Cropping and Fertilization Practices for the Production of Sugar Beets in Western Nebraska[1]

H. F. RHOADES AND LIONEL HARRIS[2]

Crop rotation experiments were conducted at the Scotts Bluff Experiment Station from 1912 to 1949. Scofield and Holden (10)[3] and Hastings (3) reported the results through 1934. The results for sugar beets during the entire period are summarized here.

Some of the specific objectives of this paper are: (a) to show the influence of cropping and manurial practices on soil properties and the production of sugar beets; (b) to show the relationships between soil properties and the sugar percentage of sugar beets; (c) to compare the influence of

Table 1.—Some Rotations Including Sugar Beets at the Scotts Bluff Experiment Station. 1912-49.

Rotation No.[1] 1942-49	1912-41	Crop sequence and fertilization for period 1942-49.[2]
		ROTATIONS WITHOUT ALFALFA
		No Legume
20	20	Sugar beets, potatoes
21	21	(M) Sugar beets, potatoes
20C	—	(N, P) Sugar beets, (N, P) potatoes
35	30	Sugar beets, barley, potatoes
35B	31	(M) Sugar beets, barley, potatoes
35C	—	(N, P) Sugar beets, barley, (N, P) potatoes
		Field Beans Only Legume
43B	—	(M) Sugar beets, barley, beans, potatoes
43C	—	(N, P) Sugar beets, barley, beans, (N, P) potatoes
67B	..	(M) Sugar beets, barley, beans, (M) sugar beets, barley, potatoes
67C	—	(4/3 N, P) Sugar beets, (4/3 N) barley, (P) beans, (4/3 N, P) sugar beets, (4/3 N) barley, (4/3 N, P) potatoes.
		ROTATIONS WITH ALFALFA
41	40	Sugar beets, barley (alf.), alfalfa, potatoes
41B	—	(M) Sugar beets, barley (alf.), alfalfa, potatoes
41C	—	(2 N, P) Sugar beets, barley (alf.), alfalfa, (P) potatoes
66B	—	(M) Sugar beets, barley (alf.), alfalfa (2 yrs.), potatoes, beans
66C	—	(2 N, P) Sugar beets, barley, (alf.), alfalfa (2 yrs.), potatoes, beans
63	60	Sugar beets, barley (alf.), alfalfa (3 yrs.), potatoes
63B	61	(M) Sugar beets, barley (alf.), alfalfa (3 yrs.), potatoes
63C	—	(2 N, P) Sugar beets, barley (alf.), alfalfa (3 yrs.), (P) potatoes

[1] Where rotation numbers are given for both periods, there were only slight changes made in 1942. Where rotation numbers are given for the period 1942-49 only, old rotations were modified appreciably.

[2] M = 12 tons manure per acre applied for the crop indicated; N = 250 pounds ammonium sulfate or approximately 51 pounds nitrogen ner acre; and P = 125 pounds superphosphate (45% P_2O_5) or approximately 56 pounds P_2O_5 per acre. Manure and commercial fertilizer were applied prior to the following crop mentioned. During the period 1942 to 1944, N = 125 pounds ammonium sulfate rather than 250 pounds.

[1] Contribution from the Nebraska Agricultural Experiment Station and the Soil and Water Conservation Research Branch, Agricultural Research Service of the U. S. Dept. of Agriculture. Published with the approval of the Director as Paper No. 645, Journal Series, Nebraska Agricultural Experiment Station.

[2] Agronomist, Nebraska Agricultural Experiment Station and Western Section of Soil and Water Management, Soil and Water Conservation Research Branch; and Associate Agronomist, Superintendent Scotts Bluff Experiment Station, Nebraska Agricultural Experiment Station and Western Section of Soil and Water Management, Soil and Water Conservation Research Branch, respectively.

[3] Numbers in parentheses refer to literature cited.

farm manure and commercial fertilizers for the production of sugar beets; and (d) to discuss the application of the results obtained at the Scotts Bluff Experiment Station to other soils in western Nebraska.

