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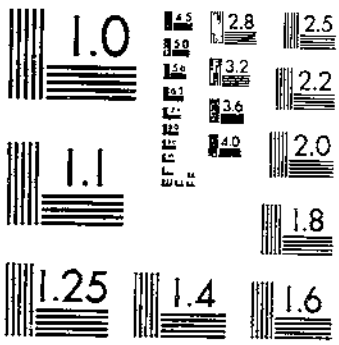

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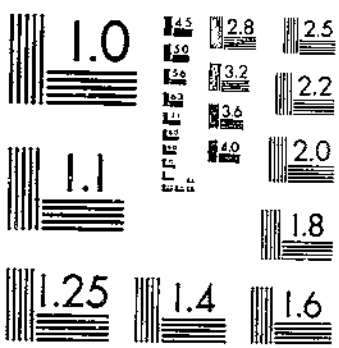

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NATIONAL BUREAU OF STANDARDS-1963-A

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INFLUENCE OF FARM MANURE ON YIELDS AND SUCROSE OF SUGAR BEETS [1]

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INTRODUCTION

Sugar-beet production has been and is at present one of the more important agricultural enterprises on the North Platte reclamation project located in western Nebraska. How to maintain the yields of beets in order that adequate cash returns may be expected has been a continual problem confronting farmers, and has been one of the objectives of the investigational activities at the Scotts Bluff Field Station.[2] Here, as well as in many other sections, where staple farm crops are grown and irrigation is practiced, crop yields have been most effectively maintained either by crop rotation and including a leguminous crop such as alfalfa or sweetclover in the crop sequences, or by applications of farm manure. However, information is inadequate as to the crops and rotational practices and the soil amendments that are conducive to promoting high soil productivity. This was recognized soon after the station was established, with the result that in 1912 a rather extensive series of rotation experiments was included as a part of the station's investigational activities (*1*, *2*, *3*, *4*, *5*, *6*, *7*).[3] Among other features a number of rotations were included for the purpose of ascertaining the influence of applications of farm manure on crop yields. With sugar beets in particular the manurial treatment has proved to be a highly effective agency for stimulating crop yields (*2*). In these experiments the farm manure is applied at the rate of 12 tons per acre once during the completion of the cycle of each rotation. However, no information had been obtained as to the

[1] Received for publication June 30, 1937.
[2] This station was established in 1903 by the Division of Western Irrigation Agriculture and is located on the North Platte reclamation project about 6 miles east of Mitchell, Nebr.
[3] Italic numbers in parentheses refer to Literature Cited, p. 12.

residual influence of the manurial treatment over a period of years, nor was it possible to observe the extent crop yields were influenced by increased applications. In view of the foregoing, in the spring of 1926 an experiment was inaugurated at this station to ascertain to what extent sugar-beet yields would be influenced by varying amounts and frequency of applications of the manurial treatment.[4]

This bulletin presents the summary of the results from the manurial treatment applied to the irrigated rotations covering the 24-year period from 1912 to 1935. Following these data are presented the results from series 1 and 2 for the first 5-year treatment period together with yields from subsequent 5 years, which afford information as to the residual influence of manure on the yields of sugar beets. Also, beginning in 1930 the sucrose content of the sugar beets has been determined with a view to ascertaining the influence the manurial treatment has had on the sugar content of the beets. These data are included in the interpretations of the results obtained.

RESULTS FROM THE IRRIGATED ROTATIONS

In these rotation experiments where direct comparisons are possible, there are three pairs of rotations, one of which in each group receives the manurial treatment, otherwise the rotations are identical. In this series there are two 2-year rotations and one 3-year rotation. These results show the extent that sugar-beet yields have been influenced by the manurial treatment over a long period. These data are recorded in table 1 and are summarized by four 6-year periods giving the mean increases in pounds of beets per ton of farm manure applied.

