A STUDY OF THE EFFECTS OF SOME DIFFERENT SODS AND FERTILIZERS ON SUGAR BEET YIELDS

by

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A STUDY OF THE EFFECTS OF SOME DIFFERENT SODS AND FERTILIZERS ON SUGAR BEET YIELDS

Differences observed in growth behavior of sugar beets when planted on a field previously laid out in a pasture experiment, led to the present experiment. The pasture plots were a twenty fourth of an acre in size, and included eight replications of eleven different forage mixtures. It was possible to restake the original pasture plots by observable differences in the growth of the beets during their first two months of growth. In an attempt to see if these observable differences could be measured and interpreted, the following experiment was set up.

The grasses used in this study were smooth brome grass (Bromus inermis), orchard grass (Dactylis glomerata), Kentucky bluegrass (Poa pratensis), Canada bluegrass (Poa compressa), redtop (Agrostis alba Var. vulgaris), timothy (Phleum pratense), sheep fescue (Festuca ovina), and chewings fescue (Festuca rubra var. commutata). Red clover (Trifolium pratense) was seeded with timothy. Alfalfa (Medicago sativa) was seeded in mixture with brome grass and orchard grass. The present paper deals only with the results following the aforementioned grasses when planted alone or with the legumes.

The field on which this study was made was very gently rolling with less than two per cent slope at any place.

LITERATURE REVIEW

Numerous studies have been made on the effect of crop sequence upon sugar beet yields. Most of these studies have been on cultivated crops and legume crops. In these various studies conducted to find ways of increasing sugar beet yields, a number of conditions which contribute to better yields have been discovered. However, no one factor can be credited as a solution to the problem of getting better beet yields or preventing a decrease in yields.

Farnsworth (7) suggested (a) the lack of plant nutrient supply, (b) deterioration of soil structure and (c) disease as being the three chief limiting factors, any one of which would depress sugar beet yields. The same author also states (7) (8) that the air capacity in the soil for optimum sugar beet growth ranges from about 12 to 22 per cent.

Coke (3) reported that so long as soil moisture is maintained above the permanent wilting point but below the moisture equivalent, the rate of root and sucrose development is not greatly influenced by the quantity of moisture in the soil. Doneen (5) said the growth of sugar beets is independent of soil moisture so long as readily available water is in the soil.

Smith and Cook (18) (19) found that excessive compaction greatly decreased sugar beet yields and that excess water on a compacted soil magnified the detrimental effects of compaction of the soil.

Ulrich (20) found that a nitrogen deficiency produced beets with a high sugar percentage, while an excess of nitrogen resulted in beets with a low sugar percentage. His theory was that a heavy supply of nitrogen at the first of the season that would be depleted near the last of the growing season could result in both high yield and high sugar percentage from the crop. Cook and Davis (4) found the sucrose content of beets following alfalfa was lower than that of beets following corn. However, they believed that the decrease was due partly to the larger size of the beets. Doxtator (6) found that there was a definite trend in favor of higher sucrose content in higher acre populations.

Organic matter content and favorable physical conditions were maintained relatively higher under a grass cover than under cultivation according to McHenry and Newell (14). The same authors also found that grasses apparently differ in their ability to stabilize soil aggregates and that it seems to be due to difference in root development of the individual perennial grasses. Odland and Smith's (17) work indicated that a number of factors were involved in the effects of certain crops on succeeding crops.

EXPERIMENTAL PROCEDURE

Since the different grasses have different effects on succeeding crops it was deemed desirable to conduct an investigation on growing sugar beets after several different sods to determine if possible which sod brings about the best growing conditions in the soil for sugar beets and to attempt to find what fertilizer treatment gives best results following the sod.

The plots used in this test were seeded to grass and grass-legume mixtures in 1943 (16), on a soil described as Conover light silt loam. There were sixteen different types of sods of which only ten will be considered in this paper. Sugar beets were grown on these plots two years in succession in order to better observe persistency of the effects of the different sods on the sugar beets, even though it has been shown that the yield and quality of marketable beets is depressed by growing sugar beets following sugar beets (13). At harvest the beets were counted, weighed, and sucrose tests run on a representative sample from each plot. In 1948 physical measurements were made on beets in a section of each plot. During the growing season of 1948 observations were made as to the appearance of the beets and are shown in table 1.

Table 1. Observation of Growth Conditions of Beets in 1948.

