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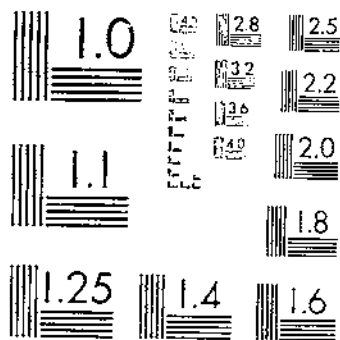
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EXPERIMENTS IN GROWING ROOTS AS FEED CROPS

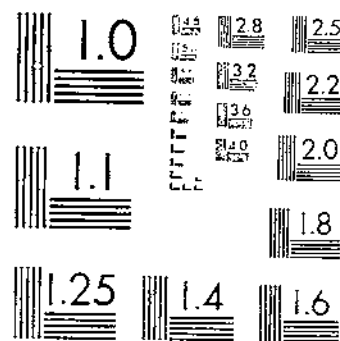
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MICROCOPY RESOLUTION TEST CHART
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NATIONAL BUREAU OF STANDARDS-1963-A

UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D.C.

EXPERIMENTS IN GROWING ROOTS AS FEED CROPS

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The Bureau of Plant Industry in Cooperation with the Agricultural
Experiment Stations of Kansas, Oregon, Montana, and North Dakota

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INTRODUCTION

Since 1920 the Division of Forage Crops and Diseases, in cooperation with the Division of Dry Land Agriculture and several State experiment stations located in the northern part of the United States, has been conducting tests with sugar beets, mangels, rutabagas, turnips, and carrots grown as feed crops. These tests have had as objectives:

(1) A determination of the possibilities of obtaining profitable yields; (2) comparison of productiveness of the different varieties under various soil and climatic conditions; and (3) consideration of the value of root crops as compared with corn silage as a source of succulence for feeding cattle.

In most cases it is believed that the tests have been of sufficient duration to give a true indication of the possibilities of these root crops. Since general cultural and feeding recommendations have been fully covered in *Farmers' Bulletin 1699*,² these phases will not be discussed here, but the practices in conducting the tests at the various experiment stations will be briefly described.

¹ The writers acknowledge data furnished and cooperation given at various times by D. A. Savage, Hays, Kans.; Morgan W. Evans, North Ridgeville, Ohio; A. E. Engbretson, Astoria, Oreg.; Robert Withycombe, Union, Oreg.; George W. Morgan and M. A. Bell, Havre, Mont.; I. J. Jousen, N. F. Woodward, and Harold E. Towor, Moccasin, Mont.; John F. Sarvis, Mandan, N. Dak.; Leroy Moomaw, Dickinson, N. Dak.; Samuel Garver, Redfield, S. Dak.; and Ray S. Towle, Sheridan, Wyo.

² Westover, H. L., Schoe, H. A., and Semple, A. T. *GROWING ROOT CROPS FOR LIVESTOCK*. U.S. Dept. Agr. Farmers' Bull. 1699, 13 pp., illus., 1933.

CLIMATIC RELATIONS

As previous experience has shown that mangels, rutabagas, turnips, and carrots require relatively cool weather for satisfactory growth, the tests reported in this bulletin have been conducted in the northern half of the United States. Productivity is also closely correlated with available moisture, and for this reason precipitation records of the stations where the tests were located are presented in table 1. Since there is no Weather Bureau station at North Ridgeville, Ohio, data are given for Oberlin, about 10 miles distant.

TABLE 1.—Annual and average precipitation (in inches) at stations named for period covered by root-crop experiments

[Data obtained at stations whose locations are here marked with an asterisk (*) are from the records of the U. S. Weather Bureau; if the locations are marked with a dagger (†) the data are from the records of the Division of Genetics and Biophysics of the Bureau of Plant Industry]

Stations	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	Average
Redfield, S. Dak. *	22.03	-----	20.93	16.40	22.01	10.17	13.00	26.70	15.34	17.12	22.17	14.78	18.85
Havre, Mont. †	11.30	13.37	10.20	10.03	12.52	17.64	8.90	19.04	11.74	12.25	8.88	8.20	12.51
Moccasin, Mont. †	18.36	15.48	15.38	18.58	12.14	13.50	14.70	18.02	12.21	13.28	12.18	10.72	14.39
Dickinson, N. Dak. †	15.81	15.70	18.20	10.67	15.13	12.10	13.11	10.62	15.30	17.21	13.79	18.17	16.00
Mundana, N. Dak. †	12.09	15.23	17.35	14.41	16.25	14.08	11.51	20.30	16.85	14.22	17.38	17.44	15.64
Hays, Kans. *	21.28	18.16	18.08	27.10	14.51	23.02	16.45	27.21	20.04	26.57	25.03	26.08	22.88
Shridan, Wyo. †	13.64	10.01	17.95	25.18	13.98	17.95	14.10	22.10	17.77	17.05	8.68	14.63	15.21
Oberlin, Ohio †	20.81	37.10	31.18	35.57	42.40	35.00	45.02	37.15	30.32	43.52	27.51	30.41	36.00
Corvallis, Oreg. *	37.12	41.05	38.45	37.07	37.87	34.07	40.04	47.87	39.87	24.45	23.68	39.13	36.72
Astoria, Oreg. *	30.00	63.50	-----	55.40	67.00	62.01	-----	60.07	69.49	62.62	68.28	88.47	72.06
Union, Oreg. *	14.70	14.70	8.28	17.30	9.42	11.61	15.88	16.48	9.45	10.90	13.51	9.88	12.70

In general, the root crops tested yielded best at those stations receiving the highest annual precipitation. Where the rains have occurred at opportune times, however, some remarkably satisfactory yields have been obtained at stations having a relatively low rainfall.

EXPERIMENTS AT HAYS, KANS.

The tests with root crops at the Fort Hays Branch Station, State Agricultural Experiment Station, Hays, Kans., have been under way only 4 years. The data are given in table 2. The 1929, 1930, and 1932 seedings were on fallow and the 1931 seedings on land that had been in root crops the previous year. Seedings have been made early in May in 42-inch rows with a grain drill with a press-wheel attachment. About 10 days or 2 weeks after emergence the plants were thinned. Mangels have been spaced 15 to 24 inches, rutabagas 12 to 18 inches, turnips 15 to 20 inches, and carrots 13 to 20 inches. As shown in table 1, the annual average precipitation at Hays, Kans., for the years 1920-31, inclusive, was 22.88 inches.

