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Experiments *on the use of* Sweetclover *for* Green Manure

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EXPERIMENTS ON THE USE OF SWEETCLOVER FOR GREEN MANURE

C. J. WILLARD and E. E. BARNES[1]

This bulletin reports experiments by the Ohio Agricultural Experiment Station on sweetclover as a green manure crop.

The first bulletin on sweetclover from a state experiment station in the United States was Bulletin 244 (5) of the Ohio Agricultural Experiment Station, published in 1912. This bulletin called attention to its great value as a green manure crop, showed clearly that it required a neutral or nearly neutral soil for success, and gave many other facts and experiences with the crop.

The U. S. Department of Agriculture published a bulletin (11) on sweetclover in the same year. Since that time, far too many studies of the crop have been published to be reviewed here. Sweetclover was rapidly recognized as the outstanding legume for use as a nitrogen accumulating catch crop.

METHODS AND DATA

Fry Farm Rotations. When Director C. G. Williams started the Fry Farm rotation experiments at Wooster in 1915, he included a considerable number of rotations which included sweetclover as the legume. These experiments were revised by R. M. Salter in 1937, and the number of rotations involving sweetclover was increased. The yields in these rotations compared very favorably with the yields in other rotations. The data have been published and discussed elsewhere (2) (3) (10). Much of the numerical data to be given later in this bulletin was given in the first two references, with little or no discussion.

Paulding County Experiment Farm. An experiment involving seven plots was started on the Paulding County Experiment Farm in 1917. Four of these were in a two-year rotation of corn and oats, with a legume catch crop on three plots and no legume sowed on the fourth. The other three were in a three-year rotation of corn, oats and legume hay. The legumes in both rotations were sweetclover, medium red clover, and mammoth red clover.

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[1]Deceased.

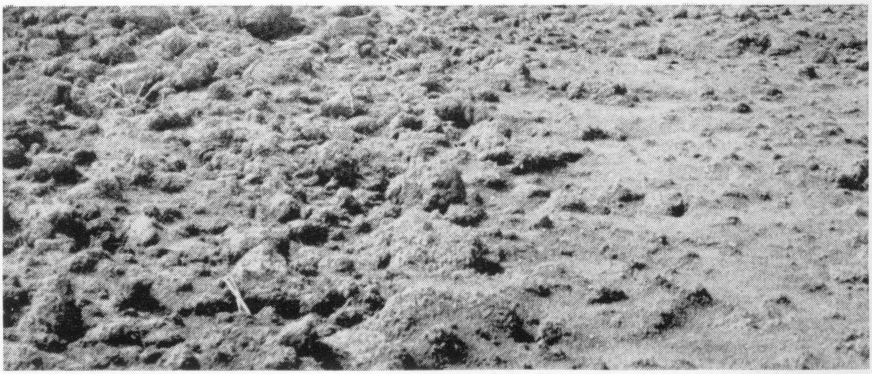


Fig. 1.—Sweetclover Promotes Soil Tilth.

A heavy clay soil (Paulding County Experiment Farm) summer plowed and left without any working for a month. Left, oat stubble; right, sweetclover plowed under.

Although this experiment did not have each crop represented each year, sweetclover in the 3-year rotation more than doubled and in the 2-year rotation nearly doubled, the corn yield, compared to corn not preceded by a legume (Fig. 1). The red clovers were valuable, but less effective. These results were extraordinary on a farm where no fertilizer treatment had ever increased the yield of corn, and did much to stimulate the use and study of sweetclover.

Miami County Experiment Farm. A fertilizer test with the two-year rotation of corn and oats with sweetclover catch crop for green manure was established at the Miami County Experiment Farm on soils of the Miami catena in 1927, and continued until the farm was discontinued in 1950. The data from this experiment are given in Table 1, along with yields from three plots in another fertility study on the same soil types at the same farm. The rotation here was corn, oats, wheat, alfalfa-clover-timothy hay.

It is notable that corn yields have been as well maintained by the 2-year rotation as by the four-year one. There was a considerable response to phosphate, little or none for potash in addition. Sweetclover was fully equal to six tons of farm manure in maintaining productivity.

Northwestern Experiment Farm, Holgate. Dr. R. M. Salter laid out an experiment on sweetclover for green manure at the Northwestern Experiment Farm at Holgate in 1929. The senior author continued it after Dr. Salter left the state in 1940. The soil is now known as Hoytville clay but was referred to as Brookston clay during the time that the

TABLE 1.—Corn, Oats (swcl) Rotation at the Miami County Experiment Farm

All plots limed except 3. Sweetclover on all plots except 9.

Plot No.	Fertilizer Kind	Fertilizer Amount on Corn	Fertilizer Amount on Oats	Yield per acre Corn 1928-1949	Yield per acre Corn 1942-1946	Yield per acre Oats 21-year average
		Lb /A	Lb /A.	Bu.	Bu	Bu.
1	4, 7, 10, checks	None	None	70 1	74 2	36 5
2	0-20-0	100	200	74 5	78 2	47 9
3	0-14 6, no lime	100	200	75 5	82 2	47 1
5	0 14 6	100	400	81 5	90 2	46 7
6	0-14-6	100	200	83 4	90 8	47.2
8	Floats, every 4 years Muriate of potash, every 4 years	800 broadcast 70 broadcast		78 8	82 4	41 7
9	0-20-0 Farm manure	100 6 tons	200	80 5	91 8	44 7
	3 plots in a corn, oats, wheat, alfalfa-clover-timothy rotation for comparison					
				1927-1946	1942-1946	1927-1946
	0-14-6			73 4	78 4	51 6
	0-20-0 and manure 2/3 crops			76 9	85 2	51 7
	0-14-6 and manure 1/2 crops			76 2	80 8	51.0

experiment was in progress. The experiment was on Range 8, which was divided into six sections, A, B, C, D, E, and F, each including eleven plots, 13 feet 2 inches × 16 feet, including 2 foot alleys. The rotation was a two-year one of corn-oats, with Sections A, C, and E in one crop and B, D, and F in the other. The treatments applied on each plot with footnotes indicating the dates of various changes in the plan are given in Table 2. Sweetclover was summer-sown in 1929, but failed, so the first corn to follow sweetclover was in 1931.

In 1933, the rainfall in April was 3.0 inches, and in May, 7.3 inches. It was not possible to plow any of the plots until June 1, when the heavy (5300 pounds, dry weight) growth of sweetclover was plowed under and corn planted June 3. The rainfall in June was 1.15 inches; in July 1.72 inches; and in August, 2.06 inches. The yield of corn after sweetclover, as an average of Plots 2, 4 and 6, was 8.5 bushels, while Plots 1, 3 and 5 made 27.3 bushels.