TABLE 1.—*Influence of applications of 12 tons of manure per acre on sugar-beet yields in the irrigated rotations, summarized by 6- and 24-year periods, Scotts Bluff Field Station, 1912–35*

Rotation No.	Crops in the rotations	Yields of beets per acre					Yield increases per ton of manure applied
		1912–17	1918–23	1924–29	1930–35	1912–35 mean	
		Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Pounds*
20	Sugar beets, potatoes	13.1	10.3	10.2	7.6	10.3	
21	Sugar beets (manure), potatoes	14.7	16.7	18.5	15.8	16.4	
	Difference in favor of manure	1.6	6.4	8.3	8.2	6.1	1,017
22	Sugar beets, oats	12.8	9.8	9.9	7.4	10.0	
23	Sugar beets, oats (manure)	17.4	18.1	19.8	17.3	18.2	
	Difference in favor of manure	4.6	8.3	9.9	9.9	8.2	1,367
30	Sugar beets, potatoes, oats	12.9	9.9	10.4	7.4	10.2	
31	Sugar beets, potatoes, oats (manure)	18.2	16.9	18.8	16.6	17.6	
	Difference in favor of manure	5.3	7.0	8.4	9.2	7.4	1,233
	Mean untreated rotations	12.9	10.0	10.2	7.5	10.2	
	Mean treated rotations	16.8	17.2	19.0	16.6	17.4	
	Mean difference in favor of manure	3.9	7.2	8.8	9.1	7.2	1,200

It is evident from these beet yields that the land in its virgin state was relatively productive, as the mean beet yield from the three untreated rotations Nos. 20, 22, and 30 was 12.9 tons of beets per

[4] This investigation was initiated by the late James A. Holden, superintendent of the Scotts Bluff Field Station, and carried on by him until his death in December 1934.

acre for the first 6-year period. Even in view of such relatively satisfactory yields for the group the mean yield increase attributable to the manurial treatment amounted to 3.9 tons per acre and in the instance of the 30-31 pair was 5.3 tons increase per acre. This latter figure is equivalent to 883 pounds of beets per ton of manure applied. Recognition should be taken of the fact that the manure was applied directly to the beets in rotations 23 and 31, whereas in rotation 21 the manure has been applied to the potatoes, therefore, in this latter rotation the beets benefit only partially from the manurial treatment. This fact is reflected in the yields, for in no instance have the yield differences due to the manure been as great between these two rotations as in the other two pairs where the manure was applied directly preceding the beet crop.

The highest mean 24-year yield of 18.2 tons of beets per acre has been harvested from the beets-oats rotation No. 23 and the lowest from the companion rotation No. 22 with a mean yield of 10.0 tons per acre, a difference of 8.2 tons attributed to the applications of farm manure. This increase is equivalent to 1,367 pounds of beets per ton of manure applied. The 6-year 1930 to 1935 mean yield of beets dropped sharply as compared with the previous 6-year period in the treated as well as the untreated rotations. There occurred three unfavorable seasons for beets out of six for the last period, which in a large measure accounts for this yield decline. However, the differences in beet yields in favor of the treatment are close in each instance, the mean yield difference being only 0.3 ton in favor of the last 6-year period.

In presenting the foregoing data, consideration has been given only to the extent the manurial treatment has influenced the yields of sugar beets. It is to be expected that the stimulus from the manurial treatment is imparted not only to the sugar beets but to the other crops included in the three pairs of rotations. The method adopted in presenting these data has been to determine the yield differences in percentages of yield increases for the three crops involved—sugar beets, potatoes, and oats. These percentage increases are tabulated in table 2 for the four 6-year periods, together with the mean increases for the 24 years.