TABLE 2.—Annual and average acre yields of root crops at the Fort Hays Branch Station, State Agricultural Experiment Station, Hays, Kans., 1929-32

Crop and variety	Tops, green weight					Roots					Yields of roots in comparison with Mammoth Long Red mangel	
	1929	1930	1931 ¹	1932	Average	1929	1930	1931 ¹	1932	Average		
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Com- para- ble years	Per- cent
Mangels:												
Mammoth Long Red.....	2.82	2.96	1.05	6.34	8.44	12.81	11.40	8.34	25.67	14.58	4	100.0
Danish Sludstrup.....	3.03	2.90	1.08	5.27	3.66	13.24	12.11	7.89	19.53	13.19	4	90.5
Giant Red Eckendorf.....	1.92	1.89	.93	2.72	1.86	11.23	11.43	9.27	15.00	11.75	4	80.6
Golden Tankard.....	1.62	2.09	1.23	4.60	2.39	6.53	7.77	6.48	15.30	9.29	4	63.7
Rutabagas:												
American Purple Top.....	3.89	4.16	1.44	(?)	3.10	6.79	4.19	1.95	(?)	4.31	3	39.6
Hurst Monarch.....	2.00	3.60	1.29	(?)	2.20	4.27	4.07	1.83	(?)	3.32	3	30.5
Carter Hardy Swede.....	2.09	2.28	1.23	(?)	1.87	4.27	3.71	2.70	(?)	3.58	3	32.9
Turnips:												
Purple Top Strap-leaved.....	2.01	(?)	(?)	-----	2.01	4.04	(?)	1.17	-----	2.81	2	24.7
Purple Top White Globe.....	1.52	(?)	(?)	-----	1.52	3.44	(?)	1.25	-----	2.34	2	22.1
Carrots:												
Ox-heart.....	1.28	(?)	1.08	-----	1.18	3.35	(?)	2.10	-----	2.70	2	26.1
Long Orange.....	1.22	(?)	.87	-----	1.05	2.99	(?)	1.98	-----	2.47	2	23.4

¹ All root crops were badly damaged by army worms.² Yields not reported. Badly damaged by heat and root rot. Not included in averages.³ Badly damaged by flies, drought, and root rot. Not included in averages.⁴ Destroyed by rabbits. Not included in averages.

The average yields indicate that with the exception of mangels root crops have little promise in western Kansas. The high summer temperatures are unfavorable for turnips, especially when sown in the spring. Jack rabbits are very likely to destroy carrots unless the crop is fenced, though a large acreage might minimize this trouble. Rutabagas stand summer heat better than turnips but in the average season are not very productive. Mangels are the only roots that have produced a greater tonnage of succulence than sorghum silage. Mammoth Long Red mangels gave a 4-year average yield of 14.58 tons as compared with 9.45 tons per acre of Early Sumac sorgho, but much more labor was involved in growing the mangels. In most cases weights were also obtained of the tops, which constituted the following percentages of the total weights of the various roots: Mangels, about 20 percent; rutabagas, 35 to 40 percent; carrots, approximately 30 percent; and turnips 40 percent.

EXPERIMENTS AT HAVRE, MONT.

The experiments with root crops under dry-land conditions at the Northern Montana Branch Station, State Agricultural Experiment Station, Havre, Mont., have been carried on continuously since 1920. The seedlings were made on summer-fallow, the land usually being spring-tooth harrowed as early as conditions permitted, to encourage germination of the weed seeds, Russian-thistles in particular, so that many of the weeds, which later might become troublesome, could be destroyed by a thorough shallow cultivation just before seeding. In the early years of this experiment the seed was sown with a grain drill, but more recently a beet drill has been used. The seed usually was sown in 36-inch rows early in May, although in about one half of the years reseeding was necessary on account of uneven emergence resulting from soil crusting following a dashing shower, or from too

dry weather after seeding. Insect damage also contributed to the injury of stands at emergence, necessitating reseeded. After the plants attained sufficient size they were blocked out with a hoe and thinned by hand to single plants 8 to 10 inches apart. The roots were harvested, usually between October 1 and October 15, a beet lifter being used to loosen them. Mangels, especially the Golden Tankard variety, were much more easily removed from the ground than sugar beets. Yields secured from these crops during the years 1920-32, inclusive, are given in table 3.

TABLE 3.—Annual and average acre yields of root crops at the Northern Montana Branch Station, State Agricultural Experiment Station, Havre, Mont., 1920-32

Crop and variety	1920	1921	1922	1923	1924	1925	1926	1927
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
Sugar beets.....	2.84	5.85	4.30	(?)	3.69	6.30	3.80	7.20
Mangels:								
Mammoth Long Red.....	4.57	7.07	5.43	(?)	5.24	13.17	5.71	7.98
Golden Tankard.....	3.26	6.52	6.04	(?)	6.49	11.30	5.23	7.29
Danish Sludstrup.....	2.70	7.38	6.50	(?)	6.35	14.16	7.43	8.45
Giant Red Eckendorf.....			5.92	(?)	4.19	14.62	0.88	10.88
Rutabagas:								
American Purple Top.....	1.77	(?)	1.86	(?)	6.11	12.03	5.23
Carter Hardy Swede.....	1.17	(?)	3.33	(?)	5.35	9.21	3.19	9.01
Hurst Monarch.....	1.25	(?)	1.10	(?)	3.60	9.75	4.44
Turnips:								
Purple Top Strap-leaved.....		2.81	3.41	(?)	6.82	9.74	4.15	8.87
Purple Top White Globe.....				(?)				11.00
Carrots:								
Mastodon.....	(?)	(?)	(?)		.28	(?)	(?)	4.95
Long Orange.....	(?)	(?)	(?)		.64	(?)	(?)	5.04