TABLE 2.—Sweetclover for Green Manure, Holgate
Rotation: Corn-oats, with or without a sweetclover catch crop.
All plots except 9 and 10 received 200 lb/A of 0-14-6 on corn and oats

Plot	Legume or manure	Straw‡	Date plowed	Yield per acre							
				Corn				Oats			
				1931-1937	1938-1942	1943-1946	1931-1946	1931-1937	1938-1942	1943-1946	1931-1946
				Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1	None	No	May 1‖	42.0	42.8	33.6	40.0***	46.7	43.0	37.0	42.9***
2	Sweetclover	No	May 1‖	56.1	68.1	43.9	56.9***	48.2	50.3	44.6	47.9***
3	None	No	May 15	47.3	44.8	33.8	42.9	44.5	45.1	33.0	41.6
4	Sweetclover	Yes	May 15	56.1	60.0	39.5	53.0***	45.5	49 5	43.6	46.3***
5	None	Yes	May 1	48.8	46.8	33.8	44.1***	44.3	45.9	37.0	42.9***
6	Sweetclover	Yes	May 1	58.5	67.0	43.4	57.3***	47.9	52.4	47.1	49.2***
7	Manure, 8 tons	No	May 1	54.0	55.4	45.2	52.1	47.1	53.7	46.4	49.1
8	Mammoth red clover§	Yes	May 1	53.1	58.8	44.9	52.8***	46.4	54.6	39.7	47.3***
9*	Sweetclover	Yes	May 1	56.8	62.3	42.3	54.8	44.4	50.9	40.9	45.7
10†	Sweetclover	Yes	May 1	56.6	65.6	40.6	55.3	42.7	51.9	42.3	45.7
11	Sweetclover	Yes	Nov. 1**	54.1	59.7	48.5	54.5***	42.4	50.3	41.5	44.8***
Average Plots 2-4-6-9-10-11				56.4	63.8	43.0	55.3***	45.2	50.9	43.3	46.6
Average Plots 1-3-5				46.0	44.8	33.7	42.3***	45.3	44.7	35.7	42.5
Gain for sweetclover				10.4	19.0	9.3	13.3***	—0.1	6.2	7.6	4.1

*Plot 9 received 140 pounds per acre of 0-20-0 on both corn and oats.
†Plot 10 received 1000 pounds per acre of rock phosphate and 96 pounds per acre of muriate of potash on alternate rotations.
‡Straw was applied in 1938 and following. None applied or left on plots before that.
§Only since 1934. Some commercial nitrogen used, 1929-1933. Mammoth red clover failed, 1934 and 1935.
‖In 1938 and thereafter. Plots 1 and 2 were plowed April 15, 1931-1937.
**For the 1940 crop and thereafter. Received 1000 pounds per acre of ground limestone on oats, before that.
***These averages are not meaningful, because of changes in plan.

That the difficulty lay in the mass of organic matter plowed under just before a severe drouth is evidenced by the experience on Range A in the same year. The first cutting of alfalfa hay on Range A was made on May 31, the range plowed June 2, and planted to corn. This corn made 48 bushels per acre. The 1933 data have been omitted from all averages.

The applications of straw were begun in 1938 because of the apparently extremely favorable effects of straw in the sweetclover green manure experiment at Wooster (Page 19).

The averaged data are presented in Table 2 in three groups of years. The first is from 1931 through 1937, before the applications of straw and the dropping of the April 15th date of plowing. The next group, 1938 through 1942, gives the five years of straw applications before the advent of the sweetclover weevil (Page 22). The yields from 1943 through 1946 are four years of near-failures of sweetclover because of sweetclover weevil attacks. In 1932 to 1941, there was an average on all sweetclover plots of 154 sweetclover plants per square yard; in 1943 to 1946, the average was 20 plants per square yard. The experiment was continued in 1947, but both corn and oats almost failed on the farm generally that year and the inclusion of the 1947 data would simply reduce the four-year average without adding any information. The experiment was discontinued after 1947.

Southwestern Experiment Farm, Germantown. In 1939, Dr. H. W. Batchelor sponsored Bankhead-Jones Project 29, "Additions of carbonaceous crop residues with sweetclover for green manure." He planned to make a study of the process of decomposition of the sweetclover and crop residues plowed under. Plots were established at Germantown in 1941. Dr. Batchelor left for war work shortly thereafter, and did not return to the Station. Direction of the cultural phases of the experiment was assumed by the senior author and no other studies were made. The soil was Miami silty clay loam and remarkably uniform for that type. The average yield of corn for the first year, when no treatment had affected the results, was 56 bushels per acre. The plots were 1/15 acre and all treatments were quadruplicated. The corn was husked from the standing stalk except on those plots where the stover was to be taken off. Oats were all harvested with a binder but the straw was returned immediately after threshing to all plots except those where the straw was to be taken off. The land was plowed for both corn and oats. Two hundred and fifty pounds per acre of 0-12-12 fertilizer were applied each year for both corn and oats. The plots were limed to pH 6.5.

The data and treatments are presented in Table 3. As can be seen from the treatments, this experiment was primarily to study the interaction of sweetclover and residues on this soil type. The response to sweetclover was remarkable. The average increase in corn yield for sweetclover in the first year (1942) was 18.6 bushels. There was not much carry-over to the oats crop until the later years of the experiment. The corn yields for 1949 (the Southwestern Experiment Farm was abandoned in 1950) give an excellent picture of the final state of the plots and are included in the table. Oats were a total failure at the farm in 1948 and not harvested, but since such failures are somewhat part of growing oats that far south in Ohio, the yields in six years have been averaged over the seven years (1943-1949). (Oats were not influenced by sweetclover until 1943). The year 1946 was favorable for oats, so that soil differences were given an opportunity to have an effect, and the yields for that year are also included in the table. It is clear that on this soil type, the two-year corn, oats(swcl) rotation definitely increased soil productivity.

TABLE 3.—Sweetclover for Green Manure, Southwestern Experiment Farm

Corn-oats rotation; sweetclover catch crop or not as indicated; averages of quadruplicate plots each year.

Plot	Treatment	Yield per acre				
		Corn 1942-49	Increase	Corn 1949	Oats 1943-49	Oats 1946
		Bu.	Bu.	Bu.	Bu.	Bu.
1	No sweetclover; strow and stover taken off	65.1		53.8	34.1	55.8
2	No sweetclover; straw and stover left on	68.6	3.5	65.5	35.8	56.3
3	Sweetclover; straw and stover taken off	83.9	18.8	93.0	40.6	73.1
4	Sweetclover; straw left on, stover taken off	87.9	22.8	95.4	40.7	72.2
5.	Sweetclover; straw taken off, stover left on	86.8	21.7	96.5	41.5	74.1
6	Sweetclover; straw and stover left on	89.9	24.8	97.5	42.2	74.6
Av.	Plots 3, 4, 5, 6	87.1		95.6	41.2	73.5
Av.	Plots 1, 2	66.9		59.7	35.0	56.1
Av.	Gain for sweetclover	20.2		35.9	6.2	17.4

SWEETCLOVER GREEN MANURE ROTATION, WOOSTER

When the Snyder farm at Wooster was acquired one of the first experiments established concerned sweetclover for green manure. It was planned by R. M. Salter, and several members of the staff have worked on it in the years since. For much of the time, Dr. E. E. Barnes was in charge. He prepared a report of the experiment just before his death in 1957, and the material in this bulletin is based on this manuscript.