Seed Plots	Dates of Observations				
	July 17	July 23	Aug. 3	Aug.10	Sept. 6*
Brome-Alfalfa	Good	Good	Good	Good	Rich green
Timothy-Red Clover	Weak	Average	Average	Average	Med. green
Brome grass	Average	Good	Good	Good	Med. green
Kentucky Bluegrass	Good	Good	Good	Good	Pale green
Chewings Fescue	Average	Weak	Average	Average	Pale green
Sheep Fescue	Weak	Weak	Weak	Weak	Med. green
Redtop	Average	Good	Average	Average	Med. green
Canada Bluegrass	Average	Good	Good	Good	Med. green
Orchard-Alfalfa	Good	Good	Good	Good	Med. green
Orchard grass	Average	Average	Good	Good	Pale green

*Foliage appearance at harvest time

The beets from brome grass, brome-alfalfa, orchard-alfalfa, and plots of both bluegrass sods showed better than average growth appearance, while beets on the timothy-red clover and plots of both fescues were below average in their growth.

Yield of Sugar Beets

The rainfall was about 50 per cent of normal during July and August in 1948, therefore the yields from all plots were rather low. The rainfall for the same two months in 1949 was about normal, consequently the average yield from all plots was about as high as in 1948 in spite of a poor stand, averaging 49 per cent as compared to 74 per cent in 1948.

The monthly precipitation is presented in Figure 1.

Figure 1. Monthly Total Precipitation For 1948 and 1949.