Crop and variety	1928	1929	1930	1931	1932	Average	Yields in comparison with Mammoth Long Red mangel	
	Tons	Tons	Tons	Tons	Tons	Tons	Comparable years	Percent
Sugar beets.....	10.30	3.42	5.76	2.21	5.83	5.14	12	67.8
Mangels:								
Mammoth Long Red.....	16.94	4.30	8.13	1.69	10.78	7.68	12	100.0
Golden Tankard.....	13.30	3.68	5.34	1.65	6.72	5.36	12	83.9
Danish Sludstrup.....	19.22	5.76	7.67	1.97	9.17	7.90	12	104.2
Giant Red Eckendorf.....	13.05	3.30	7.37	.92	6.94	7.37	10	92.9
Rutabagas:								
American Purple Top.....						5.40	5	79.1
Carter Hardy Swede.....	13.07	2.76	3.77	.91	5.98	5.28	11	69.2
Hurst Monarch.....						4.04	5	69.3
Turnips:								
Purple Top Strap-leaved.....	13.79	3.48	2.62	1.20	6.05	5.62	11	71.6
Purple Top White Globe.....	16.73	4.20	2.08	2.19	7.26	7.35	6	88.6
Carrots:								
Mastodon.....	12.07	2.35	2.76	0	4.03	3.78	7	48.1
Long Orange.....	7.40	2.45	2.27	0	3.50	3.09	7	39.9

¹ Average of several varieties.

² Destroyed by insects. Not included in averages.

³ Destroyed by jack rabbits. Not included in averages.

These yields are satisfactory considering the low annual precipitation, which averaged only 12.72 inches during the years covered by the test. Yields, compared with many other dry-land crops, were especially good in the drier seasons of 1922, 1926, 1929, and 1930. Results in the extremely adverse year of 1931, however, were unsatisfactory, due partly to lack of moisture reserve in the fallowed land on which the roots were planted.

Mangels, with averages ranging from 6.36 to 7.90 tons per acre, produced the highest average yield of the roots tested, returning a considerably greater tonnage of succulent feed than corn or sunflowers, the green weight of which averaged only 3.13 and 3.81 tons per acre, respectively, during 11 years of the period 1920-32 when yield data were obtained.

Sugar beets, rutabagas, and turnips were considerably less productive than mangels. The lowest yields were obtained from carrots which were destroyed by jack rabbits in nearly one half of the seasons.

Weights of tops, obtained in most seasons, showed a wide variation from year to year in relation to the total weight. As a rule, mangel tops constituted 25 to 30 percent of the total weight, with extremes of a little more than 10 to about 50 percent. In the case of rutabagas and turnips, the proportion of tops to total weight averaged approximately 35 percent, with extreme variations even greater than in the case of mangels.

EXPERIMENTS AT MOCCASIN, MONT.

The experiments with root crops at the Judith Basin Branch Station, State Agricultural Experiment Station, Moccasin, Mont., began in 1920 and continued until 1929, covering a period of 10 years. The average annual precipitation for the years 1920-31 amounted to 14.39 inches. The seed was generally sown on land that was fallowed the previous summer and which was prepared in the early spring by cultivating with a spring-tooth harrow or duck-foot cultivator and finished with a smoothing harrow. The seeding was made in 36-inch rows early in May with a hand drill. The roots were harvested after the first killing frost. Annual as well as average yields obtained in these tests are given in table 4.

TABLE 4.—Annual and average acre yields of root crops at the Judith Basin Branch Station, State Agricultural Experiment Station, Moccasin, Mont., 1920-29, inclusive

Crop and variety	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	Average	Yields in comparison with Mammoth Long Red mangel	
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Comparable years	Percent
Sugar beets.....			0.77	9.10	3.77	3.90	7.73	(1)	(1)	(1)	6.07	6	79.0
Mangels:													
Mammoth Long Red.....	3.36	0.74	.98	11.39	4.01	5.17	9.94	(1)	7.32	.89	5.17	9	160.0
Golden Tankard.....	3.27	.19	1.03	8.08	4.24	4.02	9.13	(1)	(1)	.52	4.41	8	84.7
Danish Sludstrup.....	2.23	.69	.52	12.05	3.75	3.36	9.79	(1)	(1)	(1)	4.71	7	91.1
Giant Red Eckendorff.....	(1)	(1)	.01	12.60	5.45	4.79	12.00	(1)	6.27	1.10	6.17	7	107.2
Rutabagas:													
American Purple Top.....	2.80	1.51	1.91	11.63	5.80	5.49	6.38	12.21	9.57	1.08	5.27	9	108.4
Carter Hardy Swede.....	2.31	1.68	1.38	9.87	6.08	2.97	5.28	(1)	(1)	(1)	4.31	7	83.4
Hurst Monarch.....	3.00	1.57	3.58	13.31	8.04	3.09	6.30	4.09	6.27	(1)	5.72	8	106.8
Turnips:													
Purple Top Strap-leaved.....	(1)	(1)	(1)	9.54	7.18	4.51	3.68	12.67	6.08	1.02	7.01	6	91.9
Carrots:													
Long Orange.....	1.57	.22	(1)	4.18	.43	2.83	2.07	(1)	1.87	(1)	1.97	7	32.4
Mastodon.....	1.43	.42	(1)	0.32	.92	3.03	4.90	(1)	1.65	(1)	2.87	7	47.2

¹ No seed sown; not considered in averages.

² Destroyed by rabbits and insects; not considered in averages.

A striking fact brought out by these data is the small difference in the average yields of mangels, rutabagas, and turnips. The yields are not sufficient to offer much encouragement to the production of root crops on a large scale, since the indications are that nearly as much succulence can be obtained from silage corn at considerably less expense. Jack rabbits destroyed the carrots on several occasions, and the average yields were too low to recommend the crop to the farmer.

This is the only dry-land station where higher average yields were obtained from rutabagas than from mangels. During the period 1920-26, the only years for which comparable data are available, the green weights obtained from corn and sunflowers averaged 3.70 tons and 4.53 tons, respectively, as compared with an average yield of 7.01 tons from the Purple Top Strap-leaved turnip, the highest-yielding root crop. Much more difficulty, however, has been encountered in obtaining satisfactory stands of the roots.

EXPERIMENTS AT DICKINSON, N.DAK.