This experiment is divided into two periods: Period I, 1927 to 1941, Period II, 1944 to 1951. The plan of the experiment was again changed in 1952. This plan is still in progress and is not discussed here.

Period I, 1927-1941. The first yields were taken in 1927. Tile drains were installed in 1929. The layout was composed of two sections, A and B, each containing 22 plots of one-twentieth acre each, numbered from the north. The first six plots on section B (east) were only half length for the first few years due to an oil well located in this area. The soil was non-uniform, especially these plots at the north end, and the first five years did little but establish the rotation and treatments. Accordingly the results of the first five years have been omitted. The treatments of and yields from each plot during Period I are given in Table 4.

The rotation employed was a two-year one of corn and oats. Plots 1, 4, 7, 10, 13, 16, 19 and 22 were checks, with no legumes seeded in the oats and fertilized uniformly. Plots 11 and 12 had no legumes sown and received applications of farm manure. On the others, sweetclover or other legume was sown in the oats, allowed to grow during the summer and fall and plowed under for corn the next year.

The basic fertilizer treatment was 150 pounds per acre of 20 percent superphosphate in the hill on corn and 250 pounds per acre drilled on oats, except where noted.

On Plots 14 and 15 raw rock phosphate was applied at the rate of 400 pounds per acre annually on both corn and oats. This was all applied broadcast. Plot 11 received 4 tons, and Plot 12, 8 tons, per acre of manure on corn, and no legume was seeded in the oats.

One ton limestone per acre was applied on corn, except on Plot 15, which was limed at half that rate, to see if the raw rock phosphate would give better returns under these conditions.

Plots 2, 3, 5, 6, and 8 were to study the best time to plow down sweetclover for corn. All other plots were plowed on May 1st.

TABLE 4.—Sweetclover for Green Manure. Wooster. Period I
Rotation: corn, oats, with or without legume as indicated. Plots not replicated

plot	Legume sown	Date of plowing	Fertilizer			Corn			Oats		
			Material	Rate per acre		Yield per acre		Increase	Yield per acre		Increase
				Corn	Oats	1932-1936	1937-1941	1932-1941	1932-1936	1937-1941	1932-1941
				Lb.	Lb.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1	None	May 1	0-20-0	150	250	50.6	62.2	____	30.2	29.2	____
2	Sweetclover	Oct. 15	0-20-0	150	250	57.3	74.0	11.0	29.8	37.3	3.2
3	Sweetclover	Dec. 1	0-20-0	150	250	59.2	68.7	11.2	30.0	39.4	3.6
4	None	May 1	0-20-0	150	250	52.3	49.6	____	31.8	31.5	____
5	Sweetclover	April 15	0-20-0	150	250	54.1	60.0	8.5	28.8	37.4	1.1
6	Sweetclover	May 1	0-20-0	150	250	58.6	64.8	15.4	31.1	36.7	1.6
7	None	May 1	0-20-0	150	250	45.6	42.3	____	27.8	37.2	____
8	Sweetclover	May 15	0-20-0	150	250	59.2	66.5	16.5	32.0	49.1	7.5
9	Sweetclover	May 1	0-14-6	270	360	62.4	76.9	21.1	33.4	53.4	9.7
10	None	May 1	0-20-0	150	250	53.0	48.8	____	28.5	39.9	____
11	None	May 1	0-20-0	150	250	64.8	76.0	19.9	33.8	44.6	4.7
			Manure	4 tons							
12	None	May 1	0-20-0	150	250	65.0	79.1	21.8	34.4	47.8	6.3
			Manure	8 tons							
13	None	May 1	0-20-0	150	250	50.8	49.0	____	28.7	41.2	____
14	Sweetclover	May 1	Rock phosphate	400	400	55.0	56.8	6.3	26.2	43.4	0 5
15*	Sweetclover	May 1	Rock phosphate	400	400	52 4	57.1	5.6	23.3	41.8	—1.1
16	None	May 1	0-20-0	150	250	50.7	47.0	____	27.4	38.4	____
17*	Sweetclover	May 1	0-20-0	150	250	69.6	83.4	29.9	33.2	53.3	11.0
18	Alfalfa	May 1	0-20-0	150	250	55.4	59.7	13.3	30.5	45.6	6.4
19	None	May 1	0-20-0	150	250	43.6	40.4	____	26.3	35.4	____
20	Mammoth red clover	May 1	0-20-0	150	250	51.2	61.3	12.4	26.9	43.9	4.9
21	Medium red clover	May 1	0-20-0	150	250	52.7	57.9	9.7	27.4	45.2	6.1
22	None	May 1	0-20-0	150	250	47.7	46.8	____	23.3	36.4	____

*See text for important additional treatments.

On Plot 17 (Fig. 2) the straw and stover which grew on the plots were stored, returned to the plot in the spring, and plowed down for corn. The amount added averaged about 3500 pounds per acre of stover and 1700 of straw.

On Plot 18, alfalfa (after the first three years), on Plot 20, mammoth red clover, and on Plot 21, medium red clover, were the green manure crops.

Legume seeds were inoculated. The corn was Clarage until 1936, after that W-17 hybrid. The oats variety was Fulghum. Commercial white blossom sweetclover was used throughout the experiment.

Period II, 1944-1951. It became evident from the appearance of the corn about 1940 that the yields on almost all plots were being limited by lack of available potash. The fertilizer treatments in this experiment were changed in 1944. Potash was applied to 17 of the 22 plots, leaving five without potash. In addition, the study of different dates of plowing sweetclover, the comparisons of legumes as catch crops, the uniform checks, and the differential limestone application on Plot 15, were dropped. Instead of storing the stover and straw and applying it on the sweetclover in the spring on Plot 17, the stover and straw

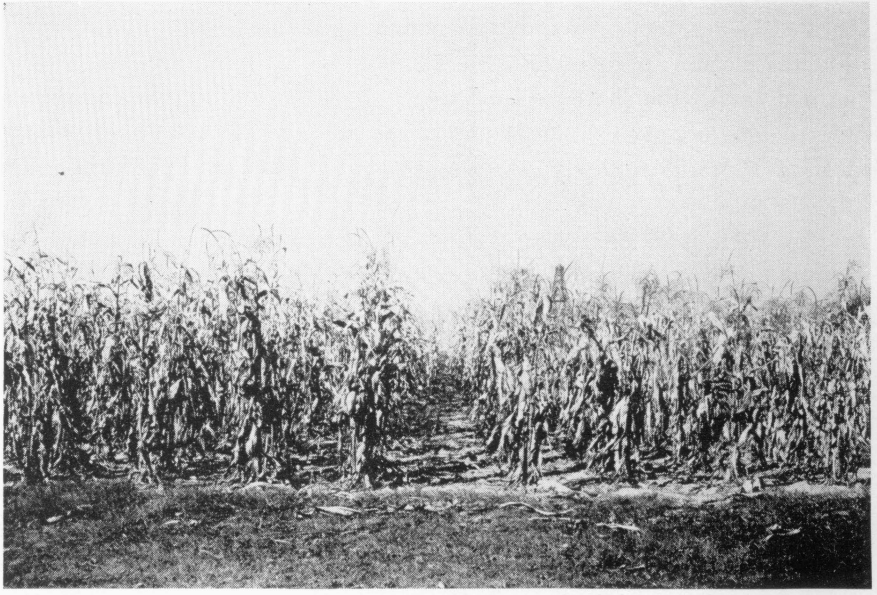


Fig. 2.—Sweetclover Increases Corn Yields (Wooster).

