp, and other feed on the farm. As stated above, animals

can not be finished for the market on the beet by-products, and unless other feed is available it will not be advisable to purchase animals for feeding purposes with a view to turning them on the market later. If the farmer is provided with dairy cows, it is advisable to furnish them with one or two feeds of tops or pulp each day. The tops, when cured or pitted, will keep for several months; the pulp when left in a large pile will not spoil for feeding purposes, except in a thin layer on the surface. If the tops or the pulp are fed heavily to dairy cows, a distinct increase in the flow of milk marks the top and pulp feeding period, and there will generally be a marked falling off in the flow of milk when this feed is discontinued. Since the supply of tops and pulp is limited, it is better to continue the feeding over a longer period, giving a smaller amount to each of the animals daily. The tops and pulp should always be fed in combination with other feeds in order to make a balanced ration.

LABOR PROBLEMS.

One of the most serious problems on many of the beet farms is that of labor. The difficulties in connection with the labor question as related to sugar-beet culture are due to the fact that a part of the work must be done by hand and is tedious; furthermore, the labor in connection with this crop is not continuous. For example, there is a period in the spring when considerable labor is required for the blocking and thinning of the beets, as shown in Plate III, figure 1. The work during midsummer is light, consisting of a little hoeing. In the fall there is another increase in the labor requirement, due to the harvest, followed by the winter months, when little or no field work in connection with this crop is done. The need for labor at harvest time is apparent, as the beets must be harvested promptly when they are mature. The reasons for pushing the beet harvest are several: Fall rains may set in and cause the roots to deteriorate in quality, the roots may be frozen in the ground if harvest is delayed, the mill must have sufficient roots to operate continuously, and the farmer must get the beet crop out of the way in order to do his other fall work. The question of obtaining and holding the necessary labor for the handling of this crop has been one of the serious problems in sugar-beet growing in this country. Beet labor may be classified under three heads—family labor, community labor, and hired labor, the latter being divided again into general labor, regular and transient, and into contract labor.

Family labor.—By this term is meant the labor furnished by the family which has contracted with the sugar company to grow the beets. It may be the family of the landowner or the family of the tenant. Usually the most successful operations in sugar-beet grow-

ing are in those localities where the labor is handled by the family of the grower. In those localities the beet acreage per farm is usually small and the beet labor is not burdensome. This class of labor is usually more vitally interested in the success of the crop than other kinds of labor, and therefore greater pains are taken to produce and maintain good stands.

Community labor.—By community labor is meant the exchange of labor between the beet-growing families in a given community. Usually not all the beets in a given community are ready to be thinned or harvested at the same time, and since both of these operations must be done as promptly as possible when the beets are ready, it has been found advantageous for families in the same community to use the exchange-labor method in handling this crop. This exchange system is not confined to the beet crop, but is a common practice in many localities in carrying on all kinds of farm work which needs to be done quickly, such as haying and grain harvesting.

General labor.—By general labor is meant that labor which is employed by the day, month, or year for the general farm work. Transient labor is that part of this labor that comes and goes without any certainty as to its permanency and with little responsibility as to the results of the work. It is seldom used in handling the sugar-beet crop, as it is not sufficiently dependable. All farming communities are familiar with this kind of labor to a greater or less extent. It is unreliable and unsatisfactory, but sometimes enables a farmer to get through a temporary rush period without serious damage to his crop. On many farms there are monthly or annual laborers who take part in all of the farming operations, including the sugar-beet work. Usually this class of labor is very satisfactory in the beet fields, and the farmers are fortunate if by the aid of their general helpers they are able to care for the beet crop in addition to the other work.

Contract labor.—This is the most common class of labor employed to do the handwork in caring for the sugar-beet crop, and, as the term implies, the work is done under contract. The term "contract labor" as used in this connection is often misunderstood. It is thought by some who are not familiar with beet-growing conditions that the so-called beet-labor contracts are decidedly to the advantage of the landowner or of the sugar company and that such labor is compelled to work under contract. Usually the sugar company has no interest in the contract labor except in helping the grower to get his work done at the proper time and in the best possible manner. The landowner or beet grower desires a contract, so that he will be sure of the necessary help in handling his crop at the proper time, but above all the laborers themselves desire a contract which specifies the number of acres of beets that a given individual, family, or other

group of workers will be permitted to handle and the price that they will receive per acre for their labor. These contracts are usually made with so-called labor families, although individuals and groups of individuals sometimes enter into the contracts. The labor families are usually in the cities during the winter, employed in mills or factories, and in the summer they go out and work in the beet fields. For their own protection they must have a contract before they can afford to leave their employment to take up a new line of work. Many of these families return from year to year to work for the same beet growers.