TABLE 2.—*Crop yield increases from the irrigated rotations, expressed as percentages, attributed to applications of 12 tons per acre of farm manure, Scotts Bluff Field Station, 1912–35*

Rotation Nos.	Crop	1912–17	1918–23	1924–29	1930–35	Periodic mean
		Percent	*Percent*	*Percent*	*Percent*	*Percent*
20–21	Sugar beets	12	62	81	108	66
	Potatoes	16	43	96	104	65
22–23	Sugar beets	36	85	100	134	89
	Oats	3	28	106	80	56
30–31	Sugar beets	41	71	81	124	79
	Potatoes	9	41	55	68	43
	Oats	17	20	68	97	53

For the 24-year period the most pronounced mean percentage increases occur with sugar beets, with the exception of the 20–21 pair. As the manure is applied to the potatoes in rotation 21, whereas in the others it is applied to the beets, these higher percentages for

rotations 22-23 and 30-31 are to be expected. However, in a large measure this percentage reduction in sugar beets is absorbed by the potatoes, as the mean increase for potatoes is 65 percent in the 20-21 pair whereas in the instance of the 30-31 pair, where the manure is applied to the beets followed by potatoes, the mean percentage increase for the potato crop is reduced to 43, a difference of 22 percent.

In every instance the manurial treatment has resulted in increased yields. Even with oats in rotations 30 and 31, where there occur two intervening crops between the treatment and the oats there is a mean 24-year increase of 53 percent. The lowest increases have occurred for the first 6-year (1912–17) period, although the indicated increase for sugar beets is substantial where the manure is applied directly to the beets, as has been the practice with rotations 23 and 31. With the exception of oats for the last 6-year period involving Nos. 22 and 23 there have been consistently progressive increases for the four periods for each of the three crops.

RESULTS WHERE RATE AND TIME OF APPLICATION HAVE VARIED

In the experiment to provide information as to the effect of different rates and frequencies of application of farm manure on the yields of sugar beets, two adjoining plots of land were utilized and designated as series 1 and 2. In series 1, a total of 30 tons of farm manure was applied in different amounts, throughout a 5-year period, to each of the five ¼-acre plots, numbered 7 to 11; the treatments ranging from five consecutive 6-ton applications on plot 7 to an initial application of 30 tons to plot 11. In series 2, equal amounts of farm manure were applied each season during the 5 years, ranging from 6 to 30 tons, or a total for the 5 years of from 30 to 150 tons per acre. The material was weighed as it came from the corrals and, consequently, had a relatively high percentage of moisture, but it was typical of that generally available on the farms throughout the area. Similar to series 1, the five plots in series 2 were numbered 7 to 11. In these experiments it was deemed advisable to continue both series for a 10-year period. By so doing, beet yields would be obtained not only for the 5 years involved in the treatments, but additional information would be available as to the residual influence of various treatments on the yields of beets. The procedure followed and the yields of beets harvested from the two series for the 10 years are recorded in the following tables.

The manurial treatments applied to series 1 and 2 for the 5 years are given in table 3.

The annual yields of sugar beets harvested from series 1 and 2 for the first 5 years and the subsequent 5 years are given in table 4. Also, the 10-year mean yields and the mean yields by the two 5-year periods, 1926–30 and 1931–35, are included. The yields show the direct and residual influence of the manure.

TABLE 3.—*Year and rate of application of farm manure, in tons per acre, applied to the plots in series 1 and series 2, at the Scotts Bluff Field Station, 1926–30*

SERIES 1

Plot No.	1926	1927	1928	1929	1930	Total
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
7	6	6	6	6	6	30
8	12	6	6	6	0	30
9	18	6	6	0	0	30
10	24	6	0	0	0	30
11	30	0	0	0	0	30

SERIES 2

7	6	6	6	6	6	30
8	12	12	12	12	12	60
9	18	18	18	18	18	90
10	24	24	24	24	24	120
11	30	30	30	30	30	150

TABLE 4.—*Sugar-beet yields, per acre, from the 10 plots in series 1 and 2 at the Scotts Bluff Field Station, 1926–35*