Plots 17 (sweetclover plus crop residues), left, and 16 (check, no sweetclover), right, in September 1939.

were left on the plots where they were produced, as they would be in farm practice. The corn, which had been checked in hills 42 inches apart each way, was drilled 10 inches apart. The exact plan and yields of corn and oats for the period are shown in Table 5.

In the spring of 1940 the junior author determined total nitrogen, exchange potassium, available phosphoric acid and pH value of soil samples taken from Plots 6 to 17 in 1925 at the beginning of the experiment and samples taken in the spring of 1940.

Total nitrogen. As an average for the 12 plots examined (Table 6), the percentage of nitrogen in the soil dropped in the 15 years from 0.094 to 0.084. The drop was greatest on the check plots where no sweetclover was sown, where the percentage of nitrogen was lowered 0.014 percentage points in the 15 years. The four plots on which sweetclover had been grown with superphosphate lost an average of 0.004 percentage points in nitrogen, which compares with 0.007 points in the plots receiving farm manure.

Phosphoric acid. Available phosphoric acid (Table 7) was determined by using a mixture of malic, citric, and oxalic acids, which does not remove as much phosphorus as the solvents commonly used in quick tests, and measures only that portion which is readily "available". The "available" phosphoric acid as measured by this solvent about doubled on all the plots except Plot 15 (raw rock phosphate). Since Plot 16 also received no superphosphate and the same amount of raw rock as Plot 15, there is no clear reason for the low percentage on Plot 15.

In 1949 *total* phosphoric acid was determined on four plots from samples taken in 1925 and 1949 respectively (Table 8). The only plot among the four examined which increased in total phosphoric acid in the plow layer was the plot receiving raw rock phosphate.

Exchangeable potassium. The data on exchangeable potassium (Table 9) show that, as an average, potassium in exchange form increased during the 15 years between 1925 and 1940. The distinct potash shortage shown on crops in 1940 was, therefore, due to the increased nitrogen resulting in a relative deficiency of potash rather than to a decrease in the potash-supplying power of the soil.

Soil reaction. When the experiment was first designed one ton of limestone was plowed under for corn each rotation, on all plots except Plot 15, which received only one-half ton. When the reaction of the

TABLE 5.—Sweetclover for Green Manure, Wooster. Period II
All plots received 300 pounds per acre of fertilizer drilled with corn, 200 pounds with oats

Plot	Fertilizer analysis	Manure or sweetclover	Straw and stover applied	20-0-0 per acre for corn	Yield per acre					
					Corn			Oats		
					1944-1947	1948-1951	1944-1951	1944-1947	1948-1951	1944-1951
				Lb.	Bu.	Bu.	Bu.	Bu.	Bu.	Bu.
1	0-20-20	None	No	600	65.2	96.0	80.6	40.9	31.4	36.1
2	0-20-20	Sweetclover	Yes	400	69.6	107.7	88.7	48.6	33.6	41.1
3	0-20-20	Sweetclover	Yes	None	63.6	106.8	85.2	45.5	32.8	39.2
4	0-20-20	None	No	None	42.2	71.0	56.6	40.5	27.6	34.1
5	0-20-20	None	Yes	400	59.2	98.7	79.0	46.9	26.9	36.9
6	0-20-20	Sweetclover	No	None	60.4	97.4	78.9	52.0	36.0	44.0
7	0-20-20	None	Yes	None	38.9	72.4	55.7	36.7	23.9	30.3
8	0-20-10	Sweetclover*	No	None	60.0	98.5	79.3	48.8	41.6	45.2
9	0-20-10	Sweetclover	No	None	57.3	94.2	75.8	51.2	39.6	45.4
10	0-20-10	None	No	None	41.8	65.7	53.8	42.8	33.1	38.0
11	0-20-10	4 tons of manure	No	None	52.5	82.2	67.4	47.6	37.2	42.4
12	0-20-10	8 tons of manure	No	None	55.6	89.2	72.4	50.3	40.3	45.3
13	0-20-10	None	Yes	None	43.4	75.0	59.2	39.8	25.2	32.5
14	Special†	Sweetclover	No	None	54.9	93.6	74.2	43.9	36.2	40.1
15	Special†	Sweetclover	Yes	None	54.8	96.8	75.8	40.0	30.6	35.3
16	0-20-10	None	Yes	400	60.8	97.4	79.1	40.6	29.4	35.0
17	0-20-10	Sweetclover	Yes	None	66.6	103.9	85.3	49.2	36.2	42.7
18	0-20- 0	Sweetclover	No	None	44.4	74.8	59.6	44.7	38.5	41.6
19	0-20- 0	None	Yes	400	39.3	78.9	59.1	42.1	28.6	35.4
20	0-20- 0	Sweetclover	Yes	None	51.0	84.6	67.8	44.1	32.4	38.3
21	0-20- 0	None	Yes	None	37.0	62.4	49.7	43.6	26.4	35.0
22	0-20- 0	None	No	None	34.1	55.4	44.8	37.8	26.2	32.0

*Also four tons of manure.

†The special fertilizer was made up of rock phosphate and muriate of potash to make a fertilizer analyzing 20 percent total P_2O_5 and 10 percent K_2O. Five hundred pounds per acre of raw rock was then broadcast before plowing for corn to make a total application of raw rock, including that in the mixture, of 400 pounds per acre per year.