The contract labor usually covers all of the handwork used in growing the beet crop; namely, the blocking, thinning, hoeing, pulling, and topping. The landowner and tenant do all the teamwork, from the plowing of the land to the hauling of the beets to the sugar mill or loading station.

The hand laborers usually work for a specified rate per acre, a part of which amount is furnished them after each operation. Occasionally they receive a specified bonus for each ton above a yield agreed upon. The object of this bonus is to encourage the laborers to maintain the best possible stands and to produce the highest possible yield per acre.

THE SUCCESSFUL GROWER.

The successful production of sugar beets on any farm depends to a great extent upon the temperament of the farmer and upon his attitude toward the production of this crop. As in other lines of business, the man's ability to conduct his business successfully is largely a matter of individual temperament, judgment, and ability to do the right thing in the right way and at the right time. There are many farmers, as there are many men in other lines of business, who are not adapted to the kind of work upon which they are engaged. It is not to be expected that these men would have any more success in the growing of sugar beets than in other lines of agriculture. Again, there are farmers well adapted by temperament to the particular line of farming which they are following, but who would not be successful in some other line of agriculture; for example, a man might grow grain on a large scale and do it very successfully; he might not at all be adapted to dairying or to the feeding of live stock. Some people can not handle live stock successfully even though they have right ideas in regard to the handling of crops; likewise, the grain farmer may not be adapted to the growing of sugar beets. Frequently grain production is extensive rather than intensive, while sugar beets should be handled intensively rather than extensively. At any rate intensive methods should be employed in growing this crop. Some growers of the extensively grown crops,

like grains and forage, sometimes become very successful growers of sugar beets, but generally they prefer the line of agriculture which they have followed and from which they do not like to depart. The same is true of the live-stock man, although the man who handles live stock, especially dairy cows, is more inclined to take up the growing of such an intensive crop as sugar beets and is more apt to succeed in this line of agriculture than the grain or forage crop man. This does not apply, however, to the live-stock man who grows for the market, and especially the man who produces or handles large herds of cattle. The point to be made in regard to the grower is that he must have the natural qualifications for intensive agriculture and must be fitted by training and experience for the growing and handling of crops requiring intensive cultivation.

DISEASES.

Diseases are among the most apparent limiting factors in sugar-beet production. A crop of beets that might otherwise be very profitable is frequently turned to a loss by some disease. The sugar beet, like all other plants, is subject to disease from the time it begins its growth until it is harvested; and even after the plants are harvested, if stored under certain conditions, the beets may decay to a greater or less extent, impairing or destroying their value for sugar-making purposes. Some of the diseases are well known and easily controlled; others, while known, are handled with difficulty; and still others are obscure as to their causes. The losses produced by diseases may be brought about by a destruction of the plant itself or by some injury which reduces the size or quality of the beet root.

Damping-off.—Among the diseases which attack the beet during the early stages of its growth is the so-called damping-off. There are several forms of this disease, due, apparently, to different organisms. Frequently the young beet plants turn black just at the surface of the gound, fall over, and die. Sometimes the entire root turns black and softens, and sometimes the blackening is confined to the outer layer or epidermis. In the latter case the beets frequently recover. This disease is caused either by a fungus or a bacterium which is in the soil or on the seed when planted. If the disease is widespread, so that the stand is seriously injured, the field should be disked and replanted. Damping-off is more common in the early spring, when the ground is damp and not thoroughly warm, but the disease will not occur unless one of the damping-off organisms is present.