The tests with root crops at the Dickinson substation, State Agricultural Experiment Station, Dickinson, N.Dak., have been carried on continuously since 1920 to determine their possibilities as a source of feed for cattle in this locality. The seed usually was sown on summer fallow or following a cultivated crop, such as corn or potatoes, the land being cultivated in the early spring with a disk or duck-foot harrow to induce germination of the weed seeds. Just before seeding the root crops, the weeds were destroyed with a spring-tooth or spike-tooth harrow. The seed was sown in 36- or 42-inch rows early in May with a hand drill. In a month or 6 weeks the rows were blocked out with a hoe and then thinned by hand to single plants, carrots being spaced 6 inches and mangels 8 to 12 inches. The average annual precipitation for the years 1920-31 amounted to 16 inches.

The yields as given in table 5 are not large, but certain roots could be produced to advantage if it were not for the hand labor involved. Mangels generally gave somewhat better yields than sugar beets, rutabagas, or turnips. Carrots were the least productive, but they have possibilities as a crop for human consumption locally, because with favorable soil and moisture conditions, the income from carrots is likely to be greater than from almost any other root or garden crop. Corn for silage, although producing no more succulence per acre, can be grown much more easily and cheaply. For the small farmer, however, who cannot afford a silo, root crops would appear to have possibilities even under these conditions.

TABLE 5.—Annual and average acre yields of root crops at the Dickinson Substation, State Agricultural Experiment Station, Dickinson, N.Dak., 1920-31

Crop and variety	1920	1921	1922	1923	1924	1925	1926	1927
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
Sugar beets.....	4.16	1.01	5.00	(¹)	1.65	4.01	3.45	9.24
Mangels:								
Mammoth Long Red.....	0.48	1.64	9.70	(¹)	7.05	3.75	3.80	9.05
Golden Tankard.....	5.04	.80	12.80	(¹)	3.50	4.68	2.80	7.34
Danish Sladstrup.....	5.04	1.31	10.95	(¹)	9.15	4.60	5.54	13.47
Giant Red Eckendorf.....								
Rutabagas:								
American Purple Top.....	2.78	1.46	5.40	17.75	5.05	4.01	2.95	9.95
Carter Hardy Swede.....	2.95	1.87	5.02	20.35	6.60	4.05	2.27	10.08
Hurst Monarch.....	3.58	1.49	6.60	10.20	2.70	3.42	2.86	13.06
Turnips:								
Purple Top Strap-leaved.....					10.00	3.40	2.92	16.20
Purple Top White Globe.....			8.10	11.00	1.15	5.42	2.74	10.89
Carrots:								
Long Orange.....	.76	.33	2.28	(¹)	.50	5.36	1.52	3.45
Masiodon (white).....	3.94	.72	2.32	4.30	.75	5.42	1.37	4.95
Ox-heart.....	4.38	.45	4.50	(¹)	1.20	4.39	.78	3.95

Crop and variety	1928	1929	1930	1931	Average	Yields in comparison with Mammoth Long Red mangel	
	Tons	Tons	Tons	Tons	Tons	Comparable years	Percent
Sugar beets.....	11.57	2.95		0.45	4.43	10	58.4 ¹
Mangels:							
Mammoth Long Red.....	25.09	6.09	3.94	.97	7.25	11	100.0
Golden Tankard.....	38.62	5.28	3.59	.68	5.93	11	81.8
Danish Sladstrup.....	33.00	4.00	4.60	.60	8.44	11	116.4
Giant Red Eckendorf.....	21.87	8.21	5.65	.95	9.17	9	100.0
Rutabagas:							
American Purple Top.....	14.04	(¹)	(¹)	(¹)	7.21	8	69.6
Carter Hardy Swede.....	10.97	2.24	3.34	.43	4.42	11	71.2
Hurst Monarch.....	14.05	(¹)	(¹)	(¹)	6.45	9	90.6
Turnips:							
Purple Top Strap-leaved.....	13.44	4.75	5.24	.31	7.03	8	90.8
Purple Top White Globe.....	10.00	5.86	5.22	.45	6.76	9	79.0
Carrots:							
Long Orange.....	6.60	3.56	.70	.40	2.32	11	32.0
Masiodon (white).....	10.23	4.17	1.31	.73	3.35	11	45.0
Ox-heart.....	5.70	3.60	1.08	.73	2.72	11	37.5

¹ Stand failed; not included in averages.² No seed sown; not included in averages.

EXPERIMENTS AT MANDAN, N.DAK.

Root crops were tested in a limited way at the United States Northern Great Plains Field Station, Mandan, N.Dak., for several years, the results being given in table 6. In the majority of seasons the yields were relatively low, owing to poor stands resulting from unfavorable weather at a critical time or to a moisture deficiency later in the season. As shown in table 1, the average annual precipitation from 1920 to 1931, inclusive, was 15.64 inches. In reasonably favorable seasons, such as occurred in 1922 and 1927, the yields of mangels especially were very satisfactory, exceeding that of corn grown for silage. While mangels produced a greater average tonnage for the 4 years 1922, 1923, 1926, and 1927, corn silage is a more dependable source of succulence, since less difficulty is encountered in obtaining and maintaining a stand. In 3 of the 7 years included in the test no harvest of mangels was obtained, owing to failure to obtain stands in 1928 and 1929 and to a freeze in 1925, while fair yields of silage corn were obtained in each of these years. Furthermore, much less labor is involved in growing corn.

TABLE 6.—*Annual and average acre yields of root crops at the United States Northern Great Plains Field Station, Mandan, N. Dak.*

Crop and variety	1922	1923	1926	1927	1928	1929	Average ¹	Yields in comparison with Mammoth Long Red mangel	
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Com-parable years	Percent
Sugar beets.....	4.05	1.71	1.19	9.40	(?)	(?)	4.24	4	51.2
Mangels:									
Mammoth Long Red.....	12.00	2.05	1.94	12.54	(?)	(?)	8.29	4	100.0
Golden Tankard.....			1.90	14.76	(?)	(?)	8.33	2	90.2
Rutabagas:									
Carter Hardy Swede.....	7.05	1.39	2.95	10.25	7.06	3.78	5.41	4	65.3
Turnips:									
Purple Top Strap-leaved.....	3.15	0	0.75	9.96	8.70	8.71	4.97	4	60.0

¹ Does not include 1924, when no root crops were sown, and 1925, when all were killed by a freeze May 16.² No stand obtained; not considered in averages.