TABLE 6.—Total Nitrogen in Samples Taken in 1925 and 1940

Plot	Treatment	1925 Samples		1940 Samples	
		Sec. A	Sec. B	Sec. A	Sec. B
		Pct.	Pct.	Pct.	Pct.
6	Sweetclover	.091	.094	.088	.087
7	Check	.083	.093	.076	.077
8	Sweetclover	.087	.097	.089	.086
9	Sweetclover, potassium	.093	.095	.096	.086
10	Check	.089	.094	.083	.076
11	Farm manure, 4 tons	.092	.095	.086	.086
12	Farm manure, 8 tons	.087	.097	.083	.090
13	Check	.101	.090	.084	.081
14	Sweetclover, raw rock phosphate	.100	.092	.084	.082
15	Sweetclover, raw rock phosphate	.097	.088	.084	.083
16	Check	.098	.098	.078	.078
17	Sweetclover, residues	.083	.090	.083	.082
	Average	.094	.094	.084	.083

TABLE 7.—Available P_2O_5 (by organic acid extraction)*

Plot	Treatment	1925 Samples		1940 Samples	
		Sec. A	Sec. B	Sec. A	Sec. B
		Lb./A.	Lb./A.	Lb./A.	Lb./A.
6	Sweetclover	2.6	2.2	4.5	4.8
7	Check	2.8	2.6	5.1	4.6
8	Sweetclover	2.7	2.7	4.2	4.0
9	Sweetclover, potassium	2.2	2.0	4.4	4.0
10	Check	3.0	2.7	3.6	3.6
11	Farm manure, 4 tons	2.6	2.3	4.5	5.6
12	Farm manure, 8 tons	2.2	2.2	4.4	5.2
13	Check	3.0	2.7	4.3	5.2
14	Sweetclover, raw rock phosphate	2.4	2.2	4.2	4.0
15	Sweetclover, raw rock phosphate	3.3	3.3	3.1	2.8
16	Check	2.5	2.7	4.6	4.4
17	Sweetclover, residues	2.1	1.9	4.7	3.2

*Extraction medium was a mixture of malic, citric and oxalic acids. Seven grams of each of the first two and 2.5 grams of oxalic acid were dissolved in one liter of water. This was used by diluting 10 cc to 100 cc with water and leaching 50 grams of soil with the 100 cc.

TABLE 8.—Total Phosphoric Acid in Original Samples (1925) Compared to Samples Taken in 1949 on Section A Only

Plot	Treatment	1925 Samples	1949 Samples
		Lb./A.	Lb./A.
6	Sweetclover	4880	4180
11	Farm manure, 4 tons	4340	4060
12	Farm manure, 8 tons	4920	4280
14	Raw rock phosphate, 400 lb. per acre per year	3930	4980

plots had been brought to pH 7, the plan was changed to apply limestone only when the reaction had fallen below pH 7.0 (pH 6.5 on Plot 15 until 1940). The determinations (Table 10) were made with a quinhydrone electrode.

TABLE 9.—Exchangeable Potassium in Samples Taken in 1925 and 1940

Plot	Treatment	1925 Samples		1940 Samples	
		Sec. A	Sec. B	Sec. A	Sec. B
		me	me	me	me
6	Sweetclover	.190	.190	.160	.176
7	Check	.155	.160	.200	.170
8	Sweetclover	.140	.170	.165	.160
9	Sweetclover, potassium	160	.170	.210	.180
10	Check	.170	.160	.190	.184
11	Farm manure, 4 tons	.165	.190	.190	.200
12	Farm manure, 8 tons	.120	.160	.190	.200
13	Check	.130	.160	.160	.184
14	Sweetclover, raw rock phosphate	.130	.135	.120	.195
15	Sweetclover, raw rock phosphate	.130	160	.145	.184
16	Check	.120	.160	.140	.164
17	Sweetclover, residues	.125	.140	.160	.160
	Average	.144	.163	.185	.179

TABLE 10.—pH Values by Quinhydrone Electrode

Plot	Treatment	1925 Samples		1940 Samples		1944	1947
		Sec. A	Sec. B	Sec. A	Sec. B	Sec. A	Sec. B
6	Sweetclover	5.4	5.4	7.3	7.1	7.2	7.7
7	Check	5 7	5.7	7.4	7.0	7.2	8.0
8	Sweetclover	5.6	5.7	7.6	7.1	7.3	7.8
9	Sweetclover, potassium	5 7	5.4	7.5	7.3	7.1	7.8
10	Check	5.5	5.3	7.5	7.1	7.2	8.0
11	Farm manure, 4 tons	5.4	5.3	7.0	7.0	7.3	8.0
12	Farm manure, 8 tons	5 7	5.3	7.1	7.0	7.2	7.5
13	Check	5.6	5.6	7.2	6.8	7.3	7.8
14	Sweetclover, raw rock phosphate	5.6	5.6	6.9	6.8	7.4	8.0
15	Sweetclover, raw rock phosphate	5 5	5.2	6.7	6.5	7.1	7.6
16	Check	5 5	5.7	7.5	7.5	7.3	8.0
17	Sweetclover, residues	5.6	5.7	7.4	7.3	7.2	7.9

DISCUSSION

When should sweetclover be plowed down? The basic determiners of the time to plow sweetclover are the amount of nitrogen available in the sweetclover tops and roots and the extent to which the sweetclover will be killed by plowing. Sweetclover produces crown buds (Figure 3) in the fall, the first ones appearing in August, from which the second year's growth starts. They never produce shoots in the seeding year. After these buds are formed, plowing sweetclover does not kill it; it will sprout the next spring, regardless of when it was plowed. We have had sweetclover, plowed for wheat in September and planted to wheat, sprout enough the next spring to interfere seriously with harvesting the wheat and cause the wheat to grade sample grade on account of the odor of *Melilotus*. The only way to avoid sprouting, at one time, was to wait until the sweetclover had produced shoots at least four or five inches tall in the spring of the second year before plowing; this would be in April, the date depending upon the season and the latitude. With the advent of 2,4-D, however, it has become possible to spray with one to two pounds of 2,4-D to the acre before plowing and kill the plants so that they do not sprout.

In many years of experimentation and observation, we have never seen the sprouting of sweetclover become a problem in corn. Although it sprouts in the corn, normal cultivation destroys 95 percent or more of

it and what is left does no harm. Before oats, sugar beets, and similar crops, one should avoid plowing down first-year sweetclover before the shoots are well started unless they are first killed by 2,4-D.

These are the important considerations. Otherwise sweetclover plowed October 20 to May 1 will respond as the soil without sweetclover responds. At Holgate fall-plowed sweetclover outyielded the others (in the 1943-1946 comparisons, sweetclover plowed November 1 averaged 48.5; May 1, 42.6; and May 15, 39.5 bushels per acre), just as any fall plowing for corn at Holgate outyielded spring plowing as a long-time average. At Wooster, fall plowing is not generally favorable, and insofar as the Wooster results are significant, that is a sufficient explanation for the unfavorable results for fall plowing. The Wooster results for plowing April 15, however, are completely unreliable. This is evidenced, first, by the fact that in the first five years the plots on which the April 15 plowing was located were so abnormal that they indicated a *loss* from sweetclover; certainly something that never really happened. Then, the universal experience of farmers and experimenters is that, aside from considerations already mentioned, one early plowing date is as good as another.