Nematodes.[2]—The sugar-beet nematode is a minute wormlike organism, sometimes called an eelworm, which attaches itself to the

[2] See list of publications on p. 57.

root and when present in sufficiently large numbers retards the growth of the beet. There are several species of the nematode which attack the sugar beet, but only one is considered especially serious; hence, this species is known as the sugar-beet nematode (*Heterodera schachtii*). This pest has been known for many years in Europe and has existed in isolated localities in this country for more than a decade. It is spreading, both by its own activity in certain stages of its existence and by being carried from the present infested areas by various agencies. The pest lives in the soil from year to year and travels slowly, so that the infested area is gradually increased, until frequently an entire field or even a group of fields may become useless from the standpoint of beet production. Unfortunately, this pest will attack many plants besides the sugar beet. This makes it extremely difficult to control by crop rotation, which is one of the best methods known for the control of many of our plant pests. However, there are numerous plants that the nematode attacks to a very slight extent or not at all. Again, the nematode passes through several stages of development; one of these is known as the brown-cyst stage. In this stage the nematode is very resistant to unfavorable conditions and will remain alive in the soil for a number of years; the exact length of time is not known. The Office of Sugar-Plant Investigations is making every effort to determine the crops that are resistant to the nematode under the local soil and climatic conditions where the nematode exists and also to determine the proper length of the rotation with these resistant crops, so that the nematodes will be reduced to such a small number that sugar beets may be grown with profit in spite of the pests. Various soil treatments also are being tested on nematode-infested areas. Some of these tests are very promising but will need to be repeated before anything definite can be said regarding their beneficial effects. Careful surveys have been made in some of the infested areas, and all fields or spots in fields containing nematodes have been listed and marked, either for study or for the purpose of growing crops other than sugar beets on them. A similar campaign is planned in the other infested areas where the sugar-beet nematode has gained a foothold, while a careful watch is being kept over all sugar-beet areas in order to detect and combat the pest on its first appearance.

Curly-top.—The curly-top is confined to the western part of the United States. So far as is known, it has not been seen in the eastern portion of the sugar-beet area or in any of the beet fields of foreign countries. It has appeared in practically all States west of Minnesota and Iowa where sugar beets are grown commercially, although it has not been seen in all of the sugar-beet areas of the West. It is not due to unfavorable climatic or soil conditions; nor is it due to the kind or quality of seed used. It is connected in some

way with a so-called leafhopper, which appears to be only a carrier and not the real cause of this disease. A further study of curly-top has been undertaken by the Office of Sugar-Plant Investigations in cooperation with the Bureau of Entomology, in the hope of being able to determine the exact cause of the disease, and especially for the purpose of finding some practical means of control. Curly-top does not usually occur to any serious extent two years in succession in the same field, although there are some exceptions to this rule. Frequently it will occur over a given area, destroying or stunting to a worthless size practically all of the beets for a season and then almost entirely disappear, so that the next year beets of good tonnage and quality may be grown on the same fields. It is possible that there are other carriers besides the leafhopper and that certain soil and climatic conditions favor the development of this disease. The real cause, however, is undoubtedly organic in nature; it is probably either an organism or an organic compound; but until this cause is known little progress can be made in finding a reliable method of control. Curly-top has played an important part in closing at least two beet-sugar mills and has caused losses of hundreds of thousands of dollars in other localities.

Root-rot.—There are several destructive diseases of the sugar beet known as root-rot. One of these is due to a fungus called Phoma and another is due to a fungus known as Rhizoctonia. Other root rots less extensive or little known are due to other fungi or to bacteria. The Phoma rot seems to be more prevalent and more destructive than the Rhizoctonia. These fungi attack the beets in the field, usually in midsummer. Sometimes they destroy the plants before they are harvested, causing a serious loss to the grower. In other cases they make only a slight attack on the beet in the field, but develop more or less rapidly when the beet has been placed in storage, either for sugar-making purposes or for seed production. The Phoma fungus causes more loss to stored roots than any other agency, especially if the temperature favors the development of the fungus. These diseases are found in all parts of the sugar-beet area in this country and in Europe. The most successful means of combating the root-rot of beets in the field is crop rotation, and if it does not get started in the field there is little danger of its developing in storage.

Leaf-spot.—Two fungi which produce spots on the leaves of beets are more or less general throughout the United States and Europe. One of these is known as Cercospora and the other as Phoma; the latter is the same fungus that produces the root-rot. When the spores of either of these fungi fall upon the beet leaves and the conditions are favorable the fungus growth attacks the tissue of the leaf, producing distinct and characteristic spots. The Cercospora