SERIES 1

Plot No.	1926	1927	1928	1929	1930	1931	1932	1933	1934	1935	10-year mean	5-year 1926–30 mean	5-year 1931–35 mean
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
7	13.6	19.2	20.9	15.5	20.8	12.1	16.3	12.7	7.4	12.1	15.1	18.0	12.1
8	15.1	18.5	21.4	16.8	19.3	10.8	15.6	11.5	7.6	11.1	14.8	18.2	11.3
9	16.2	19.5	21.3	16.5	17.1	10.0	11.8	11.5	6.3	11.4	14.2	18.1	10.2
10	16.0	19.3	21.3	16.6	17.8	10.8	13.8	12.1	6.3	12.3	14.6	18.2	11.1
11	17.1	18.8	19.4	16.1	16.8	10.5	10.7	13.2	6.0	12.7	14.7	17.6	11.8

SERIES 2

7	13.1	18.0	20.5	14.6	18.8	11.2	14.4	11.3	6.0	11.1	13.9	17.0	10.8
8	13.8	18.8	22.6	18.6	21.6	13.1	17.8	13.6	7.8	13.2	16.1	19.1	13.1
9	13.9	19.4	24.1	20.9	23.9	12.8	21.7	14.9	8.6	12.7	17.2	20.4	14.0
10	14.2	20.1	26.3	20.7	23.1	13.8	18.9	16.5	10.2	13.8	17.8	20.9	14.6
11	16.2	20.8	23.9	22.9	23.0	16.3	21.2	16.1	10.5	17.0	19.0	21.8	16.3

Among the five plots in series 1, the maximum difference between the 10-year mean beet yields is only 0.9 ton, which is but slightly more than a 6-percent increase in favor of the plot that received five consecutive 6-ton applications. For the first 5-year period the mean yields of the five plots have the remarkably low range of only 0.6 ton of beets to the acre, or slightly more than 3 percent. These results indicate that for that period the initial 30 tons of manure applied to plot 11 were substantially as effective in maintaining the yields of the beets as were the five 6-ton treatments applied to plot 7. In considering the residual influence of the different treatments on the yields of beets for the period 1931–35, plot 7 again returned slightly the highest mean yield but only 0.3 ton more than was harvested from plot 11, which received one 30-ton application of manure at the beginning of the test in 1926. It is obvious that this small difference in tonnage is not significant. In the case of the remaining three plots only slightly greater yield differences have occurred, which may be attributed to accidental causes rather than to the difference in treatment.

Although there has been some variation in the positional yearly standing of plots 7 to 11, series 2, it is apparent that there has been a pronounced tendency for the sugar-beet yields to increase with the increased applications of farm manure. When the mean yields for the two 5-year as well as the 10-year period are computed it is found that in every instance the yields have progressively increased. For the first 5-year period the mean yields of beets from the heaviest application have exceeded those from the lightest by 4.8 tons per acre. When like comparisons are made for the 1931–35 5-year period the increase is 5.5 tons per acre. These results further afford an opportunity of observing the decline in the beet yields by comparing the yields from the first 5-year treatment period with those from the subsequent 5 years. The greatest difference is between the heaviest and lightest applications and amounts to a decline of 6.2 tons for the lightest application and 5.5 tons for plot 11 which received five 30-ton annual applications. When the differences between the mean yields of the first 5-year period and those of the second 5-year period are computed for plots 7 to 10, it is found that the maximum difference is only 0.4 ton per acre. Based upon these data, it is evident that by comparison the heavier applications of farm manure did not prove to be appreciably more effective in maintaining beet yields than the lighter treatments.

With the exception of plot 7 in this series it is possible to calculate the increase in the yields of sugar beets resulting from additional applications of farm manure. The successive increases for additional manure over 6 tons for 5 years show that the 12-ton annual application to plot 8 resulted in the production of 140 pounds of beets for each of the 30 tons of additional manure. The addition of 60 tons more manure, or an application of 18 tons per year for 5 years, gave a production of 113 pounds of beets per ton of additional manure. Plot 10 received 24 tons of manure per acre, or 90 tons more in 5 years than plot 7, and this additional manure indicates a yield of 87 pounds of beets for each ton. The heaviest treatment was on plot 11, which received 150 tons of manure in 5 years or 120 tons of additional manure as compared with plot 7 and here the lowest increase is indicated, as only 80 pounds of beets were produced for each of the 120 tons. From these data it is apparent that farm manure is most efficiently utilized by the lighter applications, apparently within the 6- to 12-ton limits.