EXPERIMENTS AT NORTH RIDGEVILLE, OHIO

The forage-crop field experiments at North Ridgeville, Ohio, have included a limited number of root crops each year since 1926, the yields being given in table 7. With the more favorable soil and climatic conditions, the annual precipitation amounting to about 36 inches a year at Oberlin about 10 miles distant, the average production has been considerably in excess of that obtained under the drier conditions in the northern Great Plains, but not equal to the yields obtained from the nearly ideal conditions found in some parts of the Pacific Northwest. As is generally the case, mangels have been much more productive than turnips and rutabagas. The average tonnage is also considerably greater than is usually obtained from silage corn in this locality. The Mastodon variety of carrots has given some remarkable yields, the average for a period of years being nearly equal to that of mangels.

TABLE 7.—*Annual and average acre yields of root crops at North Ridgeville, Ohio*

Crop and variety	1926	1927	1928	1929	1930	1931	Average	Yields in comparison with Mammoth Long Red mangel	
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Com-parable years	Percent
Sugar beets.....	11.67		9.85	9.40	7.49	16.52	10.99	5	52.1
Mangels:									
Mammoth Long Red.....	22.80	17.78	16.79	19.68	13.53	29.58	20.53	6	100.0
Golden Tankard.....	20.50	13.55	11.54	11.60	9.49	20.53	14.54	6	70.8
Barre Bludstrup.....	(1)	17.31	18.25	14.97	(1)	(1)	16.24	3	93.1
Rutabagas:									
Carter Hardy Swede.....	(1)	2.33	5.43	1.43	6.13	10.46	5.16	5	25.7
Hurst Monarch.....	(1)	3.33	7.79	1.57	7.45	10.89	6.21	5	30.9
Turnips:									
Purple Top Strap-leaved.....	(1)	2.00	6.95	1.02	6.15	7.69	4.94	5	24.6
Carrots:									
Mastodon.....	19.18	14.54	19.52	15.05	10.03	25.98	16.88	6	82.2
Long Orange.....	(1)	10.74	1.30	11.51	7.53	10.77	9.50	5	47.9

¹ No seeding.

EXPERIMENTS AT ASTORIA, OREG.

Experiments with mangels, rutabagas, and turnips at the John Jacob Astor Branch Station, State Agricultural Experiment Station, Astoria, Oreg., have been in progress since 1923. The average annual precipitation at this station for the years 1920-31 amounted to 72.06 inches. The yields as given in tables 8 and 9 do not always represent a true comparison of the productivity of the different kinds of roots, owing to the fact that they were sometimes grown under quite different soil conditions and have not always received the same fertilizer treatment. Manure has been applied to all crops at the approximate rate of 20 tons per acre. In addition, mangels usually have had an application consisting of 100 pounds of ammonium sulphate, 200 pounds of superphosphate, 100 pounds of bone meal, and 150 pounds of potassium sulphate. Rutabagas and turnips were given 460 pounds of superphosphate per acre in addition to the manure until 1928, when they received 2 tons of lime and 300 pounds of superphosphate per acre with the usual application of manure. Mangels were grown on tideland, from 1924 to 1928, inclusive, while rutabagas and turnips were grown on the upland in 1923, 1924, and 1925; on both tideland and upland in 1926 and 1927; and on tideland only from 1928 to 1932, inclusive. In 1928 the stand of mangels was reduced 20 to 50 percent by cold weather after the seeds had germinated, thus affecting the yields appreciably.

TABLE 8.—Annual and average acre yields of root crops grown on tideland at the John Jacob Astor Branch Station, State Agricultural Experiment Station, Astoria, Oreg.

Crop and variety	1924	1925	1926	1927	1928	1929	1930	1931	1932	Average	Yields in comparison with Mammoth Long Red mangel	
											Com- para- ble years	Percent
Sugar beets.....	Tons 15.18	Tons 5.20	Tons 12.40	Tons 6.40	Tons 5.25	Tons	Tons	Tons	Tons	Tons 8.68	5	41.9
Mangels:												
Mammoth Long Red.....	18.31	20.32	18.75	25.20	21.00	-----	-----	-----	-----	20.71	5	100.0
Golden Tankard.....	15.62	21.75	16.50	19.70	-----	-----	-----	-----	-----	18.39	4	82.1
Danish Sludstrup.....	23.65	24.30	19.70	25.90	28.30	-----	-----	-----	-----	23.77	5	114.7
Giant Red Ecken- dorf.....	21.88	14.14	21.70	26.35	14.00	-----	-----	-----	-----	20.01	5	96.6
Fritzwinner.....	24.16	27.26	16.00	28.45	29.80	-----	-----	-----	-----	24.78	5	119.4
Giant Half Sugar.....	23.93	18.91	24.15	21.00	17.00	-----	-----	-----	-----	20.99	5	101.4
Red Intermediate.....	19.16	16.42	19.15	20.80	15.25	-----	-----	-----	-----	19.35	5	93.4
Barre Sludstrup.....	-----	23.13	-----	21.10	20.60	-----	-----	-----	-----	21.61	5	97.5
Rutabagas:												
Skirving Improved.....	-----	-----	37.75	32.62	31.25	30.90	36.45	27.80	42.95	34.23	3	156.4
Magnum Bonum.....	-----	-----	47.15	34.00	32.42	34.50	37.10	30.55	40.90	36.69	3	174.9
Hurst Monarch.....	-----	-----	40.00	31.45	32.37	34.70	37.50	33.19	38.16	35.31	3	158.9
Acquisition.....	-----	-----	41.85	27.50	40.35	35.35	35.65	28.65	36.07	35.06	3	168.9
American Purple Top Improved American.....	-----	-----	-----	31.85	30.25	34.65	35.25	-----	-----	33.00	2	134.4
Purple Top.....	-----	-----	31.25	-----	28.07	38.95	30.20	-----	42.22	35.34	2	149.2
Bangholm Giant.....	-----	-----	-----	-----	33.85	-----	38.00	27.60	37.00	33.84	1	161.2
Up-to-Date.....	-----	-----	29.25	27.05	-----	-----	-----	30.10	48.15	33.36	2	130.1
Green Top.....	-----	-----	37.35	31.05	31.05	-----	-----	38.15	-----	33.90	3	153.1
Turnips: ¹												
Imperial Green Globe.....	-----	-----	-----	23.65	32.55	30.95	27.10	49.80	53.70	36.29	2	121.6
Cowhorn.....	-----	-----	-----	31.10	31.45	63.00	31.15	41.00	52.80	42.68	2	135.4
Danish Bortfeld.....	-----	-----	-----	31.35	32.30	53.50	42.35	45.10	49.45	42.34	2	137.8
Green Top Aber- deen.....	-----	-----	-----	-----	31.00	41.00	34.10	42.45	38.50	37.37	1	161.9
Pomeranian White Globe.....	-----	-----	-----	24.90	-----	59.40	31.00	48.55	52.70	43.31	1	98.8

¹ Yields include tops.