fungus does not generally attack any part of the beet plant except the leaf blade and the petiole, while the Phoma may attack leaf and root. If these fungi are present in large numbers they may do considerable damage to the beet crop. If the attacks are severe early in the season the growth of the beets is retarded, and consequently the yield is reduced. If the attacks do not occur until late in the season, after the beets have practically reached their normal growth the disease will reduce the sugar without appreciably affecting the tonnage. If these fungi attack the beets in midsummer both the yield and the quality will be generally reduced. These diseases may best be controlled by deep fall plowing and by crop rotation. Crop rotation is especially recommended where it can be practiced, but in cases where it is necessary to follow beets with beets after these diseases have appeared, the ground should be plowed in the fall to a good depth, not less than 12 to 14 inches. In fact, all plant-pathological problems, from a practical standpoint, are closely connected with the cultural phases of crop production. Production can not be successfully studied without a knowledge of the diseases affecting that particular crop, nor can the disease of a crop be intelligently considered with reference to control measures except in conjunction with the cultural practices and with a knowledge of the conditions under which that crop is grown.

INSECTS.

The principal insects affecting sugar beets have been treated in various publications of the Bureau of Entomology. A list of these publications is given at the end of this bulletin. Among the important forms which affect the leaves are webworms and the beet army worm. In some localities blister beetles, leaf beetles, and local pests do considerable damage, mainly by destroying the foliage. They also have a retarding effect on the growth of the beet, but the principal injury is due to the destruction of the foliage and the consequent expenditure of energy and food required by the plant to produce a new set of leaves. Usually these insects start in small areas on one side or a corner of a field and spread rapidly. Of some species there are several generations in a season, and if weather conditions favor their development much damage is frequently done. In the case of insects working early in the season the tonnage of the beets may be greatly reduced, and if the insects continue until late in the season the sugar content also will be lowered considerably. Sugar-beet insects as a general rule are more or less local and are seldom very destructive for more than one or two years in succession.

All biting or chewing forms of insects are susceptible to poisons and may be controlled by the use of arsenate of lead, Paris green, or other arsenicals.

The leafhopper, previously mentioned as a carrier of curly-top, is frequently very destructive indirectly. After feeding upon diseased plants it punctures the leaf blades or leaf stems of healthy beets with its slender beak and injects into the plant some substance or organism which exerts a decidedly unfavorable effect upon its growth.

Among insects working in or near the roots are cutworms, wireworms, and white grubs, all of which are very destructive. White grubs are abundant in sod land; therefore such lands should not be selected for growing sugar beets. Wireworms and cutworms as a rule are more destructive early in the season while the beets are small. They frequently destroy the stand to such an extent that replanting is necessary. Cutworms come from the surface of the ground and cut off the plants during the night. Poisoned baits, prepared and applied according to directions which will be furnished by the Bureau of Entomology, are practically perfect remedies. Wireworms usually follow the row of young beets when they have begun their work of destruction, and since they usually remain in a row a second planting should be made in the same direction, so that the rows are parallel and several inches from the original planting, without harrowing or disking. If this method is pursued the second planting will often become so large that little wireworm damage will be done. Other remedies, however, are necessary.[3]

The false chinch bug is a serious enemy to seed beets, frequently appearing in immense numbers and working on the growing tender seed stalks and leaves. When present in large numbers it frequently absorbs by suction so much of the vital juices of the plant that either the seed stalks are destroyed or the seed fails to mature. This insect may be controlled in limited areas by the use of contact sprays, such as nicotine sulphate, 40 per cent, or fish-oil soap. The false chinch bug usually makes its first appearance on a small number of plants. Gathering the bugs from these plants and destroying them is very helpful in controlling this pest.

BY-PRODUCTS.

The principal by-products connected with sugar-beet growing and beet-sugar production are the beet tops, pulp, and lime. The first two of these have already been considered under live stock. The lime is an important by-product of the mill used in purifying the juice in the process of separating the sugar from the nonsugars in solution. For this purpose limestone is obtained and burned. The limestone should be as pure as it is possible to find it and should be thoroughly

[3] See Bulletin 123, Bureau of Entomology, U. S. Dept. Agr., "A preliminary report on the sugar-beet wireworm," 68 p., 23 pls., 9 figs. 1914. (Superintendent of Documents, Washington, D. C., price 25 cents.)