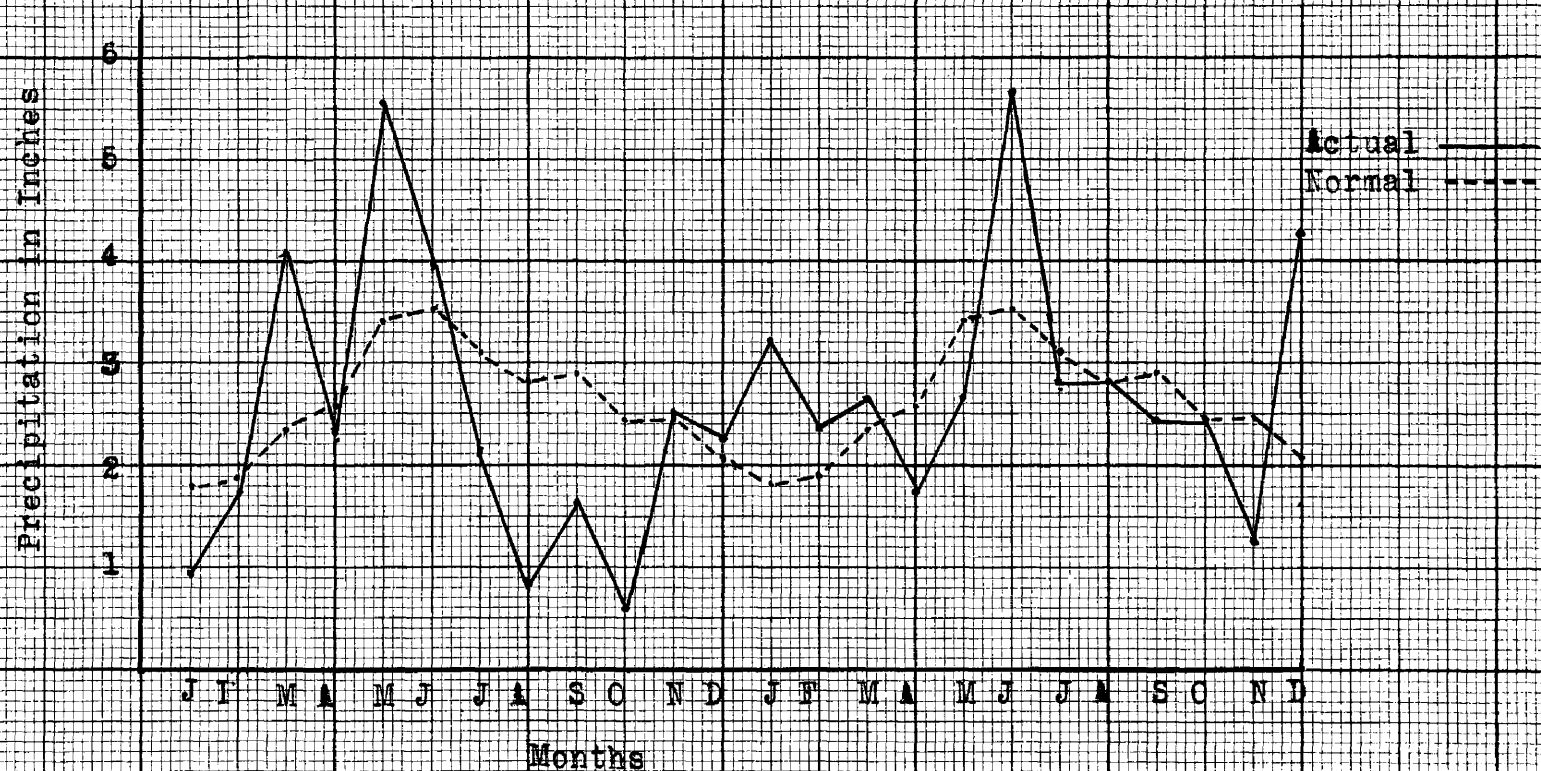

Table 2. Average Yields and Stands of Sugar Beets on Different Sods.

Sod Plots	Average % Stand 1948	Average % Stand 1949	Average Yield Tons/A 1948	Average Yield Tons/A 1949	Yield of Sugar Lbs/A 1948	Yield of Sugar Lbs/A 1949
Brome-Alfalfa	70.7	58.0	7.99	8.99	2314	2712
Timothy-Red Clover	56.6	31.4	4.88	3.80	1316	1133
Brome grass	73.8	54.6	8.09	9.12	2300	2858
Kentucky Bluegrass	68.1	30.5	7.20	4.56	2050	1368
Chewings Fescue	70.0	45.6	5.95	5.97	1758	1799
Sheep Fescue	63.3	27.9	4.25	3.31	1169	1008
Redtop	81.6	38.9	7.78	5.07	2355	1512
Canada Bluegrass	81.9	44.0	7.17	6.17	2129	1957
Orchard-Alfalfa	79.1	77.9	9.33	9.81	2682	2617
Orchard grass	91.0	78.3	8.83	13.15	2687	4123

The plots of beets following orchard grass, orchard-alfalfa, brome grass, and brome-alfalfa sods gave highest average yields per acre both years, in spite of the fact that there were higher per cent stands of beets on the redtop and Canada bluegrass sods in 1948 than on any of the sods except orchard grass. In 1949 the per cent stands on these better yielding plots were considerably higher than on any of the others. Likewise, yields of sugar beets for both years averaged the lowest following timothy-red clover and sheep fescue sods. Beets following sods of redtop and the two bluegrasses were very near the average in yields for all treatments in 1948, but the yield from chewings fescue sod plots was below average. In 1949 beet yields following Kentucky bluegrass and redtop dropped below that of chewings fescue which was approximately the same yield per acre as in 1948. Yields from Canada bluegrass, sheep fescue, and timothy-red clover sods were about one ton per acre lower in 1949 than their respective averages in 1948. On the other hand the beets following those sods that gave best yields increased their average yields in 1949 over those of 1948. Due to a high per cent of sucrose and a high coefficient of apparent purity the beets on the redtop sod plots produced a higher average yield of pure sugar per acre than any but those on the orchard grass and the orchard-alfalfa in 1948, however this condition did not prevail in 1949.

Table 3. Weights Per Beet, Per Cent Sucrose, and Coefficients of Apparent Purity.

Sod Plots	Wt. Per Beet Average 1948	Wt. Per Beet Average 1949	Average % Sucrose 1948	Average % Sucrose 1949	Average Coefficient of Apparent Purity (%) 1948	Average Coefficient of Apparent Purity (%) 1949
Brome-Alfalfa	1.20	1.65	16.1	16.7	86.75	86.85
Timothy-Red Clover	0.92	1.29	15.6	16.5	86.58	87.62
Brome grass	1.17	1.78	16.8	16.8	85.80	88.68
Kentucky Bluegrass	1.11	1.56	16.2	16.2	86.44	88.56
Chewings Fescue	0.89	1.35	16.8	16.8	87.18	88.03
Sheep Fescue	0.70	1.25	15.6	16.9	86.52	89.11
Redtop	1.02	1.39	17.2	16.6	88.20	87.13
Canada Bluegrass	0.87	1.48	17.2	17.3	86.13	88.66
Orchard-Alfalfa	1.26	1.34	17.1	15.1	85.04	88.25
Orchard grass	1.04	1.60	17.4	17.2	87.90	90.79

As shown in table 3, beets from the sod plots of brome-alfalfa, brome grass, orchard grass, orchard-alfalfa, and Kentucky bluegrass were heavier than the average weight of beets from all plots in 1948. Beets of average weight were produced on the redtop sod plots while beets from the remaining plots were considerably smaller than the average beets from all plots. Those following sheep fescue were smallest of all. In 1949 there was little change in the order of rank in size of beets though all averaged larger than in 1948. The beets from the orchard-alfalfa sod plot were smaller than average while those from the Canada bluegrass sod plots were above average in size. Beets from the sheep fescue and timothy-red clover sod plots still averaged smallest of all. Sucrose percentage was not affected by the different grasses. The same was true for apparent purity but the average was higher in 1949 than in 1948.

