

Studies of Beet-Top Silage Production in the Irrigated Rotation Experiments at the Scottsbluff, Nebraska, Field Station, 1942-1947

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CROP ROTATION experiments under irrigation have been in operation since 1912 at the Scottsbluff Field Station in western Nebraska. The elevation of the Station is approximately 4,000 feet. The 37-year mean frost-free growing season extends from May 14 to September 27, or a period of about 136 days. Mean annual precipitation has been 13.64 inches. Of this amount 11.04 inches has fallen during the growing season, April to September, inclusive, mostly during April, May, and June. The soil at the Station is classed as Tripp very fine sandy loam.

During the 30-year period, 1912-41, the rotation experiments dealt mainly with studies of farm manure and legume crops (alfalfa and sweet-clover) for the maintenance of soil productivity. In 1942, in addition to farm manure, studies of commercial fertilizers (phosphorus and nitrogen) were included in both legume and non-legume rotations. The crops grown in these rotations comprise sugar beets, potatoes, beans, barley, corn, alfalfa, and sweetclover.

This report deals only with the sugar beet crop, and mainly with the yields of sugar beet tops harvested for silage during the 6-year period 1942-47. Yields of sugar beets and gross sugar² have been tabulated to show the relationship between yields of tops, roots, and sugar.

Since 1942 sugar beet tops from most of the irrigated rotation sugar beet plots have been harvested from 1 to 10 days after the beets were topped with the exception of 1947 when snow delayed the harvest of tops for approximately 30 days. During the first 3 years (1942-44) the tops were stacked, and during the last 3 (1945-47) they were put in a pit silo. They were not chopped or cut before stacking or ensiling. Very good silage resulted from both methods of handling the tops. However, of the total weight of green tops ensiled, 78.0 percent was removed as edible silage in 1945 and 1946 from the pit silo, compared with 62.8 percent in 1942, 1943, and 1944 from the stacked tops. Edible silage referred to here represents that actually consumed by lambs in feeding experiments where soil and other inedible products were weighed back at intervals during the tests.

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In the stacked silage some mold grew on all the surface exposed to the air. Only part of this moldy silage was readily eaten by the lambs. Desirable tops of light-brown or green color were not encountered on the outside of the stack. Most of the outside tops to a depth of 6 to 12 inches were moldy, or dark-brown or black in color. In the pit silo very little surface was exposed to the air and a very small amount of moldy, slushy, or severely burned tops was encountered. Inside the stack the quality of the silage was as good as that produced in the pit silo.

The following discussion reports the yields of edible beet-top silage from various kinds of crop rotations: (a) untreated non-legume rotations, (b) untreated legume (alfalfa or sweetclover) rotations, (c) non-legume rotations treated with manure or commercial fertilizer, (d) legume (alfalfa) rotations treated with manure or commercial fertilizer, and (e) legume (sweetclover) rotations treated with manure or commercial fertilizer.

Yields of edible beet-top silage have been determined on the basis of silage production in a pit silo, and represent 78.0 percent of the green weight of tops harvested annually from each rotation.

Discussion of Results

Yields from Untreated Non-legume Rotations.—This class of rotations includes No. 20, a 2-year rotation of beets and potatoes, and No. 35, a 3-year rotation of beets, barley, and potatoes. Neither rotation has received manure, commercial fertilizer, or other treatments during the past 36 years.

During the past 6 years the mean yield (3-year mean for rotation 20) of edible beet-top silage from these two rotations amounted to 2.14 tons per acre, or 702 pounds per ton of beets (table 1). The green tops at harvest contained 64.9 percent moisture. The beets contained 18.1 percent sugar, and yielded 2235 pounds of gross sugar per acre.

Table 1.—Yields of edible beet-top silage, sugar beets, and gross sugar in untreated non-legume rotations, 1942-1947, Scottsbluff Field Station.

Rotation	Tons per acre		Pounds silage per ton of beets	Percent		Gross sugar per acre (pounds)
	Edible silage	Sugar beets		Moisture in tops at harvest	Sugar in beets	
Rotation 20	2.03 ¹	5.8	700	66.1 ¹	17.9	2087
Rotation 35	2.25	6.4	703	63.7	18.4	2383
Mean	2.14	6.1	702	64.9	18.1	2235

¹Figures marked with (1) are 3-year means.

Crop Sequence

Rotation 20—Beets, potatoes.

Rotation 35—Beets, barley, potatoes.