and evenly burned. The beet juice is treated with this burned limestone, and a large part of the mineral matter taken up by the beet plants in the process of growth combines with the lime and is removed by filtering. The lime is then washed out or otherwise removed from the mill and is known as waste lime or lime sludge. Large quantities of this material accumulate at the various mills and may be used as a soil improver and as a fertilizer. It is beneficial chiefly because of the lime, which tends to improve the physical condition of the soil, and slightly because of the mineral matter that the lime has removed from the beet juice. The use of this material as a fertilizer has not become general in this country. In some of the beet-sugar countries in Europe this by-product is all used in making commercial fertilizers. It is used in part as a filler in the manufacture of fertilizer and in part as a soil improver just as it comes from the sugar mill. It therefore has in this country two possibilities: First, it may be used just as it comes from the mill, and, second, it may be used in the manufacture of commercial fertilizers. When first removed from the mill it is wet and can be handled with difficulty, but it soon dries sufficiently to be handled readily, is friable and easily incorporated with the soil, and should all be used in improving farm lands. In some localities where the value of this material has been realized it is washed out and carried in ditches or flumes to the fields, where it is spread by the irrigating water. In this way it may be handled quickly at a minimum cost, and if care is taken it may be evenly spread. As soon as the ground on which the lime has been spread is sufficiently dry it should be plowed and the lime thoroughly mixed with the soil.

For sugar-beet culture there is very little danger of getting too much lime in the soil. Beets not only thrive well on limed soil, but the lime seems to have a beneficial effect under some conditions in retarding the development of certain plant diseases.

ROADS.

One of the most important factors in developing a beet-sugar industry is that of roads. Certain localities otherwise adapted to sugar-beet growing have been found in which this crop can not be recommended or encouraged because of the condition of the roads. Fortunately the interest in roads during the past few years has greatly reduced the number of such localities. Road building and sugar-beet culture have been mutually helpful. It is only by having good roads that crops which must be hauled to market in numerous heavy loads can be handled successfully; likewise, the demand that these crops have made for good roads has stimulated their building and improvement, as shown in Plate VI, figure 2.

There are three points to be considered in connection with roads as related to sugar-beet culture: (1) The length of the haul, (2) the

topography of the country, and (3) the nature of the roadbed. In general it has been found that 4 or 5 miles is the maximum distance that sugar beets can be hauled profitably. It is apparent that the distance depends to a great extent upon the topography and the nature of the roadbed. If the country is hilly, and especially if the hills are steep, it frequently is unprofitable to haul sugar beets.

Unless at least 3 tons of beets can be hauled per load the conditions must be very favorable to make the handling of this crop profitable. In the survey by the Office of Sugar-Plant Investigations, cooperating with the Office of Farm Management and Farm Economics, it has been found that, other things being equal, the cost of delivering beet roots increases directly with the distance. In this survey the topography and the care of the roadbed were practically the same for all cases compared. It is apparent that it would be more expensive to haul a short distance over a poor or hilly road than several times that distance over a level stone road (Pl. VI, fig. 2.) In speaking of the hauling distance, reference is made not to the distance from the factory, but to the loading station or point of delivery. In this respect the grower near the sugar mill has no advantage over the grower many miles away, provided the latter is near a beet dump.

The railroad haul is another point to be considered. As a rule, beets can not be transported more than 100 miles with profit, at least under normal conditions. There are, of course, circumstances under which longer hauls are permissible and profitable. Frequently in trying out a new sugar-beet section it is necessary to haul the roots several hundred miles, but in such cases it is not expected that any considerable profit will be obtained from these beets, and, in fact, they sometimes are transported long distances at a loss in order to determine whether beets of sufficient yield and quality to make beet growing profitable can be grown in a given locality. The length of the railroad haul depends to some extent upon the local conditions, the returns that may be obtained, and whether the haul is over a single road or over two or more lines.

CONTRACTS.

All sugar beets grown commercially for sugar-making purposes are grown under contract. These contracts are issued by the sugar company and are signed by some official or agent of the company and also by the beet grower. The principal points covered in the contracts include the acreage to be planted, the price to be paid for the beets, the methods of handling the crop, the time of harvest, and the regulation of delivery. Contracts are necessary because a definite acreage of sugar beets is required in order to make a successful mill

run. Each mill should have enough raw material for at least a 100-day run, although the average operating period for 1920 was only 91 days, as shown by Table IV. It would be a source of loss to the sugar company to undertake to operate a mill with beets enough for only 50 days, or at half capacity. Knowing the average yield of beets per acre in a given locality, it is comparatively simple to determine approximately the number of acres that will be required to produce a satisfactory run under normal conditions. Furthermore, it is important that the sugar company shall have a written agreement or contract setting forth the time of delivery of the beets. Beet roots must be delivered in sufficient quantity to supply the mill from day to day. It is very expensive to close a mill and let it remain idle even for a few hours during the sugar-making period; hence, there must be some understanding with regard to the delivery of the beets. On the other hand, the beets must not be delivered too rapidly, since they might deteriorate in quality if stored too long, especially in certain localities or under certain climatic conditions where the spoiling of the beets before they could be put through the mill might be a matter of considerable magnitude.