Detailed descriptions of the rotations and cultural practices used at the Scotts Bluff Experiment Station during the period from 1912 to 1941 have been reported (3, 10). Crop sequence and fertilization practices from 1942 to 1949 for the rotations emphasized here are reported in Table 1. Sugar beets were grown in 17 rotations during the period prior to 1942 and in 26 rotations during the period from 1942 to 1949.

Relationships of Cropping and Manurial Practices to Nitrogen, Phosphorus and Potassium Levels in Tripp Soil

Total nitrogen content and nitrification rate of Tripp soil were materially influenced by the cropping and manurial practices followed from 1912 to 1941 (Table 2). Where neither manure was applied nor legume grown (Rotations 20 and 35), the nitrogen content of the soil after 30 years was approximately 36 percent lower than the nitrogen content of the virgin soil. Furthermore, the nitrogen level of the virgin soil was not maintained even where manure was applied at the rate of 12 tons per acre to one crop in two- and three-year rotations (Rotations 21 and 35B). The nitrogen level was almost maintained at the level of the virgin soil in Rotations 41 and 63 where alfalfa was grown one-half the time, and it was maintained in Rotation 63B where alfalfa was grown one-half the time and manure was applied at the rate of 12 tons per acre to one crop in the six-year rotation. Nitrification rate of the soil was affected more by cropping practice and manure application than was nitrogen percentage of the soil.

Table 2.—Nitrogen, Phosphorus and Potassium Status of Tripp Soil to a Depth of 12 Inches After 30 Years of Cropping and Manurial Practice.[1]

Rotation Number	Nitrogen status[2]		Phosphorus status[3]		
	Total,	Nitrification rate, p.p.m.	Total, p.p.m.	Soluble at pH 5.0, p.p.m.	Exchangeable potassium,[2]
1942-49	%	NO_3-N	P	P	m.e./100 g.
			Virgin soil—sampled in 1912		
....	0.092	....	......	..	1.12
			Two-year rotations—no legume		
20	0.059	9.7	361	14.4	1.26
21	0.079	14.9	423	27.9	1.91
			Four-year rotation—alfalfa two years		
41	0.090	20.0		.	.
			Three-year rotations—no legume		
35	0.059	9.8	359	9.6	1.22
35B	0.081	16.5	421	25.9	2.12
			Six-year rotations—alfalfa three years		
63	0.085	19.5	355	7.4	0.76
63B	0.094	18.7	380	15.5	0.95

[1] Analyses on samples taken in 1941.
[2] Obtained from data reported by Kubota (5).
[3] Obtained from data reported by Yien (10).

Total and soluble phosphorus contents were greater in the soil from the manured than from the non-manured rotations, the differences being relatively greater for soluble than for total phosphorus. This effect of manure application on soil phosphorus levels was obtained even though the removal of phosphorus by crops was greater in the manured than in the non-manured rotations (Tables 2 and 3). The relatively greater effect of manure on phosphorus level in the soil from non-legume than in the soil from legume rotations was associated with greater total amounts of manure applied during the 30-year period. Alfalfa in the cropping system increased the use of phosphorus by sugar beets and other crops. No doubt the alfalfa also used considerable phosphorus. Thus the inclusion of alfalfa in the cropping system may be expected to lower the available phosphorus level of the soil compared with cropping systems not including alfalfa or other legumes.

Table 3.—Nitrogen and Phosphorus Contents of Sugar Beets at Harvest Time as Influenced by Cropping and Manurial Practices.