Table 4. Physical Study of Beets Produced in 1948.

Sod Plot	Avg. Length*	Avg. Diam.* at Shoulder	Extra Branches Number
Brome-Alfalfa	13.40	7.72	1.05
Timothy-Red Clover	12.10	7.03	0.90
Brome grass	15.45	8.24	0.90
Kentucky Bluegrass	13.07	7.72	1.07
Chewings Fescue	12.60	7.00	0.90
Sheep Fescue	9.60	6.66	0.95
Redtop	14.70	7.26	0.60
Canada Bluegrass	15.20	7.31	0.40
Orchard-Alfalfa	14.90	7.40	0.60
Orchard grass	15.90	7.37	0.40

*Measurements in centimeters.

The physical study of the beets showed little of significance except that the beets from sods of the fescues and of timothy-red clover were shortest and smallest in diameter at the shoulder. As shown in table 4 there was little branching of the beet roots on any of the sod plots. A root branching out from the main beet and as much as one-half inch in diameter at the base was counted as an extra branch.

Soil Studies

In 1948 the soil samples were taken with a golf green cup cutter. The cup cutter cuts a hole four and one-half inches in diameter and the samples were taken to plow depth. The soil samples were taken to plow depth with a Hoffer soil sampler in 1949. In both years the samples were taken just before plowing the land in April. The samples were taken from various points over a plot of each of the sods considered in this paper. These soil samples were allowed to become air dry in the laboratory and were then thoroughly mixed. The amount of organic matter was determined on triplicate samples of soil from each of the sods by means of a photoelectric colorimeter method described by Graham (10). The averages of these tests are given in table 5. The brome-alfalfa, redtop, and Canada bluegrass sods showed a higher per cent of organic matter in 1949 than in 1948 which is probably due to error in sampling or in making the organic matter analysis. Per cent of organic matter did not significantly correlate with yield of sugar beets either year on these plots.

Table 5. Summary of Soil Analysis Studies.

Sod Plots	pH	Clay %	Organic Matter % 1948	Organic Matter % 1949	Pore Space % Volume Total	Pore Space % Volume Non-Cap	Aggregates* % Water Stable
Brome-Alfalfa	7.54	15.0	2.80	3.05	55.4	20.3	82.4
Timothy-Red Clover	6.31	19.0	3.50	2.20	52.2	19.3	80.0
Brome grass	6.74	18.2	3.20	1.82	53.3	16.2	74.3
Kentucky Bluegrass	6.41	21.3	4.35	2.88	55.4	17.1	77.9
Chewings Fescue	7.38	17.8	3.25	2.65	54.2	19.9	72.0
Sheep Fescue	6.61	19.0	3.80	2.87	50.9	15.8	76.1
Redtop	6.54	15.0	2.38	3.08	53.0	17.7	67.3
Canada Bluegrass	6.64	14.2	1.51	3.20	49.8	13.3	57.9
Orchard-Alfalfa	7.38	14.0	2.26	1.96	55.8	19.9	74.1
Orchard grass	7.82	13.5	2.00	1.75	56.0	20.4	63.5

*Particles less than 0.1 mm. remaining in aggregates.

Triplicate samples from each of the sods were tested for pH with the Beckman meter. These tests were averaged in each case by converting the reading to hydrogen-ion concentrations, averaging them and converting the average back to pH. The average pH of samples from each sod plot is given in table 5.

The per cent clay in the soils was determined by using 100 gram triplicate samples in hydrometer tests described by Bouyoucos (2). Aggregation determinations were made on triplicate 25 gram samples of soil from each sod by the method described by Yoder (22). Findings of the aggregation study are shown in table 6.

Porosity determinations were made on soils following the different sods in 1949. These studies were made by the core method described by Baver (1). The cores were taken at about 28 foot intervals on one plot of each sod treatment and there were a total of six cores for each treatment. Pore space information in table 5 was derived from these tests.