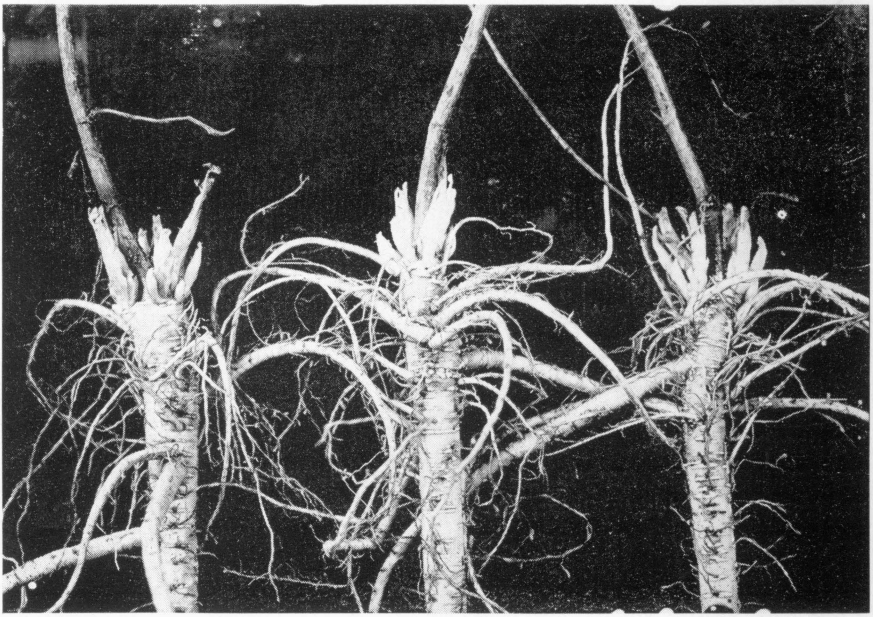


Fig. 3.—Crown buds of first-year sweetclover in November.

Between plowing May 1 and May 15 the general tendency is for May 1 to be the better. Since the season is later at Wooster than at Holgate and Columbus this tendency is less at Wooster than in the other two localities. (The recorded yields are slightly in favor of May 15, but the early yields from Plot 6 were almost as low as from Plot 5). There is some accumulation of nitrogen between May 1 and May 15 (Table 12). On the other hand, the growth from May 1 to May 15 withdraws moisture from the subsoil and if the season afterward proves dry this loss may be serious.

Sweetclover compared with farm manure. Most of the early experiments with sweetclover compared its crop-producing power with that of farm manure. In the three such comparisons reported here (Tables 1, 2, 4, 5) sweetclover compares very favorably with applications of six tons to the acre of farm manure, always nearly equalling it, often surpassing it. These results would be anticipated from the amount of nitrogen supplied by the two treatments.

Comparison of legumes for green manure. The Wooster and Holgate experiments compared sweetclover with other legumes for green manure. In every instance the sweetclover was superior to the other legumes, although the margin was not always great or even significant. The order of effectiveness was sweetclover, alfalfa, red clover, which would be expected from studies of the amount of nitrogen accumulated by these legumes at the end of the first year's growth. Because it is a strict biennial and continues accumulating nitrogen and other food materials in the roots until freeze-up of the first year, sweetclover always has more nitrogen accumulated in its roots and tops than alfalfa when going into the winter under conditions favorable for both. In the senior author's comparisons at Columbus (3), sweetclover in the late fall of the seeding year or early spring of the year following contained from 100 to 150 pounds of nitrogen in the tops and roots, while red clover and alfalfa had somewhat more than half as much. If all three crops are allowed to grow until June of the second year, the difference in nitrogen accumulation nearly disappears. As a catch crop, sweetclover (if correctly grown) is supreme.

Despite the apparent differences at Wooster in the 1937 to 1941 period, the senior author does not believe that there is a real difference between mammoth red clover and medium red clover in value for soil improvement. Some thirty comparisons (8) of nitrogen accumulated by the two at all stages of growth and on a variety of soil types failed to show any significant difference in weight of roots or nitrogen accumulation, and he feels that the differences indicated here are part of the basic non-uniformity of the plots.

After one year of hay, alfalfa has been rather consistently superior to red clover in the Fry Farm rotations at Wooster and in other localities. When equally good stands are obtained, alfalfa accumulates much more nitrogen in the roots during the first hay year than red clover does. This nitrogen in the roots is largely returned to the following crop when the alfalfa is plowed.

Effect of straw and stover plowed under with sweetclover. In the Wooster experiments, the unreplicated plot (Plot 17, Table 4) on which stover and straw were plowed under along with sweetclover for corn greatly outyielded all other plots. There are two possible major explanations for this result. First is the value of the organic matter plowed under. Dr. Fred Salter showed (7) that more organic matter was left in the soil when enough nitrogen was applied with low-nitrogen organic matter such as stover and straw to bring the total percentage of nitrogen in the mixture up to at least 2.0 percent than when no nitrogen was added. The Wooster soil is deficient in organic matter and organic matter normally increases yields, so it was felt that this was an increased yield from increased organic matter in the soil.

Another possible explanation of the effect of straw and stover plowed under at Wooster is the value of the straw and stover as a potash fertilizer. Almost always on potash-deficient soils the sweetclover green manure rotation runs into severe potash deficiency. Corn is especially sensitive to potash deficiency, and the large amount of nitrogen furnished by the sweetclover results in potash becoming the limiting element for corn.

It seems probable that this last effect is the one that is responsible for most of the increased yield of Plot 17 at Wooster. By 1940 all of the plots were showing potash deficiency, and the plots which received extra potash, whether from straw or the fertilizer sack, were outyielding the others. (Note Plot 9, which received 34 pounds of K_2O per acre per year, and Plot 12, which received eight tons per acre of manure, carrying considerable potash, on corn). It would seem that at Wooster both factors were adding to the increase from the straw and stover but that the potash was by far the more important. Since the soil at Holgate was especially influenced by physical factors, of which organic matter is a great determiner, the Holgate experiment was changed in 1938 to give a careful study, using triplicated plots, of the effect of straw and stover plowed under with the sweetclover. The experiment at Germantown was planned entirely to study this sweetclover-straw and stover relationship and was quadruplicated.

At Holgate the straw and stover did not increase the yield either alone or when plowed under with sweetclover. The Brookston (Hoytville) soil does not respond to potash for corn, and apparently the experiment was not continued long enough for the additional organic matter to affect soil structure or corn yields on this high-organic-matter soil.

On the Miami soil at Germantown there was a small but significant response to the straw and stover plowed under: between both straw and stover plowed down, and neither plowed down, the difference averaged six bushels per acre over the 8-year period. With 250 pounds per acre of 0-12-12 applied for every crop, there should not have been a deficiency of potash on this soil, which responds only moderately to potash. It would seem that this six bushels measured the organic matter response, which was obviously increasing as the plots became older, and that the great value of sweetclover on this soil type was for its nitrogen. In the Miami County experiment on a similar soil type, the potash plots yielded only slightly more than the 0-20-0 plots.

These conclusions are further borne out by the results at Wooster in Period II, which are brought together in another form in Table 11 to show the influence of potash. The gain for potash is about 14 bushels per acre and it is seen throughout the other treatments including straw and stover. It is notable that even on this potash-deficient soil there was no gain for 0-20-20 over 0-20-10 when both were applied at 500 pounds per acre per two-year rotation.