Rotation Number, 1942-49	Percentage N (dry basis) in		Percentage P (dry basis) in		Pounds per acre in crop[2]	
	Tops[1]	Roots	Tops[1]	Roots	N	P
			IN 1935 AFTER 24 YEARS[3]			
			Two-year rotations—no legume			
20	1.88	0.50	0.15	0.08	67	7.7
21	2.51	0.88	0.18	0.11	221	22.0
			Four-year rotation—alfalfa two years			
41	2.60	0.88	0.15	0.09	191	14.3
			Three-year rotations—no legume			
35	1.77	0.50	0.15	0.09	40	5.7
35B	1.89	0.69	0.19	0.13	111	17.0
			Six-year rotations—alfalfa three years			
63	1.74	0.50	0.14	0.08	95	10.5
63B	2.02	0.74	0.16	0.09	147	14.3
			IN 1950 AFTER 39 YEARS[4]			
			Two-year rotations—no legume			
20	1.66	0.46	0.15	0.08	54	6.3
21	2.49	0.65	0.20	0.29	154	28.1
			Four-year rotation—alfalfa two years			
41	2.23	0.65	0.18	0.08	119	11.3
			Three-year rotations—no legume			
35	1.64	0.38	0.14	0.09	46	6.1
35B	2.03	0.61	0.29	0.13	113	19.6
			Six-year rotations—alfalfa three years			
63	2.25	0.72	0.11	0.07	170	11.1
63B	2.61	0.87	0.17	0.09	265	20.5

[1] Does not include crowns in 1935; includes crowns in 1950.
[2] Total removed in tops, crowns, and roots.
[3] Data in 1935 obtained by J. C. Russcl, M. D. VVeldon, H. F. Rhoades and Lionel Harris. Nebraska Agricultural Experiment Station.
[4] Yields for 1949 used in calculating total nitrogen and phosphorus used per acre.

Exchangeable potassium was increased materially in Tripp soil by the application of manure in the non-legume rotations (Table 2). In contrast, where alfalfa was grown one-half the time there was a reduction in exchangeable potassium. Nevertheless, the levels of exchangeable potassium were well above the amounts needed to supply the crop even where alfalfa was grown.

Nitrogen and phosphorus levels in the soil due to cropping and manure application were also evaluated by determining percentages of nitrogen and phosphorus in various crops at harvest time in 1935 and 1950. Nitro-

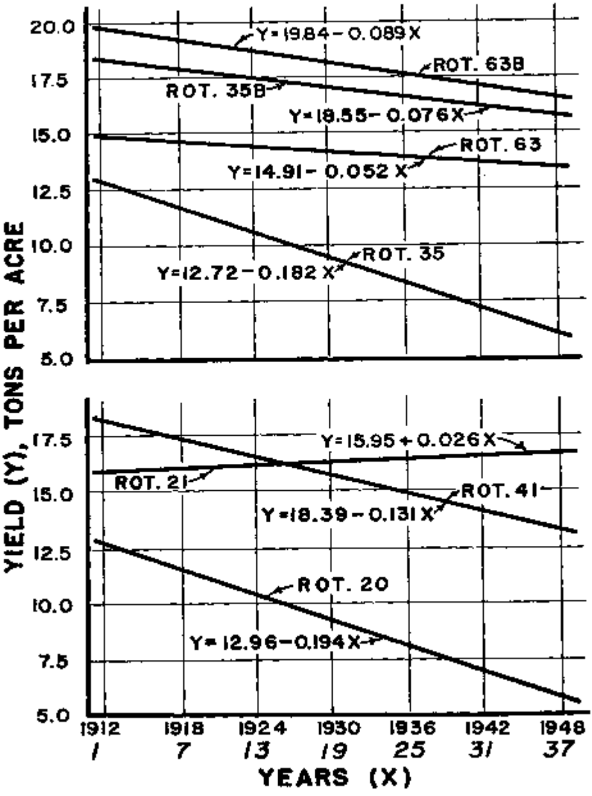

Figure 1. Influence of alfalfa in this cropping system and manure application on the yields of sugar beet roots at the Scotts Bluff Experiment Station for a period of 38 years. Linear regression of yields (Y) and years in rotation (X).

gen and phosphorus percentages in the tops and roots of sugar beets and the total amounts of these elements removed per acre in the crops were materially greater for the manured than for the non-manured rotations (Table 3). In general, nitrogen percentages in the tops and roots and the total amounts of nitrogen and phosphorus removed per acre by sugar beets were greater in the legume than in the non-legume rotations. However, phosphorus percentages in the tops and roots of sugar beets from the legume rotations were essentially the same as the percentages of that element in sugar beets from non-manured rotations without a legume.