COMPUTED VALUE OF FARM MANURE

The foregoing tables and text present the influence of farm manure on the yields of sugar beets both in the irrigated rotations, which include other crops, and with continuous cropping to sugar beets where the rate and time of applications of manure varied. In four out of seven instances 1 or more years intervened between the manurial treatment and the crop affected, and the results recorded in table 2 indicate the extent to which the stimulus of the manure was imparted to the other crops, to which the manure was not directly applied. However, this presentation of the results obtained does not afford an opportunity of ascertaining the farm value of the manure. A somewhat similar method has been used in previous reports to determine the comparative value of manure and alfalfa (*1*, *7*). The method herein adopted has been to place a price on the various crops under consideration and multiply these figures by the yield increases, and the

result then will reflect the approximate farm value of the manure. The unit prices placed on the three crops involved are as follows: Sugar beets, $6 per ton; potatoes, 50 cents per bushel; and oats, 40 cents per bushel. These figures are believed to be representative of the price relationships that have existed since 1931. The amounts recorded following the different crops are obtained by multiplying these unit prices by the yield increases that occurred. These data afford information as to the total and per-ton values of 12-ton applications of farm manure for 24 years.

Based upon these price relationships by 6-year periods, 12-ton applications of farm manure in these three rotations have a total value ranging from a minimum of $23.95 to a maximum of $131.80 (table 5). The lowest value for manure occurred during the 6-year period (1912–17) when the yields from the unmanured rotations were relatively high, as is evidenced by the data recorded in tables 1 and 2. During this period the indicated value of a 12-ton application of farm manure ranged from the minimum of $23.95 to a maximum of $46.63 per acre. For the remaining three 6-year periods the differences are more pronounced. For the 24 years for the three groups there was a range from a minimum value of $56.30 for the 22–23 pair to a maximum of $90.62 for the 3-year rotation.

Considering by intervals of 6 years, the per-acre value of each ton of farm manure applied, it is found that the minimum value is $1 and the maximum $5.49. The minimum value of $1 per ton of manure is measurably in excess of the estimated cost of the application, and there are substantial excess returns in all instances for the three 6-year periods from 1918 to 1935. In rotation 21 the manure was applied to the potato crop whereas in the other two rotations receiving the treatment it was applied to the sugar beets. However, the reduction in the returns from the beets in No. 21 in a large measure is absorbed by the increase in the returns from potatoes.

TABLE 5.—*Calculated gross and per-acre values of 12-ton applications of farm manure in the irrigated rotations at the Scotts Bluff Field Station, 1912–35*

Rotation Nos.	Crop	Value per acre				
		1912–17	1918–23	1924–29	1930–35	Periodic mean
20–21	Sugar beets	$9.60	$38.40	$49.80	$49.20	$35.75
	Potatoes	14.35	23.25	82.00	63.60	45.80
	Gross	23.95	61.65	131.80	112.80	82.55
	Per ton	1.09	2.57	5.49	4.70	3.44
22–23	Sugar beets	27.60	49.80	59.40	59.40	49.05
	Oats	.88	5.60	13.36	9.16	7.25
	Gross	28.48	55.40	72.76	68.56	56.30
	Per ton	1.19	2.31	3.03	2.86	2.35
30–31	Sugar beets	31.80	42.00	50.40	55.20	44.85
	Potatoes	10.35	26.85	60.50	54.05	37.94
	Oats	4.48	6.48	9.84	10.52	7.83
	Gross	46.63	75.33	120.74	119.77	90.62
	Per ton	1.30	2.09	3.35	3.33	2.52

The calculated values of increasing applications of farm manure have been determined in series 2 where sugar beets alone are involved. These results are given in table 6 both for the 1926–30 and the subsequent 1931–35 periods, which afford an opportunity of observing the residual value of different applications of farm manure. In this table the 5-year periodic means and the per-acre value for each plot together with the totals are presented. Because there was no check or untreated plot in the series, it is necessary to use as a base plot 7 which was treated with five 6-ton applications.