Yields from Untreated Legume Rotations.—This group of rotations includes No. 33, a 3-year rotation of beets, barley planted with sweetclover, and potatoes; No. 49, a 4-year rotation of beets, barley planted with sweetclover, sweetclover pastured, and potatoes; No. 41, a 4-year rotation of beets, barley planted with alfalfa, alfalfa, and potatoes; and No. 63, a

6-year rotation of beets, barley planted with alfalfa, alfalfa 3 years, and potatoes. In rotations 33, 41, and 63, the legume is used as a green-manure crop for potatoes, and in rotation 49, as a pasture crop for sheep. The sugar beet crop follows potatoes in each of these rotations.

Yields of edible beet-top silage, sugar beets, and gross sugar are shown in table 2. The lowest yield of edible beet-top silage was 4.24 tons (4-year mean) produced in rotation 33, and the highest yield, 6.15 tons, in rotation 63. Yields in rotation 49 (5.66 tons) and 41 (5.99 tons) varied little from the yield in rotation 63. The mean yield of 5.51 tons from the four rotations (table 2) was 3.37 tons higher than the yield from the two untreated non-legume rotations (table 1). The 6-year mean yields (1942-47) of sugar beets were 13.9 tons in rotation 41, 11.6 tons in rotation 33, 11.0 tons in rotation 49, and 10.8 tons in rotation 63. The sugar content of the beets varied from 15.6 percent in rotations 49 and 63 to 16.6 percent in rotation 33. Moisture in the tops at harvest for the four rotations was 71.4 percent.

Table 2. Yields of edible beet-top silage, sugar beets, and gross sugar in untreated legume rotations, 1942-1947, Scottsbluff Field Station.

Rotation	Tons per acre		Pounds silage per ton of beets	Percent		Gross sugar per acre (nounds)
	Edible silage	Sugar beets		Moisture in tops at harvest	Sugar in beets	
Rotation 33	4.24 ¹	11.6	731	70.7 ¹	16.6	3847
Rotation 49	5.66	11.0	1029	68.9	15.6	3461
Rotation 41	5.99	13.9	862	73.3	16.2	4498
Rotation 63	6.15	10.8	1139	72.6	15.6	3328
Mean	5.51	11.8	940	71.4	16.0	3783

¹Figures marked with (1) are 4-year means.

Crop Sequence

Rotation 33—Beets, barley-sweetclover, potatoes.

Rotation 49—Beets, barley-sweetclover, sweetclover pastured, potatoes.

Rotation 41—Beets, barley-alfalfa, alfalfa, potatoes.

Rotation 63—Beets, barley-alfalfa, alfalfa, alfalfa, alfalfa, potatoes.

Comparison of Farm Manure and Commercial Fertilizer in Non-legume Rotations.—This group comprises four pairs of rotations varying in length from 2 to 6 years. One member of each pair receives manure and the other, commercial fertilizer. For example, rotations 21 and 20C are alike in sequence but rotation 21 is treated with farm manure, and 20C with commercial fertilizer. Rotations 35B and 35C, 43B and 43C, and 67B and 67C are paired in a similar manner. The manure has been applied at the rate of 12 tons per acre annually to the sugar beet crops in rotations 21, 35B, 43B, and 67B. The sugar beet and potato crops in rotations 20C, 35C and 43C have each received annual applications of a fertilizer containing 56 pounds P_2O_5 and 51 pounds N since 1945. The two beet crops and the potato crop in rotation 67C have each received annual applications of a fertilizer containing 56 pounds P_2O_5 and 68 pounds N; the two barley crops have each received 68 pounds N, and the bean crop 56 pounds P_2O_5 since 1945. From 1942 to 1944, inclusive,

the applications of P_2O_5 were the same as listed above, but the nitrogen applied in each instance amounted to 26 pounds. Crop sequences, treatments, and yields are shown in table 3.

Table 3.—A comparison of yields of edible beet-top silage, sugar beets, and gross sugar in non-legume rotations treated with farm manure or commercial fertilizer, 1942-1947, Scottsbluff Field Station.

Rotation	Tons per acre		Pounds silage per ton of beets	Percent		Gross sugar per acre (pounds)
	Edible silage	Sugar beets		Moisture in tops at harvest	Sugar in beets	
(a) Manure:						
Rotation 21	5.09 ¹	15.2	670	69.5 ¹	17.8	5411
Rotation 35B	5.76	14.9	773	71.8	17.4	5175
Rotation 43B	4.18	12.7	658	69.4	18.3	4707
Rotation 67B	6.46	14.3	903	72.6	16.7	4787
Mean (a)	5.37	14.3	751	70.8	17.5	5020
(b) Commercial Fertilizer:						
Rotation 20C	5.14	16.0	642	68.5	17.8	5740
Rotation 35C	4.44 ²	14.5	612	74.3 ²	17.2	4964
Rotation 43C	3.62	12.4	584	66.5	17.9	4428
Rotation 67C	6.69	15.4	869	71.8	16.9	5186
Mean (b)	4.97	14.6	677	70.3	17.4	5079

¹Figures marked with (1) are 4-year means.