Yields of Sugar Beet Roots and Edible Beet Top Silage in Relation to Cropping and Manurial Practice

Yields of sugar beet roots and edible beet top silage were much greater in the rotations containing a legume or receiving manure than in the non-legume rotation without manure (Table 4). Nevertheless, the trends in yield of sugar beet roots were generally downward throughout the 38 years of study even in Rotation 63B with alfalfa three out of six years and a 12-ton application of manure for sugar beets (Figure 1). Linear regression lines depict the actual yield trends rather well for Rotations 21, 35B, 41, 63 and 63B. However, the abrupt decline in yields of sugar beets which occurred the first few years after 1912 is not shown accurately by the linear regression lines. It is believed that the decline in yield of sugar beet roots

Table 4.—Influence of Cropping and Manurial Practice on Sugar Production and the Yield of Edible Silage by Sugar Beets.

Rotation Number, 1942-49	Yield of roots, tons per acre	Sugar content, %	Gross yield of sugar, tons per acre	Edible beet top silage,[1] tons per acre
		MEAN OF VALUES FOR 1930 TO 1941[2]		
		Two-year rotations—no legume		
20	7.8	17.6	1.37	2.0
21	16.8	17.1	2.87	4.7
		Four-year rotation—alfalfa two years		
41	15.0	16.3	2.44	3.9
		Three-year rotations—no legume		
35	7.8	18.0	1.40	2.0
35B	16.6	18.0	2.99	4.6
		Six-year rotations—alfalfa three years		
63	13.4	15.9	2.13	3.6
63B	17.3	15.8	2.73	5.0
		MEAN OF VALUES FOR 1942 TO 1949		
		Two-year rotations—no legume		
20	6.7	17.8	1.19	1.8
21	15.6	17.7	2.76	5.4
		Four-year rotation—alfalfa two years		
41	14.3	16.4	2.34	5.9
		Three-year rotations—no legume		
35	6.8	18.4	1.25	2.1
35B	15.8	17.7	2.80	5.4
		Six-year rotations—alfalfa three years		
63	12.4	15.7	1.95	6.4
63B	16.7	14.6	2.44	6.4

[1]Represents 78 percent of the green weight of tops as reported by Harris (2).
[2]Yield of sugar beet roots and sugar percentage for this period taken from circular nv Nuckolls and Harris (9); yield of edible beet top silage for period 1939-41.

in the alfalfa rotations is due in part to a decline in the available phosphorus level in the soil (Table 2). Studies now underway should give more information on that point. Data reported by Schuster and Harris (9) suggest the possibility that an increased prevalence of root-knot nematode could account for a part of the decline in yields of sugar beets.

Sugar Percentage and Sugar Production Due to Cropping and Manurial Practice

Nuckolls and Harris (7) pointed out that the inclusion of manure in cropping systems at the Scotts Bluff Experiment Station decreased sugar percentages of sugar beet roots slightly during the period from 1930 to 1941. In contrast, there was a much greater reduction in sugar percentage due to the inclusion of alfalfa in the cropping systems. Somewhat similar effects of manure application and alfalfa in the rotation of sugar percentages were obtained for the periods 1930 to 1941 and 1942 to 1949 (Table 4).

In view of the marked effects of manure applications and legume in the rotation on sugar percentage and on nitrogen level of the soil, a close relationship between the capacity of the soil to supply nitrogen and the sugar percentage of sugar beets grown on the soil is suggested. Such a relationship is further indicated by the negative correlations of percentage nitrogen and nitrification rate of the soil with sugar percentage of sugar beets for the rotations at the Scotts Bluff Experiment Station (Table 5). In addition, there was a highly significant correlation of —0.73 between nitrogen and sugar percentages of sugar beet roots sampled in 1935. The latter relationship is in agreement with results obtained by Haddock (1) and Hill (4).