One might anticipate that oats sown in heavy cornstalks without an application of nitrogen would show a reduction in yield from a nitrogen shortage. There is some suggestion of this in the Wooster experiments—the oats without residues yielded three bushels per acre more

TABLE 11.—Influence of Potash on Corn Yields. Wooster, 1944-51

Plots and treatments	Yield corn per acre, receiving		
	0-20-20	0-20-10	0-20-0
	Bu.	Bu.	Bu.
Plots 3, 17, 20—Sweetclover, straw, stover	85.2	85.3	67.5
Plots 6, 9, 18—Sweetclover	78.9	75.8	59.6
Plots 5, 16, 19—Straw, stover, 400 lb. 20-0-0	79.0	79.1	58.1
Plots 7, 13, 21—Straw, stover	55.7	59.2	50.5
Plots 4, 10, 22—Nothing	56.6	53.8	44.8
Average	71.1	70.6	56.1

than those with residues. The experiments on the other two farms, however, do not bear this out. Apparently the carry-over of nitrogen from the sweetclover plowed down for the corn was enough on these farms to overbalance the unfavorable effects of the stalks. At Southwestern the oats on the plots receiving residues but no sweetclover even outyielded the oats with no residues and no sweetclover by 1.7 bushels as a seven-year average. This is hardly significant but at least does not suggest a loss in oats yield from leaving residues on the soil.

Sweetclover compared with fertilizer nitrogen. Period II at Wooster compared added nitrogen from the fertilizer sack with sweetclover for green manure. Plot 1, which received no residues and no green manure but 120 pounds per acre of nitrogen in sulfate of ammonia, did not yield as much as either of the two sweetclover plots next to it. Plot 2, which had 80 pounds per acre of nitrogen added to the sweetclover plowed under, yielded only 3½ bushels more than Plot 3 which had sweetclover but no added nitrogen. Plots 5, 16 and 19, which received straw, stover and 400 pounds of 20-0-0 (80 pounds of nitrogen) on corn (Table 5) yielded significantly less than the sweetclover, straw and stover plots and slightly but not significantly more than sweetclover alone. It would seem that there is little profit in using fertilizer nitrogen when *good* sweetclover is plowed under for corn.

The use of rock phosphate. Since various laboratory experiments have shown that sweetclover can utilize insoluble phosphate to a greater extent than many other plants, it seemed reasonable to include in the sweetclover experiments plots in which superphosphate was replaced by raw rock phosphate as a source of phosphorus. This was done on Plots 14 and 15 at Wooster and Plot 10 at Holgate. At Holgate the rock phosphate plot was as high yielding as any other. Unfortunately there was no "no phosphate" plot with which to compare it, but the evidence from other experiments at Holgate was that there was no significant response to phosphate on this soil, so the equivalence of superphosphate and rock phosphate should cause no surprise and had no significance. At Wooster, despite the fact that a much larger amount of phosphorus was applied in raw rock than in super, the raw rock phosphate plots were consistently lower yielding than those where superphosphate was used. In the first period Plot 15 was kept at a lower pH than the rest of the range and, as would be anticipated for sweetclover, yielded less than Plot 14 which was kept above pH 6.5. In the second period Plot 15 had straw and stover plowed under with no improvement in yield of corn or oats. The Wooster soil responds greatly to phosphate and the value of raw rock under these circumstances is tested by the increase of

the raw rock plots over the adjacent checks in Period I. Like other experiments at Wooster, this showed that raw rock has the ability to furnish phosphorus when that element is deficient, but does not do so as extensively or as profitably as superphosphate.

Sweetclover in Ohio. The use of sweetclover as a catch crop for green manure has been extensive in Ohio. No accurate statistics on the acreage of sweetclover grown for green manure have ever been collected. The acre sown to sweetclover catch crop appears in crop statistics first as an acre of oats or wheat and the next year as an acre of corn. Since it is entirely a catch crop it is difficult to devise a method to enumerate the number of acres sown to sweetclover and in practice this has not been done.

However, careful studies and estimates by county agents indicate that the period of 1925 to 1940 represented the largest use of sweetclover in Ohio. For at least part of that period, sweetclover was second only to red clover in acreage sown. Several things have led to reductions in sweetclover acreage:

1. A serious disease of sweetclover, identified by Dr. Fred R. Jones as a *Phytophthora* root rot (4), began to attack sweetclover severely in the late '20s. The senior author's first experience with it was in early May of 1927, when a farmer asked him what was happening to a stand of second year sweetclover. The symptoms were a soft rot of the crown. Death of the plants followed sudden and complete wilting (Fig. 4). The disease might destroy an entire field, or a few plants. The disease did not greatly reduce the value of sweetclover as a catch crop for soil improvement, since it attacked mainly in the spring of the second year, but it did prevent its being used for second-year pasture, for which it was then widely used. The amount of sweetclover sown in many areas was cut in half in two or three years with the advent of this disease.

2. In the '30s greater acreages of and experience with alfalfa led to use of alfalfa for pasture. Since alfalfa can be made to furnish pasture in midsummer and beyond when sweetclover conspicuously dies out, alfalfa has largely replaced second-year sweetclover for pasture.

3. The sweetclover weevil migrated into the United States from Canada from 1939 to 1943. The senior author found the work (Fig. 5) of the sweetclover weevil for the first time in Ohio on the sweetclover for green manure plots at Holgate in 1943. He reported the work to T. H. Parks and R. H. Davidson, who visited the plots and found and identified the weevil (6). In that year and since, stands of sweetclover in Northwestern Ohio and considerably even as far south as Columbus

Fig. 4.—Phytophthora **root-rot on sweetclover, Columbus, May 9, here affecting a single plant in a cultivated breeding row.**

have been severely damaged or reduced to practical failures by this insect. It has now been shown (14) that this insect can be controlled, and it need not now interfere with the use of sweetclover. Nevertheless, the necessity for spraying at a busy time of year is a definite drawback.

4. Since 1950 the cost of commercial nitrogen has dropped until now chemical nitrogen can be purchased in Northwestern Ohio at from 9 to 12 cents a pound applied to the land. The basic value of the sweetclover catch crop is that it can be counted on to furnish about 100 pounds per acre of readily available nitrogen for the corn crop. Cheap chemical nitrogen reduces the advantage of legume nitrogen.

5. If sweetclover is made into hay or silage and heats, the coumarin (the compound which gives sweetclover its bitter taste) which it contains may be changed to dicoumarol, a product which, taken internally, reduces or destroys the clotting power of the blood. Animals which have been fed on spoiled sweetclover hay or silage may bleed to death from minor operations such as dehorning or castration, or, ultimately, may bleed to death internally without any external injuries. This "sweetclover disease" makes the use of second-year sweetclover hay, which can hardly be cured sufficiently so that it will not heat, so

hazardous that second-year sweetclover should never be made into hay in Ohio except in emergencies. Silage is safer, but if air gets to it, it also is dangerous.