TABLE 9.—*Annual and average acre yields of rutabagas and turnips grown on uplands at the John Jacob Astor Branch Station, State Agricultural Experiment Station, Astoria, Oreg.*

Crop and variety	1923	1924	1925	1926	1927	Average	Yields in comparison with Skirving Improved rutabaga	
	Tons	Tons	Tons	Tons	Tons	Tons	Comparable years	Percent
Rutabagas:								
Skirving Improved.....	20.00	27.50	25.11	20.00	17.05	23.85	5	100.0
Magnus Bonum.....	20.85	24.00	31.35	31.95	20.65	25.78	5	108.0
Hurst Monarch.....		29.87	26.33	29.75	17.75	25.93	4	104.4
American Purple Top.....		20.60	29.85	31.90	10.80	24.78	4	99.6
Improved American Purple Top.....	20.65	10.15		32.05		22.95	3	89.3
Bangholm Giant.....	21.00			30.00	10.40	22.47	3	101.1
Champion.....			20.87	27.25	21.00	20.04	3	108.9
Acquisition.....			30.55	31.50	20.00	27.35	3	114.3
Up-to-Date.....			30.85	33.20	21.20	28.42	3	118.8
Crimson King.....			29.64	31.90	19.60	20.98	3	112.8
Green Top.....				33.80	22.45	28.13	2	120.0
Turnips:								
Imperial Green Globe.....	31.37	34.00	42.82	33.70	20.80	32.71	5	137.1
Green Top Aberdeen.....	27.50		41.09	22.60	19.55	27.69	4	120.7
Hardy Green Round.....	28.20		46.13	32.60	20.25	31.80	4	138.6
Cowhorn.....	20.94		46.37	28.00	17.45	29.34	4	127.9
Pomeranian White Globe.....			40.13	32.75	19.75	32.88	3	137.5

* Weights given include roots and tops.

Yields of mangels and rutabagas as given in the tables are of roots only, while the turnip yields include roots and tops. Turnips are usually fed without topping, since the tops are regarded as being nearly equal to the roots for feeding. Mangels were not included in the upland tests, but on tideland both turnips and rutabagas were more productive. When allowance is made for weight of tops, rutabagas as an average exceeded turnips in tonnage. No striking or consistent differences in productivity of the different varieties is apparent. Both rutabagas and turnips gave much higher yields on tideland than on upland.

In 1923 weights were obtained of mangel tops, and they were found to constitute 20 to 35 percent of the total weight, depending upon the variety, the average for all varieties being about 30 percent.

Root crops produced a considerably greater tonnage than was obtained from oat-and-pea silage, which amounted to from 7 to 9 tons per acre.

EXPERIMENTS AT CORVALLIS, OREG.

The root-crop experiments at the State Agricultural Experiment Station, Corvallis, Oreg., have included sugar beets and several varieties of mangels. Rutabagas, turnips, and carrots were not included, as previous experience had shown rather definitely that turnips and rutabagas are of little value in the Willamette Valley because of root maggot, while carrots do not produce sufficient tonnage to compete with mangels as feed for livestock. The tests were conducted on a clay-loam soil that was manured before plowing for root crops. The seed usually was sown early in May and the plants thinned by hand when the fourth leaf appeared. The crop was usually harvested in October. The yields from this test are given in table 10.

TABLE 10.—Annual and average acre yields of root crops at the State Agricultural Experiment Station, Corvallis, Oreg., 1922-32

Crop and variety	1922	1923	1924	1925	1926	1927	1928
	Tons	Tons	Tons	Tons	Tons	Tons	Tons
Sugar beets.....			9.20	11.40	9.07	11.28	9.78
Mangels:							
Mammoth Long Red.....	21.30	12.40	17.08	14.26	15.01	16.57	10.11
Half Sugar.....	22.95	13.20	15.23	17.00	13.22	22.38	19.14
Golden Tankard.....	17.23	9.95	14.25	12.92	13.97	18.05	14.22
Danish Sludstrup.....	21.37	11.45	13.78	15.76	15.07	19.41	15.81
Red Eckendorf.....	16.42	9.95	13.18		15.75	13.94	14.90
Red Intermediate.....			13.40	13.05	13.77	19.85	17.28
Barre Sludstrup.....					10.92	16.90	18.42
Heavy Cropper.....	21.45		12.80			19.05	17.70
Prize Winner.....					13.83	18.41	13.44
Yellow Eckendorf.....						13.48	17.70
Yellow Globe.....			14.00	14.44	14.10		
Kirscho Ideal.....					11.75	10.59	13.50
Yellow Intermediate.....							15.50
Giant Intermediate.....	21.64	11.75	12.46				