Table 5.—Correlation of Percentage Nitrogen and Nitrification Rate of Soil with Sugar Percentage of Sugar Beets. Rotation Experiments at the Scotts Bluff Experiment Station.

Correlation of soil property and sugar percentage of sugar beets	Correlation coefficient, r: 0 to 6 inch depth	Correlation coefficient, r: 0 to 12 inch depth
Percentage nitrogen in the soil (1935 sampling) with:		
Percentage sugar in 1935	—0.58[1]	—0.54[1]
Mean percentage sugar for 1930 to 1941	—0.71[2]	—0.68[2]
Percentage nitrogen in the soil (1941 sampling) with:		
Percentage sugar in 1941	—0.47[1]	—0.44
Mean percentage sugar for 1930 to 1941	—0.71[2]	—0.68[2]
Mean percentage sugar for 1942 to 1949	—0.85[2]	—0.85[2]
Nitrification rate of soil (1941 sampling) with:		
Percentage sugar in 1941	—0.48[1]	—0.37
Mean percentage sugar for 1930 to 1941	—0.65[2]	—0.53[1]
Mean percentage sugar for 1942 to 1949	—0.63[2]	—0.62[2]

[1] Significant at the 5 percent level.
[2] Significant at the 1 percent level.

It is of interest to speculate on the resason for the relatively small effect of manure on sugar percentage of sugar beet roots compared with the effect of legume in the rotation even though both practices influenced the nitrogen level of the soil and the percentage nitrogen in sugar beet roots to about the same degree. One suggestion comes from the relatively high phosphorus levels in the soil and the relatively high phosphorus percentage in sugar beet roots from the non-legume rotation receiving manure compared with the legume rotations. Possibly the manure supplied sufficient phosphorus for sugar beets to reduce the deleterious effect of added nitrogen. This was further suggested by the partial correlation coefficient of 0.45 in 1935 between percentage phosphorus and percentage sugar in sugar beets holding nitrogen percentage constant. Although the partial correlation coefficient of 0.45 was not significant at the 5 percent level (value of 0.47 required for significance), it seems reasonable to assume that the greater phosphorus supplied by manure might account in part at least for the relatively different effects of manure application and alfalfa *in* the cropping system on sugar percentage of sugar beets.

Maximum yields of sugar per acre were obtained in the non-legume rotation receiving manure (Table 4). That was due to a combination of moderate to high yields of roots with relatively high sugar percentages. The failure of the legume rotations to produce maximum yields of sugar was definitely associated with the unfavorable effects of legumes on sugar percentage. Because of this circumstance it should be desirable to grow sugar beets in the rotation as far away from the legume as possible.

Comparison of Manure and Commercial Fertilizer for the Production of Sugar Beets

One of the important differences between the revised rotations and those conducted prior to 1942 was the inclusion of commercial fertilizer in the revised rotations. A combination of nitrogen and phosphorus fertilizers was applied in amounts approximately equal to the nitrogen but nearly double the amount of phosphorus supplied by manure in comparable rotations (Table 1). There was one important difference; all of the manure used in the rotations was applied for sugar beets, whereas the fertilizers were divided among two or more non-legume crops. The amount of phosphate applied for sugar beets was constant for all rotations; twice as much nitrogen was applied for sugar beets in the legume as in the non-legume rotations (Table 6).

There was some advantage of commercial fertilizer compared with manure in terms of root yields and sugar production by sugar beets in the rotations without alfalfa (Table 6). The reverse tended to be true in the alfalfa rotations. Similar sugar percentages and yields of edible beet top silage were obtained from manure and fertilizer applications. It is impossible to determine from the results obtained the individual effects of nitrogen and phosphorus on the production of sugar beets in the different rotations.

Application of Results to Other Soils in Western Nebraska

To what extent will the influence of cropping and fertilization practices on soil properties and sugar beet production reported here for Tripp soil apply to other soils in western Nebraska? It seems likely **that the** same practices would maintain soil nitrogen at a higher level in the finer-textured Mitchell and Minatare soils than in the Tripp soil. On the other hand, the nitrogen level would not likely be maintained as high by the same practices in the sandy Parshall and Bayard soils as in Tripp soil.