There was barely a positive correlation at the five per cent level between the yields in tons of sugar beets and the pH of the soil on the plots. There was a positive correlation at the two per cent level between pH and the per cent stand of beets at harvest time in the 1949 crop but there was no significant correlation in the 1948 crop.

Table 6. Aggregate Analysis and Per cent Clay

Sod Plots	Per cent of sample retained on different size seives, in mm.* 4	2	1	.5	.25	.10	0.00	% Clay**
Brome-Alfalfa	13.6	8.8	11.2	13.6	26.0	16.0	10.8	15.0
Timothy-Red Clover	14.8	4.0	4.8	15.6	29.6	18.8	12.4	19.0
Brome grass	11.6	5.2	5.2	13.6	26.4	22.4	15.6	18.2
Kentucky Bluegrass	2.0	3.2	6.0	20.4	34.0	20.0	14.4	21.3
Chewings Fescue	3.2	2.4	4.0	15.2	32.0	26.0	17.2	17.8
Sheep Fescue	4.0	2.4	4.4	17.2	35.2	20.8	16.0	19.0
Redtop	8.0	5.6	5.6	10.8	29.6	21.2	19.2	15.0
Canada Bluegrass	5.2	4.0	4.0	9.2	25.6	27.6	24.4	14.2
Orchard-Alfalfa	23.6	5.6	5.2	9.2	21.6	20.0	14.8	14.0
Orchard grass	3.2	5.6	4.8	11.6	28.4	26.0	20.4	13.5
Dispersed								
Brome-Alfalfa	1.6	2.0	1.2	2.8	10.4	20.4	61.6	15.0
Timothy-Red Clover	2.8	1.2	1.2	2.0	9.6	20.4	62.8	19.0
Brome grass	6.4	1.2	1.6	2.4	9.2	18.4	60.8	18.2
Kentucky Bluegrass	1.6	1.2	2.4	2.0	9.2	18.4	65.2	21.3
Chewings Fescue	1.6	1.6	1.6	2.8	12.4	18.4	61.6	17.8
Sheep Fescue	0.8	1.2	1.2	2.4	8.8	18.4	67.2	19.0
Redtop	2.8	1.6	1.2	2.4	11.6	21.6	58.8	15.0
Canada Bluegrass	3.2	0.8	1.2	2.4	13.2	21.2	58.0	14.2
Orchard-Alfalfa	2.8	1.6	1.2	2.8	11.6	22.8	57.2	14.0
Orchard grass	1.2	1.2	1.6	2.8	14.0	23.2	56.0	13.5

*Averages of triplicate samples.
**Averages of triplicate samples by hydrometer test.

Per cent clay content showed a significant negative correlation at the one per cent level to the per cent stand of beets in 1948, but the relation was significant at only the two per cent level in 1949. In both years per cent of clay had a negative correlation to yield in tons of sugar beets and to yield in pounds of pure sugar per acre, at the five per cent level.

There was no correlation between per cent of aggregation and per cent stand of beets or production of beets per acre in these plots. Neither total pore space nor non-capillary pore space showed any correlation to yield.

Penetrometer Tests

Penetrometer tests were made periodically throughout the growing season in 1949. The penetrometer used in these tests was one designed by C. M. Hansen of Agricultural Engineering and L. S. Robertson of Soil Science, both at Michigan State College. This machine known as the Hanbertson Penetrometer is so constructed that it draws a curve upon a card as the probe is forced into the ground and then by using a key scale on the curve the amount of pressure required at any depth reached can be determined. Twelve readings were made on each plot at each test date. The figures appearing in table 7 are averages of those twelve readings for each date. In cases where it was evident that the probe had struck a stone or a dry weather crack in the soil the reading was eliminated in calculating the averages. Moisture determinations were made on soil samples from each plot on the date of the penetrometer test except on May 24.

These determinations showed that the brome grass, brome-alfalfa, orchard grass, and orchard-alfalfa sod plots, though relatively firm at first, were less compact than any of the other plots until about July 20. The tests made on July 22 showed a reversal in that the soils of these same four treatments that had remained so mellow had now become more compact than any of the others. The average pressure required to

Table 7. Penetrometer Pressure Tests on the Different Plots at Four Different Dates.