The growers require a contract because they must be insured a market for the beets at a fixed price. This is one of the few crops grown on a commercial scale in which the market price or at least the basis for fixing the price is known even before the seed is planted and for which there is no market of any importance except for sugar-making purposes.

There are three general forms of contract so far as the price to be paid for beet roots is concerned, namely, the flat rate, the sliding scale, and the profit-sharing plan. This feature of the contract relating to the price of beets differs with different companies and in different localities.

Flat rate.—The flat-rate contract fixes a definite price which the farmers are to receive for the beets regardless of the quality of the roots. It is usually stipulated in the contract that the roots must possess a specified sugar content and purity in order to be accepted, but in all of the beet-growing areas there is no record that any sound sugar beets have been rejected because of poor quality. The advantage in this clause in the contract lies in the fact that the fields that are not testing as high in sugar and purity as is required by the contract can be held until a later date before harvesting. Usually the sugar content of the roots increases rapidly in the fall, so that a delay of a few days at or near harvesting time frequently means a decided increase in the sugar content and an improvement in the purity of the roots. The flat rate is the price per ton for the clean and properly topped roots. It differs in different localities and

varies from year to year in the same locality. The direction and extent of the variation depend upon labor conditions and upon the wholesale price of sugar.

Sliding scale.—The second form of contract so far as the price of the beet roots is concerned is the so-called sliding scale. The other features in the contract, aside from the price to be paid for the beets, are usually the same as in the flat-rate contract. The sliding scale of beet prices is based either upon the percentage of sugar in the beet or upon the market price of sugar at a given time and place, or it is based upon a combination of the sugar in the beet and the price of sugar. In those contracts in which the scale of prices for beets depends upon the sugar content of the beet root there is a minimum price per ton for a beet of a given quality and an increased price per ton for each unit or fraction of 1 per cent of sugar in the beet above the minimum. The minimum price and the minimum quality of the root agreed upon differ in different localities, but are definitely stated in the contract. The rate of increase also varies in different localities; for example, one sugar company may agree to pay a minimum price of $5 per ton for beets testing 12 per cent sugar, while another company may agree to pay a minimum price of $6 per ton for a minimum of 14 per cent sugar content. They may also agree to increase the price 25 cents or 33⅓ cents per ton for each per cent of sugar above the minimum.

The price scale for beets, based upon the market price of sugar, was in use in several localities for the first time in 1917. Since that date the price of sugar has played an important part in the price of beet roots in all sugar-beet areas. In these contracts the price of sugar at a given time and for a definite stated period is taken as the basis. If the price of sugar at the place and for the time specified is $6 per hundred, for example, the price paid for the beets will be $6 per ton or $7 per ton, as may be agreed upon and specified in the contract. Usually a minimum price to be paid for the roots is stated in the contract with a stated increase for each unit of increase in the price of sugar. This would seem to be an equitable arrangement, since the greatest profit to the grower and to the sugar company would result when the price of sugar is high, and both would share the smaller profit or the loss when the price of sugar is low.

Profit sharing.—In the profit-sharing contract the grower is guaranteed a fixed minimum price for beets, the sugar companies to accept a minimum price for sugar, which presumably will give the grower and the sugar company approximately the same profit per ton of beets. It is further agreed that all profits in excess of the amounts above mentioned shall be divided equally between the grower and the sugar company. In areas where this contract or the

sliding scale contract is offered the grower, a flat-rate contract is available, if desired.