TABLE 6.—*Calculated values of increasing applications of farm manure applied to sugar beets, series 2, Scotts Bluff Field Station, 1926–30*

Plot No.	Total value			Per-ton value		
	1926–30	1931–35	Total	1926–30	1931–35	Total
8	$93.00	$69.00	$132.00	$2.10	$2.30	$4.40
9	102.00	96.00	198.00	1.72	1.80	3.30
10	117.00	114.00	231.00	1.27	1.27	2.57
11	144.00	165.00	309.00	1.20	1.38	2.58

As is to be expected, there is a progressive total value increase as the applications have been increased, and this increase is consistent in both 5-year periods. The total values of the increases range from a minimum for the smallest application of $131.40 to a maximum of $306.60 for plot 11, to which there was applied five 30-ton applications. The farm value of the manure can be the most readily observed from the figures recording the calculated per-ton values. For the first 5-year treatment periods these have ranged from a maximum of $2.08 for the lightest five 6-ton increased applications to $1.19 for the heaviest, or 24 tons annually in excess of the amount applied to plot 7.

INFLUENCE OF MANURIAL TREATMENT ON THE CALCULATED SUGAR PRODUCTION

As shown in the preceding pages the crop yield increases resulting from certain of the manurial treatments have been substantial. However, in the instance of sugar beets the price per ton the processor can afford to pay the producer for his sugar beets is dependent upon the pounds of recoverable sugar, which, it appears, may vary somewhat under different conditions. Not infrequently sugar-beet growers and processors have been apprehensive that where substantial increases in yield have resulted from applications of farm manure there would be a sharp decline in the sucrose percentage of the beets.

To ascertain the extent the manurial treatment has influenced sucrose percentage of the beets, beginning in 1930 the sucrose percentages and the apparent purity coefficients of the beets from the irrigated rotations, as well as those produced from series 1 and 2, have been determined by sampling the plots. The procedure adopted in obtaining this information was as follows: In sampling the plots only normally competitive beets were taken. The number of beets comprising the samples ranged from 10 to 20. Sucrose percentages were determined by the Sachs-LeDocte method, and the apparent purity coefficients were computed from refractometer readings of total solids, except in 1930 and 1931 when the Brix spindle was used to determine

the total solids. The results from the six plots under observation in the irrigated rotations are given in table 7 in which there is included the 5-year (1931–35) mean for sucrose percentage, apparent purity, and the yield increase in percent for tonnage of beets and for indicated available sugar.

TABLE 7.—*Calculated sucrose and apparent purity coefficient expressed as percentages, together with the yield and calculated sugar per acre given as percentage increases attributed to applications of farm manure, from the irrigated rotations, Scotts Bluff Field Station.*

Rotation No.	Sucrose	Apparent purity coefficient	Yield increase	
			Tons	Calculated sugar production
	Percent		*Percent*	*Percent*
20	17.7	92.6	108	95
21	17.0	91.3		
Difference	.7	1.3		
22	17.6	92.8	134	110
23	16.4	89.2		
Difference	1.2	3.6		
30	18.1	93.3	124	112
31	17.5	91.2		
Difference	.6	2.1		

In all three instances the sucrose percentage was slightly lower in the beets from the manured rotations with a mean difference of only 0.8 percent. There is a slightly greater decline in the apparent purity coefficients of the beets from the treated plots when compared with the untreated, the mean being 2.3. However, differences for both these factors are very small and are insignificant when it is considered that the minimum yield increase based upon the calculated sugar production per acre is 95, the maximum 112, with a mean of 106 percent.