Sod Plots	Lbs. Resistance at Different Depths 1"	3"	6"	9"	% Water
5/24/49					
Brome-Alfalfa	3	31	37	50	
Timothy-Red Clover	4	16	27	30	
Brome grass	9	21	30	35	
Kentucky Bluegrass	6	19	29	31	
Chewings Fescue	6	17	30	31	
Sheep Fescue	6	17	27	29	
Redtop	6	17	32	33	
Canada Bluegrass	7	17	27	32	
Orchard-Alfalfa	12	22	36	41	
Orchard grass	12	24	37	48	
7/2/49					
Brome-Alfalfa	11	29	31	52	16.40
Timothy-Red Clover	14	35	38	47	15.60
Brome grass	13	29	33	46	16.80
Kentucky Bluegrass	12	29	34	39	19.40
Chewings Fescue	13	32	38	49	17.28
Sheep Fescue	9	31	32	45	18.20
Redtop	14	31	34	48	16.12
Canada Bluegrass	9	34	38	45	15.76
Orchard-Alfalfa	7	34	43	49	15.00
Orchard grass	2	29	42	51	13.68
7/16/49					
Brome-Alfalfa	5	27	38	46	14.20
Timothy-Red Clover	6	38	45	54	14.60
Brome grass	9	27	37	51	18.00
Kentucky Bluegrass	5	32	43	48	17.76
Chewings Fescue	6	30	44	58	15.68
Sheep Fescue	7	38	48	52	17.00
Redtop	5	32	43	50	15.36
Canada Bluegrass	9	35	47	52	17.44
Orchard-Alfalfa	5	30	37	45	14.32
Orchard grass	7	27	41	60	13.60
7/22/49					
Brome-Alfalfa	9	45	74	100	14.68
Timothy-Red Clover	8	52	67	80	14.52
Brome grass	6	43	73	83	14.32
Kentucky Bluegrass	10	40	55	74	17.33
Chewings Fescue	7	38	53	87	13.96
Sheep Fescue	10	59	67	89	14.93
Redtop	15	54	64	95	14.72
Canada Bluegrass	12	55	69	95	12.48
Orchard-Alfalfa	7	55	82	104	13.56
Orchard grass	10	52	78	109	10.96

press the penetrometer to a six inch depth into the soil was 42 pounds July 16, but on July 22 the average pressure required had increased to about 68 pounds and only the brome grass, brome-alfalfa, orchard grass, and orchard-alfalfa sod plots required considerably more than the average pressure to penetrate to this depth. The tests August 15 were made just three days after a rainfall of 1.15 inches and there was little change except that all plots were less compact.

All of the sod plots were cross-checked with five different fertilizer treatments and a check strip which was not fertilized. They were arranged in the order shown in table 8. Treatment A received approximately the fertilizer recommended for this type of soil (15) in Michigan, treatment C was the unfertilized check plot, while the other treatments were different variations from treatment A.

In 1948 there was very little benefit in yield shown from use of heavier applications of fertilizer, the yields of beets from all the plots were low. Treatment A was the only fertilizer treatment that increased beet yields above that of the unfertilized check plot enough that the value of the beet increase would exceed the cost of the fertilizer. The per cent of stand for treatment D which received only ammonium-sulfate was very low compared to the other treatments.

Results for 1949 varied much more widely between treatments, both in per cent stand at harvest time and in yield of beets per acre. Again treatment D was at the bottom in per cent

Table 8. Fertilizer Studies.

Fertilizer Used	Amount on Each Plot-Pounds Per Acre					
Kind	A	B	C	D	E	F
20-0-0	120	240	---	480	480	---
3-12-12	396	792	---	---	1584	2028
Yield in Tons of Beets**						
Per Acre 1948	6.92	7.47	5.59	6.19	8.04	8.70
1949	7.03	7.23	3.85	4.58	8.19	11.24
Per Cent Stand of Beets						
at Harvest 1948	78.2	75.7	71.9	57.5	71.9	79.7
1949	44.0	46.5	31.1	31.6	52.4	67.8
Yields in Tons of Beets Per Acre - 1948*						
Sod Plots						
Brome-Alfalfa	9.90	9.30	4.99	3.57	9.43	10.72
Timothy-Red Clover	3.58	4.56	4.29	2.91	5.02	9.19
Brome grass	6.90	8.60	6.64	8.22	7.66	10.50
Kentucky Bluegrass	8.07	8.59	5.59	5.08	7.07	8.75
Chewings Fescue	6.18	7.06	3.74	4.94	7.10	6.65
Sheep Fescue	4.82	4.99	2.82	2.84	4.62	5.39
Redtop	8.09	9.73	4.73	6.44	8.38	9.32
Canada Bluegrass	7.63	8.97	5.84	6.71	6.69	7.23
Orchard-Alfalfa	5.84	4.75	10.53	11.42	12.54	10.88
Orchard grass	8.15	8.17	6.77	9.74	11.88	8.38
Yields in Tons of Beets Per Acre - 1949*						
Brome-Alfalfa	7.84	7.85	2.87	4.14	14.97	16.59
Timothy-Red Clover	6.24	4.84	1.17	1.81	2.92	5.83
Brome grass	11.67	11.78	7.67	7.23	8.08	8.25
Kentucky Bluegrass	6.02	5.16	1.34	2.29	4.93	8.35
Chewings Fescue	5.09	4.69	2.94	4.48	8.16	10.47
Sheep Fescue	4.52	3.56	2.39	1.11	2.22	6.07
Redtop	4.84	7.29	1.63	0.76	5.25	10.62
Canada Bluegrass	5.83	5.83	2.19	1.75	9.39	12.19
Orchard-Alfalfa	5.83	10.15	6.94	8.98	11.08	15.87
Orchard grass	12.83	10.21	9.39	13.30	14.94	18.20