Tare.—One of the important factors in handling sugar beets is that of tare, and it forms an important clause in the contract. Tare consists of two distinct parts, one of which is the dirt which clings to the beet roots when delivered, and the other is the part of the crown that is sometimes left on the beet when the beet is topped. Tare is obtained by taking a sample from a load of beets and weighing it carefully. The dirt is then removed from this sample, usually by means of a stiff brush, and the beets, if not properly topped, are correctly topped and the cleaned, topped roots again weighed. The difference between the original weight of the sample and the clean, properly topped beets is the tare. This is usually reduced to a percentage, and the entire load is tared on the basis of the sample tared. Most sugar-beet tare houses are provided with scales that give a direct reading of the percentage of tare for each sample as it is weighed.

AREA COMPETITION.

Competition for acreage between adjacent sugar-beet areas secured by different sugar companies may or may not be of advantage to the beet-sugar industry as a whole, and consequently may or may not be beneficial to beet growers residing within those areas. If the acreage in a given area is sufficient to support two mills, for example, the competition in securing acreage for each of these mills may, if properly handled, stimulate the development of the industry in that area. If, on the other hand, a sugar mill is established in a given area having a limited sugar-beet acreage, due regard being had for proper crop rotation, and a second mill is built in the same area, the results may be disastrous to both of the mills and may result in retarding or preventing the development of the beet-sugar industry in that locality.

In all lines of business, competition is desirable under certain conditions, but in the beet-sugar industry a certain acreage of beets is necessary to enable a sugar mill to operate on a profitable basis. If a competing mill draws upon the beet acreage in a given locality to such an extent that the raw material is not sufficient to provide a satisfactory and profitable run for either of the mills, one or both of them must necessarily suspend operations. This result must lead to disappointment and financial loss on the part of those who have invested in the mills, and it deprives the growers of the benefits of sugar-beet production, inasmuch as the closing of the mills must necessarily leave the growers without a market for their product.

Sugar-beet producing areas may sometimes be extended by bringing in lands not previously under cultivation, by the development or extension of suitable means of irrigation, or by instituting or extending a suitable drainage system which will reclaim lands not now under cultivation. In this manner areas that are now capable of supplying but one mill with raw material may eventually be made to supply two or more mills. In all cases the necessary acreage for the maintenance of a mill should be in sight, without injury to existing mills or to local growers, before any money is expended in the erection of another mill. If this point is kept in mind, some of the financial losses and disappointments which investors have experienced in the past will be avoided.

SUGAR-BEET SEED.

One of the most important factors influencing beet-sugar production is that of seed. Not only must there be an adequate supply of seed to plant the necessary acreage for each sugar factory, but the seed must be of high grade; that is, it must be capable of germinating so that a good stand will be produced, and it must be capable of producing beets of satisfactory yield and quality. The present varieties of sugar-beet seed are apparently very much mixed, as indicated by commercial fields in all parts of the beet area. Efforts are being made at each of the beet-seed stations of the Office of Sugar-Plant Investigations to produce distinct strains of sugar beets of high quality for commercial planting. An endeavor is being made to increase the yield and quality of the seed and to establish an American beet-seed industry capable of meeting all domestic requirements.

Imported seed.—Until within recent years practically all sugar-beet seed planted in the United States was imported from Europe. This imported seed consisted of more than 20 so-called varieties, many of these varieties being simply strains bearing the name of the growers or the locality where the seed was produced. There appears to be little difference in results between the varieties imported. More seems to depend upon soil and climatic conditions and the cultural methods used in growing the crop than upon the particular variety of seed used.

Home-grown seed.—In recent years efforts have been made to produce American strains of sugar-beet seed and to produce them in commercial quantities in this country. In 1917 about 5,000 acres of beet seed were grown, yielding about 55,000 sacks of seed, and a still larger crop of American-grown seed has been produced with each succeeding year. In 1920 about one-third of the sugar-beet seed required by American growers was produced in the United States. Even with an increased home production, we must continue for some

time to look to foreign countries for a considerable part of our beet-seed supply. To make our beet-sugar industry safe and to insure American growers of sugar beets an adequate supply of high-grade seed free from the seed of stock beets we should produce annually from 16,000 to 20,000 acres of beet seed. This acreage must necessarily be increased from year to year to care for the constantly increasing acreage of sugar beets if the American beet-sugar industry is to be made safe and permanent.

PUBLICATIONS OF THE UNITED STATES DEPARTMENT OF AGRICULTURE RELATING TO SUGAR AND ITS PRODUCTION.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION.