²Figures marked with (2) are 3-year means.

Crop Sequence and Treatments

(a) Manure:

Rotation 21—Beets (M-12 tons), potatoes.

Rotation 35B—Beets (M-12 tons), barley, potatoes.

Rotation 43B—Beets (M-12 tons), barley, beans, potatoes.

Rotation 67B—Beets (M-12 tons), barley, potatoes, beets (M-12 tons), barley, beans.

(b) Commercial Fertilizer:

Rotation 20C—Beets (56 pounds P_2O_5 + 51 pounds N), potatoes (56 pounds P_2O_5 + 51 pounds N).

Rotation 35C—Beets (56 pounds P_2O_5 + 51 pounds N), barley, potatoes (56 pounds P_2O_5 + 51 pounds N).

Rotation 43C—Beets (56 pounds P_2O_5 + 51 pounds N), barley, beans, potatoes (56 pounds P_2O_5 + 51 pounds N).

Rotation 67C—Beets (56 pounds P_2O_5 + 68 pounds N), barley (68 pounds N), potatoes (56 pounds P_2O_5 + 68 pounds N), beets (56 pounds P_2O_5 + 68 pounds N), barley (68 pounds N), beans (56 pounds P_2O_5).

The mean yield of edible beet-top silage from the four manured rotations was 5.37 tons per acre compared with 4.97 tons from the four rotations treated with commercial fertilizer. The moisture content of the beet tops at harvest was 70.8 percent in the manured and 70.3 percent in the commercial-fertilized rotations. Sugar beet roots yielded 14.3 tons, contained 17.5 percent sugar, and produced 5,020 pounds of gross sugar per acre in the manured rotations, compared with 14.6 tons, 17.4 percent sugar, and 5,079 pounds of gross sugar in rotations treated with commercial fertilizer. Acre yields of beet-top silage were slightly below the yield produced by the untreated legume rotations (table 2), but much above the yield obtained in the untreated non-legume rotations (table 1).

Comparison of Manure and Commercial Fertilizer in Legume (Alfalfa) Rotations.—This group comprises one pair of 4-year rotations, and two pairs of 6-year rotations. One member of each pair receives farm manure and the other commercial fertilizer. Rotation 41B is a 4-year rotation of beets, barley planted with alfalfa, alfalfa, and potatoes. Rotation 63B is the same except that alfalfa is grown 3 years instead of 1 year. Rotation 66B is the same as 63B except that beans replace 1 year of alfalfa. The sugar beet crop in each of these rotations has received

farm manure at the rate of 12 tons per acre, annually. Rotations 41C, 63C, and 66C are respectively the same as those listed above except that the beet crop in each rotation has received a fertilizer containing 56 pounds P_2O_5 and 102 pounds N, and the potato crop, a fertilizer containing 56 pounds P_2O_5 since 1945. Previous to 1945, the applications of nitrogen amounted to 26 pounds per acre. Crop sequences, treatments, and yields are shown in table 4.

Table 4.—A comparison of yields of edible beet-top silage, sugar beets, and gross sugar in legume (alfalfa) rotations treated with manure or commercial fertilizer, 1942-1947, Scottsbluff Field Station.

Rotation	Tons per acre		Pounds silage per ton of beets	Percent		Gross sugar per acre (pounds)
	Edible silage	Sugar beets		Moisture in tops at harvest	Sugar in beets	
(a) Manure:						
Rotation 41B	7.31	17.5	835	73.2	15.8	5550
Rotation 63B	8.39	15.4	1090	76.9	14.4	4410
Rotation 66B	9.58	16.7	1147	77.6	14.3	4764
Mean (a)	8.43	16.5	1024	75.9	14.8	4908
(b) Commercial Fertilizer:						
Rotation 41C	8.00	17.2 ¹	930	73.9	16.7 ¹	5748 ¹
Rotation 63C	7.50 ¹	14.9	1007	77.2 ¹	15.0	4476
Rotation 66C	6.64	13.8	962	71.2	15.2	4231
Mean (b)	7.38	15.3	966	74.1	15.6	4818

¹Figures marked with (1) are 5-year means.