Crop and variety	1929	1930	1931	1932	Average	Yields in comparison with Mammoth Long Red mangel	
	Tons	Tons	Tons	Tons	Tons	Comparable years	Percent
Sugar beets.....	7.49	7.28	6.12	7.66	8.81	9	60.6
Mangels:							
Mammoth Long Red.....	8.48	16.65	12.33	14.29	14.96	11	100.0
Half Sugar.....	13.35	13.07	13.21	16.01	16.26	11	108.7
Golden Tankard.....	9.81	10.50	12.20	12.89	13.27	11	88.7
Danish Sludstrup.....	11.41	8.36	12.45	14.37	14.57	11	97.4
Red Eckendorf.....	10.08	8.88	12.08	14.68	13.48	10	89.7
Red Intermediate.....	9.45	11.02	13.05	13.33	13.87	9	95.5
Barre Sludstrup.....	11.62	11.70	13.05	15.33	14.00	7	98.6
Heavy Cropper.....	10.39	9.10	10.68		14.63	7	94.3
Prize Winner.....	10.03		13.06	15.42	15.03	6	101.7
Yellow Eckendorf.....	10.69	9.44	12.12	13.51	12.82	6	91.1
Yellow Globe.....	16.31	11.81	13.10		14.13	6	101.2
Kirscho Ideal.....		7.05			12.37	4	76.9
Yellow Intermediate.....	5.36	14.90	11.40		12.50	4	93.8
New Perfect Gem Intermediate.....	12.57	12.32	11.07		11.69	3	90.1
Lord Worden.....	13.51	12.99	13.17		13.21	3	105.0
Giant Intermediate.....					15.28	3	90.1

Although there was some variation in production from year to year, the annual yields as well as the average of nearly all varieties of mangels were consistently good and considerably in excess of sugar beets.

No silage-crop data are available for the period covered by this test. During the years 1927-32 drilled corn, spaced 8 inches apart in the row, averaged 6.58 tons per acre, which was about half the yield obtained from mangels during the same period. Sunflowers, spaced 12 inches apart in the row, averaged 13.98 tons per acre, which was nearly equal to the yield obtained from mangels.

EXPERIMENTS AT UNION, OREG.

Experiments with mangels were conducted at the Eastern Oregon Branch Station, State Agricultural Experiment Station, Union, Oreg., from 1924 to 1930 and with carrots from 1924 to 1931. In preparing the land for these crops it was plowed to a depth of 7 inches in the spring and worked down to a fine seed bed. Every other year 8 tons per acre of stable manure were applied. The seed was sown between April 23 and May 25 in rows usually 18 inches apart.

Considering the precipitation, which averaged only 12.70 inches for 1920-31, the yields of carrots and mangels were remarkably satisfactory, as shown in table 11. This is due to the fact that the soil on which these tests were conducted is a very fertile sandy loam, usually being subirrigated throughout the growing season. While mangels generally were most productive, two varieties of carrots gave yields that approximated those of most varieties of mangels in comparable years.

TABLE 11.—Annual and average acre yields of root crops at the Eastern Oregon Branch Station, State Agricultural Experiment Station, Union, Oreg., 1924-31¹

Crop and variety	1924	1925	1926	1927	1928	1929	1930	1931	Average	Yields in comparison with Mammoth Long Red mangel	
										Comparable years	Percent
Mangels:	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>	<i>Tons</i>		
Mammoth Long Red.....	26.12	35.59	2.7	25.6	12.8	35.0	13.0	-----	21.54	7	100.0
Danish Bludstrup.....	24.54	41.73	5.0	28.5	10.3	38.7	14.0	-----	24.11	7	111.9
Giant Red Eckendorf.....	29.37	40.32	4.9	32.9	15.99	38.7	13.8	-----	25.14	7	116.7
Golden Tankard.....	21.63	31.13	3.0	16.2	13.5	32.0	14.4	-----	18.92	7	87.8
Giant Intermediate.....	24.79	38.69	5.5	23.4	13.7	36.4	11.0	-----	21.94	7	101.9
Half Sugar.....	26.27	40.21	4.7	18.0	18.4	-----	-----	-----	21.72	6	105.6
Danish Barre.....	-----	45.79	3.1	-----	-----	-----	-----	-----	24.44	2	127.7
Kirsche Ideal.....	-----	-----	6.6	24.6	16.0	34.3	-----	-----	20.38	4	107.1
Danish Giant Half Sugar.....	-----	42.32	3.6	-----	-----	37.5	10.1	-----	23.35	4	108.4
Carrots:											
White Belgian.....	31.7	30.98	23.0	19.9	7.7	13.1	18.1	5.4	20.35	7	94.4
Danvers Half Long.....	-----	-----	-----	10.8	0.6	13.8	20.6	-----	15.76	4	73.8
Short White.....	19.13	26.78	25.5	-----	-----	-----	-----	-----	23.80	3	110.6
Yellow Belgian.....	-----	-----	-----	21.6	-----	10.0	20.2	4.3	14.03	3	70.4
Improved Short White.....	-----	-----	-----	18.9	-----	-----	-----	-----	18.90	1	73.8
Yellow Giant.....	27.53	22.88	14.2	-----	-----	-----	21.5	2.9	17.80	4	111.3
Obantena.....	23.6	21.83	15.0	18.7	5.7	10.9	16.2	5.1	15.99	7	74.2

¹ During the season of 1926 the mangel crop was severely damaged by curly top. No planting of mangels was made in 1931.

EXPERIMENTS AT REDFIELD, S.DAK.

The forage-crop field experiments at Redfield, S.Dak., included tests with root crops each year since 1920. Seedlings were made the latter part of April or early in May with a garden drill on fall-plowed land that was variously cropped the previous season and then prepared by disking and harrowing before seeding. Considerable difficulty was encountered in obtaining satisfactory stands of sugar beets and mangels, due to the tendency of the soil to crust. Freezes and insects also took their toll, necessitating reseeding on several occasions. When the stands were uniform the plants were spaced about as follows: Carrots, 4 to 6 inches; rutabagas and turnips, 8 to 10 inches; and mangels and sugar beets, 10 to 12 inches. On the average, roots were cultivated four times during the season. They were harvested by hand early in October just before the ground was likely to freeze. The yields obtained are given in table 12.