TABLE 8.—*Sucrose percentages and apparent purity coefficients, together with mean yields of sugar beets from series 1 and 2, Scotts Bluff Field Station, 1930–35*

Series and plot No.	1930		1931		1932		1933		1934		1935		1930–35 mean		1930–35, mean yield per acre
	Sucrose	Purity coefficient	Sucrose	Purity coefficient	Sucrose	Purity coefficient	Sucrose	Purity coefficient	Sucrose	Purity coefficient	Sucrose	Purity coefficient	Sucrose	Purity coefficient	
Series 1:	*Percent*		*Percent*		*Percent*		*Percent*		*Percent*		*Percent*		*Percent*		*Tons*
7	16.4	88.0	18.2	90.8	16.5	90.0	18.6	94.0	20.0	93.6	20.3	88.6	18.3	90.8	13.6
8	16.6	89.4	19.1	93.3	16.1	90.0	18.6	94.0	19.1	93.6	19.9	87.9	18.2	91.5	12.6
9	17.0	88.7	19.3	91.9	15.7	91.3	18.6	93.9	20.1	94.2	20.2	88.5	18.5	91.4	11.4
10	16.3	88.9	19.5	92.8	15.9	91.2	18.6	93.3	19.6	94.8	19.2	90.7	18.2	92.0	12.2
11	16.1	90.4	19.1	91.9	16.5	91.9	17.5	91.4	18.0	92.6	18.7	91.5	17.7	91.6	12.6
Series 2:															
7	16.4	88.2	18.4	91.1	16.1	90.7	18.8	92.9	18.8	93.4	19.0	89.0	17.9	90.9	12.1
8	15.4	85.9	17.3	89.1	16.0	89.5	17.8	92.4	19.4	92.0	18.7	91.8	17.4	90.1	14.5
9	13.5	83.3	17.1	88.1	15.9	89.3	17.7	92.7	20.3	95.0	19.2	89.0	17.3	89.6	15.6
10	13.0	81.4	17.1	88.7	15.3	88.2	17.8	91.5	19.2	93.4	20.0	89.5	17.1	88.8	16.0
11	11.1	77.9	15.1	84.0	14.7	87.7	16.3	90.5	17.5	92.1	18.8	89.9	15.6	87.9	17.7

In table 8 there are presented the sucrose percentage and the apparent purity coefficient as determined from samples, together with the mean yields of sugar beets for the 1930–35 period from the five plots in series 1 and 2. As the determinations of sucrose percentage and apparent purity coefficients were not made until 1930, only during this year was it possible to observe the direct effects of manure applications.

While there is some annual variation in these determinations, the differences occurring in the 6-year means are too close to be considered significant. The maximum range for mean sucrose percentage for the five plots is only 0.8 and for the apparent purity coefficient the maximum range is 1.2. It is apparent from these results that calculated indicated available sugar for these five plots has not been influenced appreciably by the different methods of applying the manurial treatment.

From these data given in series 2 it is evident that the more excessive applications of farm manure have had a tendency to depress both the sucrose percentages and apparent purity coefficients of the beets. This is particularly noticeable in 1930, the last year of the treatment, and the subsequent year, 1931. Following these 2 years the differences were progressively less.

In view of the fact that the heavier applications of farm manure apparently have depressed the sucrose and purity values, it is informative to compare the acre yields of sugar [5] as calculated from these determinations of quality of the beets for the five plots in series 2 for the 6-year period. The results of these computations are presented in table 9.

TABLE 9.—*Calculated sugar production from the five plots in series 2 at Scotts Bluff Field Station, 1930–35*

[Results given as pounds of indicated available sugar per acre]

Plot No.	1930	1931	1932	1933	1934	1935	1930–35 mean
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
7	5,438	3,788	4,206	3,947	2,107	3,754	3,873
8	5,715	4,039	5,098	4,474	2,784	4,532	4,440
9	4,971	3,887	6,163	4,594	3,317	4,341	4,646
10	4,861	4,187	5,101	5,375	3,758	4,940	4,702
11	4,333	4,185	5,466	4,750	3,385	5,746	4,643

The last application of manure occurred in 1930, and for this season beginning with plot 8 the net number of indicated pounds of sugar per acre from plots 9, 10, and 11 progressively declined.