*Averages for all replications for each treatment.
**Yield of entire fertilizer treatment without regard to previous sod treatment.

stand, but this time treatment C, the check, was equally as low. In the other treatments per cent stand and yields in tons of sugar beets per acre were increased when the amount of 3-12-12 fertilizer was increased. This was true to such an extent that strip F which received the greatest amount of 3-12-12 fertilizer had more than twice as many beets per acre at harvest time as the check plot or the strip receiving ammonium-sulfate and about three times the yield in tons of beets per acre. The beets on the plots receiving heavier applications of 3-12-12 fertilizer emerged more quickly and grew more vigorously than those receiving the smaller amounts or none of this fertilizer.

In 1949 only on the strip D which received ammonium-sulfate alone did the treatment fail to increase the yield of beets above that from the unfertilized check plot enough to pay for the fertilizer used. Even when the ammonium-sulfate was used along with the 3-12-12 fertilizer, increasing the amount of ammonium-sulfate decreased the profit above fertilizer cost. Treatment F, which received the greatest amount of 3-12-12 fertilizer and no ammonium-sulfate, yielded far the greatest profit above fertilizer cost.

DISCUSSION

When the sods were plowed in 1948 the soil in the orchard grass and orchard-alfalfa sods were relatively loose and friable. The brome grass and brome-alfalfa sod formed a ribbon but it was deep and mellow. The bluegrass sod formed a tight ribbon and did not plow quite so deep as the brome grass sod plots. The redtop sod formed a loose ribbon of soil. The timothy sod formed a rather compact ribbon. The fescue sods plowed shallow and formed a compact shiny ribbon.

In 1949 when the plots were plowed there still remained considerable amounts of undecomposed sod materials on the fescue plots; practically none on the orchard grass plots and only small amounts on the brome grass and timothy plots. The bluegrass and redtop sod plots were intermediate in the amount of undecomposed material remaining. This is a parallel to the sugar beet yields on the sod plots except in the case of the timothy.

All of the grasses had been kept mowed and the clippings raked from the plots (16) to simulate an airport. Under this condition it seems reasonable to assume that the difference in root growth of the grasses was the major influencing factor causing the differences in yields of sugar beets.

The poor showing of the timothy-red clover sod should be charged primarily against the timothy because there was only a very small amount of red clover remaining in the plot. Previous work reported by Harrison et. al. (11) indicated that the red clover was replaced by the grasses in three years and these plots had been seeded longer than three years (16). The yields of sugar beets on these plots correlated very well with the extent of root growth of the grasses included in the study.

Gist and Smith (9) found that timothy produced much less root growth than brome grass, orchard grass, and bluegrass. Weaver (21) showed the root development of sheep fescue and timothy to be much less extensive than the other grasses appearing in this study. Kentucky bluegrass and redtop grass were shown (21) to be intermediate in the depth of abundant root growth, while brome grass and orchard grass showed greatest depth of abundant root growth of the grasses in the present study. Weaver did not include chewings fescue and Canada bluegrass in his study tables but it is reasonable to assume that they would have similar root habits to sheep fescue and Kentucky bluegrass respectively. Bluegrass is shown to exceed brome grass (9) in extent of root growth in the first three inches of the topsoil but the brome grass has more than twice as much root system as the bluegrass at the three to six and six to nine inch depths and from nine to eighteen inch depths there is quite an abundance of brome grass roots and only a very negligible amount of bluegrass roots. Likewise, the orchard grass exceeded the brome grass in extent of root growth in the top three inches of soil but the brome grass had greater amounts of roots at the deeper levels, especially the nine to eighteen inch depths. The orchard grass did have more root growth than the bluegrass at every level, exceeding it greatly at the greater depths.