Sugar and Its Value as Food. (Farmers' Bulletin 535.)
Sugar-Beet Growing under Irrigation. (Farmers' Bulletin 567, second revision.)
Sugar-Beet Growing under Humid Conditions. (Farmers' Bulletin 568, second revision.)
Leaf-Spot: A Disease of the Sugar Beet. (Farmers' Bulletin 618.)
Grasshoppers and Their Control on Sugar Beets and Truck Crops. (Farmers' Bulletin 691.)
The False Chinch Bug and Measures for Controlling It. (Farmers' Bulletin 762.)
Control of the Sugar-Beet Nematode. (Farmers' Bulletin 772.)
Sugar-Beet Sirup. (Farmers' Bulletin 823.)
Rodent Pests of the Farm. (Farmers' Bulletin 932.)
Saving Man Labor in Sugar-Beet Fields. (Farmers' Bulletin 1042.)
Beet-Top Silage and Other By-Products of the Sugar Beet. (Farmers' Bulletin 1095.)
Sugar-Beet Seed Growing in the Rocky Mountain States. (Farmers' Bulletin 1152.)
The Sugar-Beet Nematode in the Western United States. (Farmers' Bulletin 1248.)
Loss in Tonnage of Sugar Beets by Drying. (Department Bulletin No. 199.)
Conditions Influencing the Production of Sugar-Beet Seed in the United States. (Separate 503 from Yearbook for 1909.)
The Present Status of the Sugar-Beet Seed Industry in the United States. (Separate 695 from Yearbook for 1916.)
Destroying Rodent Pests on the Farm. (Separate 708 from Yearbook for 1916.)
Statistics of Crops Other than Grain Crops. (Separate 720 from Yearbook for 1916.)
Sugar Supply of the United States. (Separate 756 from Yearbook for 1917.)
Thrips as Pollinators of Beet Flowers. (Department Bulletin No. 104.)
Farm Practice in Growing Sugar Beets for Three Districts in Utah and Idaho, 1914–15. (Department Bulletin No. 693.)
Farm Practice in Growing Sugar Beets for Three Districts in Colorado, 1914–15. (Department Bulletin No. 726.)
Farm Practice in Growing Sugar Beets in the Billings Region of Montana. (Department Bulletin No. 735.)
Farm Practice in Growing Sugar Beets in Michigan and Ohio. (Department Bulletin No. 748.)
Farm Practice in Growing Sugar Beets in Three California Districts. (Department Bulletin No. 760.)
Farm Practice in Growing Field Crops in Three Sugar-Beet Districts of Colorado. (Department Bulletin No. 917.)
The Agricultural Situation for 1918, Pt. III, Sugar. (Secretary Circular No. 86.)
Sugar Supply of the United States; Its Extent and Distribution on August 31, 1917. (Secretary Circular No. 96.)

PUBLICATIONS FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

The Sugar Beet: Culture, Seed Development, Manufacture, and Statistics. (Farmers' Bulletin 52.) Price, 5 cents.

Irrigation of Sugar Beets. (Farmers' Bulletin 392.) Price, 5 cents.

Statistics of Sugar in the United States and Its Insular Possessions, 1881–1912. (Department Bulletin No. 66.) Price, 5 cents.

Field Studies of the Crown-Gall of Sugar Beets. (Department Bulletin No. 203.) Price, 5 cents.

The Sugar-Beet Thrips. (Department Bulletin No. 421.) Price, 5 cents.

Production of Sugar in the United States and Foreign Countries. (Department Bulletin No. 473.) Price, 10 cents.

The Beet Leaf-Beetle. (Department Bulletin No. 892.) Price, 15 cents.

Curly-Top, a Disease of the Sugar Beet. (Bureau of Plant Industry Bulletin No. 122.) Price, 15 cents.

The Curly-Top of Beets. (Bureau of Plant Industry Bulletin No. 181.) Price, 15 cents.

A Biochemical Study of the Curly-Top of Sugar Beets. (Bureau of Plant Industry Bulletin No. 277.) Price, 5 cents.

Experiments with Sugar Beets in 1893. (Bureau of Chemistry Bulletin No. 39.) Price, 5 cents.

The Influence of Environment upon the Composition of the Sugar Beet, 1902, Including a Study of Irrigated Sections. (Bureau of Chemistry Bulletin No. 78.) Price, 5 cents.

Analyses of Sugar Beets, 1905 to 1910, together with Methods of Sugar Determination. (Bureau of Chemistry Bulletin No. 146.) Price, 10 cents.

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