Crop Sequence and Treatments

(a) Manure:

Rotation 41B—Beets (M-12 tons), barley-alfalfa, alfalfa, potatoes.

Rotation 63B—Beets (M-12 tons), barley-alfalfa, alfalfa, alfalfa, alfalfa, potatoes.

Rotation 66B—Beets (M-12 tons), barley-alfalfa, alfalfa, alfalfa, potatoes, beans.

(b) Commercial Fertilizer:

Rotation 41C—Beets (56 pounds P_2O_5 + 102 pounds N), barley-alfalfa, alfalfa, potatoes (56 pounds P_2O_5).

Rotation 63C—Beets (56 pounds P_2O_5 + 102 pounds N), barley-alfalfa, alfalfa, alfalfa, alfalfa, potatoes (56 pounds P_2O_5).

Rotation 66C—Beets (56 pounds P_2O_5 + 102 pounds N), barley-alfalfa, alfalfa, alfalfa, potatoes (56 pounds P_2O_5), beans.

The mean yield of edible beet-top silage in the three legume rotations treated with farm manure was 8.43 tons per acre, compared with 7.38 tons in the legume rotations treated with commercial fertilizer. The manured, legume rotations produced 16.5 tons of beets per acre, with a sugar content of 14.8 percent, a yield of 4,908 pounds of gross sugar per acre, compared with 15.3 tons of beets with a sugar content of 15.6 percent and a yield of 4,818 pounds of gross sugar per acre in similar rotations treated with commercial fertilizer. Edible silage per ton of beets amounted to 1,024 pounds in the manured rotations and 966 pounds in those treated with commercial fertilizer.

As compared with the non-legume rotations (table 3), the rotations including alfalfa as a legume and treated with farm manure or commercial fertilizer produced higher yields of edible beet-top silage and higher yields of sugar beet roots, but lower percentages of sugar in the beets, and, consequently, slightly lower yields of gross sugar per acre. Moisture in the sugar beet tops at harvest amounted to 75.9 percent in the manured and 74.1 percent in the commercial fertilized legume rotations (table 4) compared with approximately 70 percent moisture in tops from similarly treated rotations without the legume crop (table 3).

Yields Under the Influence of Manure and Commercial Fertilizer in Sweetclover Rotations.—This group includes three 4-year rotations and one 3-year rotation. Rotation 49C is a rotation of barley planted with sweetclover, sweetclover pastured with sheep, potatoes, and sugar beets. Rotation 49D is the same as 49C except that the sweetclover crop the second year is used for hay and green manure instead of for pasture. Rotation 46B is a rotation of barley planted with sweetclover, sweetclover pastured, and two sugar beet crops. Number 33B is a rotation of beets, barley planted with sweetclover, and potatoes. Each sugar beet crop in rotations 49C and 49D has received a fertilizer containing 56 pounds P_2O_5 and 102 pounds N, and each potato crop, one containing 56 pounds of P_2O_5 annually since 1945. From 1942 to 1945, the application of N amounted to 26 pounds per acre in each instance. The second-year beet crop in rotation 46B and the beet crop in rotation 33B have received farm manure annually at the rate of 12 tons per acre since 1942. The manured and commercial-fertilized rotations in this group are not comparable on the basis of length of rotation and crop sequence. The data have been tabulated (table 5) on the basis of treatment to show the value of farm manure or commercial fertilizer in various unrelated rotations where sweetclover has been used as a green-manure or pasture crop.

The mean yield of edible beet-top silage from rotations 49C and 49D, treated with commercial fertilizer, amounted to 7.24 tons compared with 5.86 tons and 6.11 tons for the first and second-year beet crops, respectively, in rotation 46B, and 6.49 tons in rotation 33B. Yields of sugar beets were higher in the rotations treated with commercial fertilizer but the sugar content in the beets was lower, consequently the total yields of gross sugar was lower than the manured plots.

Table 5.—Yield of edible beet silage, sugar beets, and gross sugar in legume (sweetclover) rotations treated with farm manure or commercial fertilizer, 1942-1947, Scotts-bluff Field Station.