While for the 6-year period the mean gross tonnage of sugar beets per acre has been substantially greater for the heavier applications, yet the mean acre yields of indicated available sugar for 1930 (the last year that manure was applied) and 1931 were 8 percent greater for the plots (7 and 8) receiving the lighter treatments than those recorded for plots 9 to 11. On the other hand, when similar comparisons are made with the yields given in table 4 it is found that there is a gross tonnage yield increase for plots 9 to 11 over plots

[5] The acre yield of gross sugar for a given plot is calculated by multiplying the acre yield of roots (in pounds) by the sucrose percentage as determined from the plot samples. When this product is multiplied by the apparent purity coefficient (as a percentage) the value designated as indicated available sugar is obtained.

7 and 8 of 14 percent. Not only is the indicated available sugar in 1930 less for the plots receiving the heavier application of farm manure, but also it should be recognized that manurial treatments much in excess of 12 tons per acre annually are not practical. Furthermore, the available supply of this soil amendment is but rarely sufficient to provide for even the lighter applications.

These results combined with those given in table 7 afford evidence that moderate and practical applications of farm manure, which have proved so effective in stimulating the yields of sugar beets, do not appreciably reduce the sugar content of the beets. The use of manure at the rate of 12 tons per acre has greatly increased the available sugar per acre in these experiments. Further information regarding the effect of manure and rotations upon the sucrose content of sugar beets at this station are given in another publication (*4*).

SUMMARY AND CONCLUSIONS

On the North Platte reclamation project sugar-beet production is among the more important agricultural enterprises. The measure of the success of the settlers is dependent upon satisfactory yields of sugar beets as well as other crops being harvested.

This bulletin records the extent varying applications of farm manure have influenced the yields of sugar beets and, also, the extent the sucrose content has been affected.

The results from the irrigated rotations where the manurial treatment has been applied from three pairs of rotations are recorded covering a 24-year period.

The highest mean yield of 18.2 tons of beets per acre was harvested from 2-year rotation No. 23, which received a biennial application of farm manure at the rate of 12 tons per acre. The lowest yield of 10 tons of beets per acre was harvested from the companion rotation No. 22, or a difference of 8.2 tons per acre, which may be attributed to the manurial treatment.

Yield increases of sugar beets as well as the other crops included in the rotations have been computed as percentages, which affords an opportunity of observing the extent the manurial treatment has influenced the yields of other crops in the different rotations.

In the test with sugar beets alone the results indicate that an initial application of 30 tons of farm manure per acre has as effectively maintained beet yields as did five 6-ton applications. This condition applied not only to the 5-year treatment period, but also to the subsequent 5 years, which afforded an opportunity of observing the residual influence of the different treatments of the yields.

In the test where increasing applications of farm manure were applied to sugar beets the yields of beets progressively increased. This condition applied both to the 5 years the treatment was being given and to the following 5-year period.

The calculated per ton value of the farm manure has been determined. In the irrigated rotation it has ranged from a minimum of $1 to a maximum of $5.49 per ton. For the 24 years there is a mean indicated value of $2.77 for each ton applied. In series 2 the calculated value of increasing applications of farm manure have been computed. The largest per ton values are reflected in the lighter applications.

The extent to which manurial treatment influenced the percent of net sugar in the beets, the calculated sucrose expressed as percentage, and the apparent purity coefficient was recorded.

In the irrigated rotations both the sucrose and apparent purity coefficient percentages were only slightly less in the beets from the irrigated rotations to which farm manure was applied as compared with those not so treated.

The different methods of applying the farm manure practiced in series 1 did not influence the calculated net sugar per ton appreciably.

The computations indicate that such excessive applications of farm manure as were applied to series 2 depressed both the sucrose percentages and the apparent purity coefficient somewhat.

Moderate and practical applications of farm manure that have proved so effective in stimulating the yields of sugar beets have not significantly reduced the sucrose percentages or apparent purity coefficients of sugar beets.

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