Table 6.—Comparison of Manure and Commercial Fertilizer for the Production of Sugar Beets in Rotations with and without Alfalfa at the Scotts Bluff Experiment Station. 1945-1949.

Rotation No.	Nitrogen content of soil in 1941, %	Fertilization for sugar beets[1]	Mean yields 1945-49, tons per acre: Roots	Gross Sugar	Edible Silage	Sugar content, %
ROTATIONS WITHOUT ALFALFA						
No Legume						
21	0.079	Manure	15.3	2.69	5.0	17.6
20C	0.072	N + P	17.0	3.03	5.4	17.8
35B	0.081	Manure	16.0	2.88	6.6	18.0
35C	0.072	N + P	17.0	3.04	5.8	17.9
Field Beans Only Legume						
43B	0.065	Manure	14.6	2.76	4.9	18.9
43C	0.063	N + P	15.5	2.82	5.5	18.2
67B[2]	0.088	Manure	15.4	2.60	7.2	16.9
67C[2]	0.091	4/3 N + P	17.2	2.94	7.5	17.1
ROTATIONS WITH LEGUME						
41B	0.102	Manure	17.3	2.70	8.8	15.6
41C	0.090	2 N + P	17.4	2.70	9.4	15.5
66B	0.096	Manure	18.3	2.78	9.8	15.2
66C	0.087	2 N + P	15.9	2.43	8.6	15.3
63B	0.094	Manure	17.3	2.56	10.4	14.8
63C	0.100	2 N + P	16.3	2.43	9.6	14.9

[1] M = 12 tons manure per acre; N = 250 pounds of ammonium sulfate or approximately 51 pounds nitrogen per acre; and P= 125 pounds superphosphate (45% P_2O_5) or approximately 56 pounds P_2O_5 per acre.

[2] Mean of two crops of sugar beets per rotation.

There is evidence of a greater need of phosphorus by sugar beets grown on the calcareous Mitchell and Minatare soils than on the non-calcareous Tripp soil (6, 8). It seems likely that the Bayard and Parshall soils would be intermediate in phosphorus supply. Increases in yields of roots and sugar due to phosphate are much greater on the soils of medium-low fertility level than on soils of medium-high fertility level (Table 7). Potassium appears to be generally adequate for sugar beet production on most soils in western Nebraska. Differences *in* soils should be considered when judging the application of the results from the Scotts Bluff Experiment Station to other soils in the area.

Summary

Crop rotation experiments were conducted at the Scotts Bluff Experiment Station from 1912 to 1949. The results obtained with sugar beets during the entire period were summarized.

1. There was a marked effect of cropping practice and manure application on soil properties, on yield of sugar beet roots, on sugar percentage of sugar beets, and on yield of edible silage.

Table 7.—Response of Sugar Beets to Application of Commercial Fertilizer to Tripp, Mitchell, and Minatare Soils in the North Platte Valley of Nebraska during 1947 and 1948.[1]

Soil series	Number of experiments	° . „ commercial fertilizer	Increase or decrease due to-' N	P	N + P	N + P + K
MEDIUM-HIGH SOIL FERTILITY LEVEL[3]						
Yield of roots, tons per acre						
Tripp	**3**	**16.4**	**0.7**	**0.0**	0.5	0.8
Mitchell	**3**	**16.0**	**0.0**	**0.7**	0.7	1.0
Sugar content, %						
Tripp	**3**	**14.0**	**—0.8**	**0.2**	—0.9	—0.7
Mitchell	**3**	**12.0**	**—0.6**	**0.3**	—0.7	—0.5
Gross yield of sugar, pounds per acre						
Tripp	**3**	4,590	—75	65	—65	—15
Mitchell	**3**	3,840	—190	270	—65	70
MEDIUM-LOW SOIL FERTILITY LEVEL[4]						
Yield of roots, tons per acre						
Tripp	**4**	**9.2**	**1.2**	**1.0**	2.0	2.1
Mitchell	**5**	**8.1**	**1.0**	**2.3**	2.5	3.2
Minatare	**2**	**8.0**	**1.2**	**5.0**	5.6	5.0
Sugar content, %						
Tripp	**4**	**12.6**	**—0.1**	**0.4**	—0.1	0.0
Mitchell	**5**	**12.0**	**—0.8**	**0.2**	—0.6	—0.8
Minatare	**2**	**13.2**	**—0.3**	**0.0**	—0.4	—0.4
Gross yield of sugar, pounds per acre						
Tripp	**4**	2,320	280	330	480	525
Mitchell	**5**	1,949	95	590	470	585
Minatare	**2**	2,110	265	1,320	1,385	1,220