From the aforementioned (9) (16) (21) findings one can see a rather close parallel of the yields of sugar beets secured in this experiment and the extent and depth of root growth of the grass in the sod preceding the sugar beets. Greater yields of beets came from the sod plots of orchard grass and brome grass and there was little difference in the yield of beets whether these grasses were grown alone or in combination with alfalfa. In defense of the alfalfa it should be borne in mind that this sod was five years old and the stand of alfalfa was greatly reduced.

At the other extreme in this study were timothy and sheep fescue sods, which have been found to produce root growth of rather limited extent and depth, and which resulted in lowest yields of sugar beets both years. Redtop and the bluegrasses which have been found intermediate in extent and depth of root growth, of the sods studied here, were sods that produced intermediate yields of sugar beets in this experiment.

There was no correlation of the aggregation of the soil samples taken from plots that had grown the different sods and the yield of sugar beets from these plots. This is emphasized by the fact that samples from the timothy-red clover sod plot had second to highest per cent of particles less than one-tenth millimeter in diameter remaining in water stable aggregates and the samples from the orchard grass sod plot were next to lowest in per cent of water stable aggregates of this size.

There seemed to be sufficient pore space, both total and non-capillary in the soils of all plots. Only the soil from the Canada bluegrass plot approached the lower border of what has been classed (7) (8) optimum range of soil porosity for sugar beet production.

There was a great reduction in per cent stand of sugar beets in 1949 but in spite of the greater reduction in per cent of stand on the sheep fescue plots the beets from these plots averaged smallest while the beets from the orchard grass and brome grass sod plots averaged heaviest both years. In 1948 the Canada bluegrass and redtop sod plots ranked along with orchard grass and brome grass sod plots in producing beets of greatest length. Kentucky bluegrass ranked along with orchard grass and brome grass sods in producing beets of greatest diameter at the shoulder. The timothy and fescue sods produced sugar beets that were smallest in both of these dimensions both years. There was no significance to the number of extra branches on the sugar beets.

Some of the yields seemed to be out of line in the fertilizer treatments due possibly to the physical outlay of the plots. The brome-alfalfa plots under fertilizer treatments C and D, as shown in table 8, were in rather flat areas that gave very slow surface drainage. Under fertilizer treatment E the brome grass plots, sheep fescue plots, and some of the Kentucky bluegrass and chewings fescue plots were also relatively flat areas. Another irregularity was that the orchard-alfalfa plot in the areas of fertilizer treatments A and B had a subsoil surface, possibly from the digging of a drainage tile bell-hole just outside the plots, however plot B responded to the fertilizer very well in 1949.

Even though the rainfall was so light in the 1948 growing season that there was little fertilizer response in yield, it is noteworthy that the average per cent stand of sugar beets was greatest where the greatest amount of 3-12-12 fertilizer was used and was smallest where only ammonium-sulfate fertilizer was used. In 1949 this difference in stand of sugar beets was much more pronounced. The per cent stand of sugar beets was lower on all fertilizer treatments, but the way the per cent stand of sugar beets increased with the increased amount of 3-12-12 fertilizer applied was very noticeable. The benefit in increase in sugar beet stand was especially great in fertilizer treatment F, where the ammonium-sulfate fertilizer was left out completely.

SUMMARY

1. There was found to be a difference in the yield of sugar beets following the different sods studied.

2. Of the sods tested, orchard grass and brome grass, with or without alfalfa, gave best percentages of stand of beets and yield in tons per acre. Of the sods tested the fescues and timothy sods gave poorest results while the bluegrasses and redtop were intermediate.

3. This study indicated that increased amounts of 3-12-12 fertilizer resulted in higher per cent stands of beets than those receiving only nitrogen fertilizer.

4. There was a close correlation between the yields of sugar beets on these plots and the root growth habits of the grasses that had grown in the sods.

5. There was an indication that a soil should remain mellow for at least the first half of the growing season for best growth and production of sugar beets and that, of the grasses used in this study, orchard grass and brome grass promoted this condition best.

6. Organic matter content of the soils did not correlate with yield of beets in this experiment.

7. In this experiment there was no correlation of amount of pore space to yield of sugar beets.

8. Per cent aggregation showed no correlation to yield of beets or per cent stand of beets in this experiment.

9. There was a significant negative correlation of clay content of the soils to per cent stand and to yield of sugar beets.

10. Under conditions of this study the addition of the nitrogen fertilizer was not profitable.

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