Rotation	Tons per acre		Pounds silage per ton of beets	Percent		Gross sugar per acre (pounds)
	Edible silage	Sugar beets		Moisture in tops at harvest	Sugar in beets	
(a) Manure:						
46B—1st year	5.86	12.5	938	72.2	16.5	4144
46B—2nd year	6.11	13.7	892	70.2	16.8	4623
33B	6.49 ²	14.0	927	71.2	16.4	4614
Mean (a)	6.15	13.4	919	71.2	16.6	4460
(b) Commercial Fertilizer:						
Rotation 49C	7.57 ¹	14.8	1023	76.7 ¹	14.4	4271
Rotation 49D	6.91 ¹	14.4	960	75.7	15.1	4355
Mean (b)	7.24	14.6	991	76.2	14.8	4313

¹Figures marked with (1) are 5-year means.

²Figures marked with (2) are 3-year means.

Crop Sequence and Treatments

(a) Manure:

Rotation 46B—Barley-sweetclover, sweetclover pastured, beets, beets (12 tons M).

Rotation 33B—Beets (M-12 tons), barley-sweetclover, potatoes.

(b) Commercial Fertilizer:

Rotation 49C—Barley-sweetclover, sweetclover pastured, potatoes (56 pounds P_2O_5), beets (56 pounds P_2O_5 + 102 pounds N).

Rotation 49D—Barley-sweetclover, sweetclover hay and green manure, potatoes (56 pounds P_2O_5), beets (56 pounds P_2O_5 + 102 pounds N).

Table 6.--Summary of mean yields of edible beet-top silage, sugar beets and gross sugar in different types of rotations at the Stottsbluff Field Station, 1942-1947.

Number of rotations	Type of Rotations	Tons per acre		Pounds edible silage per ton of beets	Percent		Gross sugar per acre (pounds)
		Edible silage	Sugar beets		Moisture in tops at harvest	Sugar in beets	
2	Untreated non-legume rotations	2.14	6.1	702	64.9	18.1	2235
4	Untreated legume rotations	5.51	11.8	940	71.4	16.0	3783
4	Manure in non-legume rotations	5.37	14.3	751	70.8	17.5	5020
4	PN in non-legume rotations	4.97	14.6	677	70.3	17.4	5079
3	Manure in legume (alfalfa) rotations.....	8.43	16.5	1024	75.9	14.8	4908
3	PN in legume (alfalfa) rotations	7.38	15.3	966	74.1	15.6	4818
2	Manure in legume (sweetclover) rotations.....	6.15	13.4	919	71.2	16.6	4460
2	PN in legume (sweetclover) rotations.....	7.24	14.6	991	76.2	14.8	4313

Summary

During the 6-year period 1942-47, sugar beet tops from most beet plots in the irrigated rotation experiments at the Scottsbluff Field Station in western Nebraska have been harvested for silage production. During 3 years (1942-44) the tops were stacked on the ground, and during 3 years (1945-47) they were placed in a pit silo. The beet-top silage was used in lamb-feeding experiments where soil and other inedible products were weighed back at intervals during the tests. Consequently, edible silage in this discussion represents that actually consumed by lambs.

Of the total weight of green tops stacked (1942-44), 62.8 percent was edible silage, compared with 78.0 percent edible silage from tops placed in the pit silo in 1945 and 1946.

Yields of edible beet-top silage in this discussion have been determined on the basis of silage production in a pit silo, and represent 78.0 percent of the green weight of tops harvested annually from each rotation.

Yields of edible beet-top silage, sugar beets, and gross sugar per acre have been reported for each rotation with mean yields for different types of rotations grouped according to treatment. Farm manure has been applied to the sugar beet crop in the manured rotations at the rate of 12 tons per acre annually. Commercial fertilizer (treble-superphosphate and ammonium sulphate) has been applied in most instances at the rate of 112 pounds of P_2O_5 and 102 pounds of N per rotation.

The results according to rotation type and treatment are shown in table 6. Yields of edible beet-top silage ranged from 2.14 tons per acre in the untreated non-legume rotations to 8.43 tons in the legume rotations with alfalfa and treated with farm manure. Legume (alfalfa) rotations treated with commercial fertilizer produced 7.38 tons of edible silage per acre. A yield close to this (7.24 tons) came from legume (sweetclover) rotations treated with commercial fertilizer. Untreated legume rotations produced 5.51 tons, and manure or commercial fertilizer in non-legume rotations produced 5.37 and 4.97 tons of edible silage, respectively.

The highest yields of edible beet-top silage, and sugar beets occurred in legume (alfalfa) rotations treated with manure or commercial fertilizer, but because of higher sugar content, slightly higher yields of gross sugar per acre came from the non-legume rotations treated with manure or commercial fertilizer. Moisture in the sugar beet tops at harvest was higher in the legume rotations, than in those without a legume. Yields of edible beet-top silage in the legume rotations was very close to one-half the yield of sugar beet roots.