[1] Experiments conducted cooperatively with the Great Western Sugar Co. (8).
[2] N = 65 pounds nitrogen as ammonium nitrate; P = 100 pounds P_2O_5 as superphosphate (45% P_2O_5); and K = pounds K_2O as potassium chloride. Fertilizers were applied at the side of the row immediately after planting.
[3] Legumes included regularly in the cropping systems. Manure was applied for sugar beets and has been used frequently.
[4] Legumes included occasionally in the cropping systems. Little manure used.

2. Sugar percentage of sugar beets was negatively correlated with total nitrogen percentage of the soil, with nitrification rate of the soil, and with nitrogen percentage in the sugar beet roots.

3. There was some advantage of commercial fertilizer compared with manure in terms of root yields and sugar production by sugar beets in rotations without alfalfa. The reverse tended to be true in alfalfa rotations.

4. Greater yield responses by sugar beets from commercial fertilizers were obtained in western Nebraska on soils of medium-low fertility than on soils of medium-high fertility. The most outstanding response obtained was to phosphorus fertilizer on highly calcareous soils.

Literature Cited

(1) HADDOCK, JAY L.
1953. Sugar beet yield and quality. Utah Agr. Expt. Sta. Bul. 362.

(2) HARRIS, LIONEL.
1948. Studies of beet-top silage production in the irrigated rotation experiments at the Scottsbluff, Nebraska, Field Station, 1942-1947. Proc. Am. Soc. Sugar Beet Tech. 1-8.

(3) HASTINGS, STEPHEN H.
1936. Irrigated crop rotation in western Nebraska, 1912-34. U. S. Dept. Agr. Tech. Bul. 512.

(4) HILL, KENNETH WILFORD.
1952. Effect of nitrogen supply on the sucrose percentage of sugar beets. Proc. Am. Soc. Sugar Beet Tech. 201-206.

(5) KUBOTA, JOE.
1944. Some chemical properties of an irrigated chestnut soil after thirty years of different cropping and manurial practices. Master's thesis, University of Nebraska.

(6) LYONS, E. S., RUSSEL, J. C. and RHOADES, H. F.
1944. Commercial fertilizers for the irrigated sections of western Nebraska. Nebr. Agr. Exp. Sta. Bui. 365.

(7) NUCKOLLS, S. B. and HARRIS, LIONEL.
1948. Effect of crop rotation and manure on the yield and quality of sugar beets, United States Scotts Bluff (Nebr.) Field Station, 1930-41. U. S. Dept. Agr. Circ. 779.

(8) RHOADES, H. F. and JOHNSON, WENDELL.
1949. Commercial fertilizers for sugar beets in Nebraska. Nebr. Outstate Testing Circ. 3.

(9) SCHUSTER, M. L. and HARRIS, LIONEL.
1952. Effects of crop rotation on the incidence of root-knot disease of sugar beets in western Nebraska. Proc. Am. Soc. Sugar Beet Tech. 511-518.

(10) SCOFIELD, CARL S. and HOLDEN, JAMES A.
1927. Irrigated crop rotations in western Nebraska. U. S. Dept. Agr. Tech. Bul. 2.

(11) YIEN, CHEN HWA.
1949. Influence of management practices on the form of phosphorus in an irrigated chestnut soil. Master's thesis, University of Nebraska.