TABLE 12.—Annual and average acre yields of root crops at Redfield, S.Dak., 1920-32

Crop and variety	1920	1921	1922	1923	1924	1925	1926 ¹	1927
	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
Sugar beets.....	13.70	8.50	5.10	5.24	7.87	5.79	0	13.05
Mangels:								
Mammoth Long Red.....	30.58	17.48	13.08	10.46	19.55	20.45	0	32.02
Golden Tankard.....	14.22	9.63	9.08	5.57	12.05	10.60	0	20.47
Danish Sludstrup.....	20.70	14.20	10.05	10.23	22.30	18.06	0	25.85
Giant Red Eckendorf.....			8.97	10.68	21.42	11.18	0	25.33
Kirsche Ideal.....						15.60	0	25.45
Rutabagas:								
American Purple Top.....	11.83	4.57	4.36	4.22	7.77	1.88	0	11.63
Carter Hardy Swede.....	9.08	2.04	3.04	3.63	9.21	2.70	0	12.24
Hurst Monarch.....	9.27	2.52	1.97	3.49	6.21	1.85	0	12.48
Turnips:								
Purple Top Strap-leaved.....		3.80	3.35	1.25	8.26	3.52	0	10.83
Purple Top White Globe.....				4.48	9.86	3.86	0	14.64
Carrots:								
Long Orange.....	6.33	5.34	1.06	1.88	2.75	3.00	0	8.25
Mastodon.....	9.82	5.06	2.75	3.56	2.76	3.41	0	10.16
Ox-heart.....	11.06	9.03	1.77	3.41	4.77	2.94	0	8.55
White Belgian Field.....								7.20

Crop and variety	1928	1929	1930	1931	1932	Average	Yields in comparison with Mammoth Long Red mangrel	
	Tons	Tons	Tons	Tons	Tons	Tons	Com- para- ble years	Percent
Sugar beets.....	4.62	2.42	5.64	2.59	5.41	0.15	13	41.0
Mangels:								
Mammoth Long Red.....	12.00	0.94	14.93	4.09	6.14	14.99	13	100.0
Golden Tankard.....	6.13	3.45	9.00	1.93	3.73	8.43	13	56.2
Danish Sludstrup.....	9.44	5.42	13.05	3.63	9.33	12.67	13	83.9
Giant Red Eckendorf.....	9.09	4.14	10.02	2.28	5.16	9.84	11	73.7
Kirsche Ideal.....	8.55	5.00	11.05	4.68	8.04	10.02	8	82.5
Barre Sludstrup.....	8.33	4.30	8.07	2.04	7.71	6.23	5	69.7
Pedigreed Ideal.....		4.36	12.44	3.47	6.62	6.72	4	83.7
Rutabagas:								
American Purple Top.....	4.36	1.06	2.15	0	2.35	4.32	13	28.9
Carter Hardy Swede.....	5.30	.91	2.50	0	3.48	4.38	13	29.2
Hurst Monarch.....	4.28	1.21	1.87	0	1.96	3.55	13	23.7
Turnips:								
Purple Top Strap-leaved.....	5.71	1.53	2.53	0	.98	3.40	12	24.8
Purple Top White Globe.....	5.14	1.54	2.41	0	1.40	4.33	10	32.5
Carrots:								
Long Orange.....	4.46	3.58	4.65	.45	2.41	3.40	13	22.7
Mastodon.....	2.04	3.40	4.08	.38	2.40	3.98	13	23.6
Ox-heart.....	5.61	3.69	5.35	1.25	3.00	4.67	13	31.2
White Belgian Field.....	2.74	2.48	5.82	.60	2.94	3.61	6	28.2

¹ Root crops in 1926 were a complete failure due to drought and unusually warm weather.² Low yield in 1923 due to bacterial soft rot.

With an average annual precipitation of 18.85 inches for 1920-31, Mammoth Long Red mangels, the most productive root crop, gave an average yield of 14.99 tons per acre. This is nearly double the average yield of 8.08 tons green weight per acre of corn and 7.70 per acre of sunflowers. In a reasonably favorable season the production from all roots has been satisfactory, though mangels far exceeded rutabagas, turnips, and carrots. During the dry seasons that have been unusually frequent in recent years, the yields have been low. However, in spite of the higher yields obtained from mangels, as compared with corn for silage, it is likely that on the large farm the production of the latter will continue mainly because of the amount of hand labor involved in growing root crops.

EXPERIMENTS AT SHERIDAN, WYO.

A limited test of roots has been sown at the United States Dry Land Field Station, Sheridan, Wyo., on three occasions. The 1927 seedings were made on land that had been in sorghum the previous season, the 1928 seedings followed Sudan grass, while the 1929 seedings were made on summer fallow. The heavy rain on May 31, 1929, caused such a poor stand that no weights were taken that year. The acre yields from the other seedings are given in table 13. While the tests here recorded are very limited, the yields from the 1927 seeding are highly satisfactory and are indicative of what may be expected in a reasonably favorable season.

TABLE 13.—*Acre yields of root crops at the United States Dry Land Field Station, Sheridan, Wyo.*

Crop and variety	1927	1928	Crop and variety	1927	1928
Mangels:	<i>Tons</i>	<i>Tons</i>		<i>Tons</i>	<i>Tons</i>
Mammoth Long Red.....	11.96	3.80	Rutabagas, Carter Hardy Swede...	12.24	11.77
Golden Tankard.....	17.15	1.43	Turnips, Purple Top Strap-leaved..	13.88	9.96

SUMMARY

For several years variety trials with mangels, rutabagas, turnips, and carrots have been in progress in several of the Northern States both under dry-land conditions and with abundant rainfall. In all these tests, with the exception of those conducted at Astoria, Oreg., Sheridan, Wyo., and Moccasin, Mont., mangels yielded somewhat more than other roots tested, the Mammoth Long Red variety usually being at or near the top. At Moccasin, Mont., rutabagas and mangels produced approximately the same tonnage. At Astoria, Oreg., both rutabagas and turnips had considerable advantage over mangels. Carrots generally were the least productive of the roots tested. Varietal differences in yields of rutabagas, turnips, and carrots were not very consistent.

While roots in general produced a greater amount of succulence per acre than was obtained under similar conditions from corn or some other crop grown for silage, the large amount of hand labor they require tends to restrict their production very materially. In certain limited areas where conditions are especially favorable, as in the Pacific Northwest, and in some of the more humid Eastern States, where the seasons are too short and too cool for corn, root crops are grown to advantage as feed for dairy cattle and sheep. For the farmer with a small dairy herd or one who cannot afford a silo, root crops can advantageously supply succulence for winter feed whether under dry-land or humid conditions. Furthermore, a few roots for special purposes, such as for feeding poultry and as conditioners, are very desirable.

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