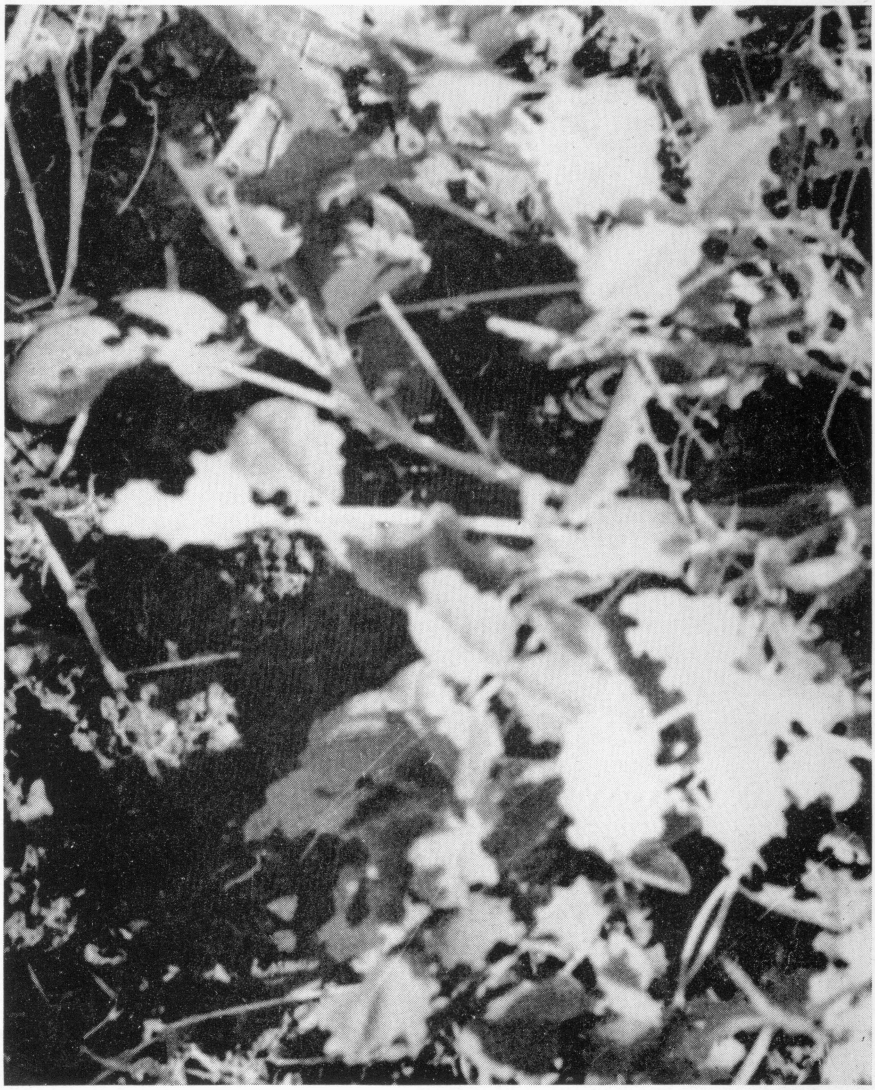


Fig. 5.—Work of Sweetclover Weevil.

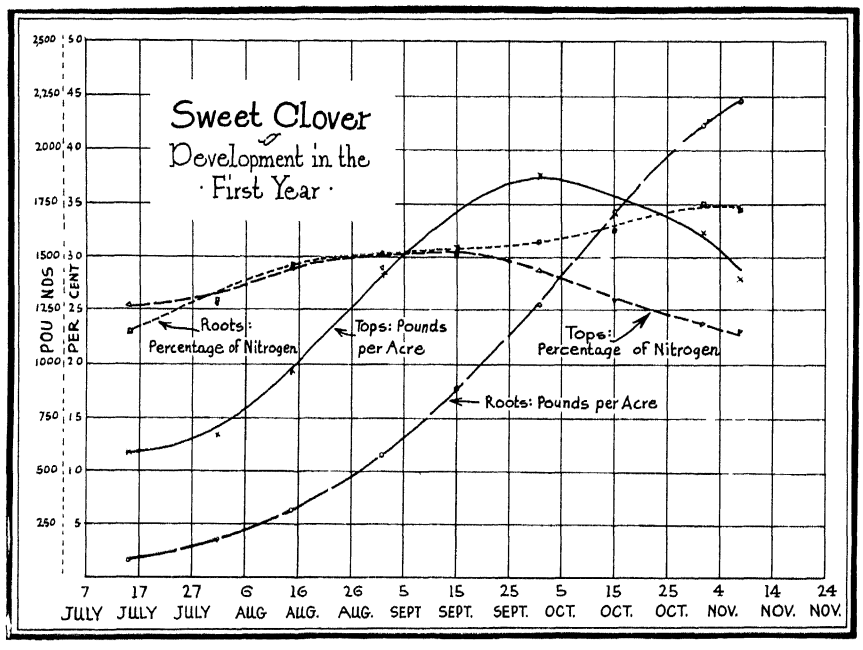
April 9. Notches in leaves of second-year sweetclover, typical of sweetclover weevil injury.

FACTORS BEARING ON THE VALUE OF THE SWEETCLOVER CATCH CROP PRECEDING CORN

Summer-sown sweetclover not effective. Because of the valuable results reported from spring-sown sweetclover catch crops, many expect similar results from summer-sown sweetclover, either sown in corn or sown alone after small grains. Many other experiments since the senior author's first report (12) have shown that sweetclover sown in the summer has much less nitrogen in its tops and roots on the next May 1st than spring-sown sweetclover. Sweetclover sown in corn is even less valuable. In many years of experimenting with cover crops in corn the most nitrogen the senior author ever obtained on the May 1st following from sweetclover sown in corn was about 40 pounds per acre, and the average was much less than 20. These figures are for yellow sweetclover, which is much more valuable in any summer seeding than white sweetclover, because of its ability to establish under dry conditions or in dry soils.

The life history of sweetclover. The value of sweetclover as a catch crop is best understood if we know its life history. Sweetclover is a biennial root crop like beets or parsnips, and is easiest understood when considered in this way. The development of white sweetclover sown in oats and not clipped after oats harvest is shown in Table 12 and Figure 6. Sweetclover never blooms in the seeding year under Ohio conditions. The maximum amount of top growth is reached at Columbus about September 25th. From then on until freezing weather, the plant appears to "stand still" but plant nutrients are rapidly being deposited in the roots. The dry weight of roots per acre doubles from September 25th until the end of the growing season. Not only does the total weight of roots increase to the end of the season but the percentage of nitrogen in the roots also increases during this period. No other legume grown in Ohio stores the amount of nitrogen in the roots at this time that sweetclover does. Alfalfa is next, but is only about half as good as unclipped well-grown sweetclover. If both are clipped, alfalfa is equal or superior in nitrogen accumulation.

During the winter the dry weight of sweetclover roots conspicuously diminishes (Table 12) while the green weight per acre greatly increases—the percentage of moisture in green roots increases from less than 70 percent in the fall to just under 80 percent in the spring. The reduction in dry weight is from winter respiration and results in substantial increases in the nitrogen content of the dry matter of the roots by April 1st of the second year compared to November of the first year. This increase will range from 0.5 to over 1.0 percentage point.



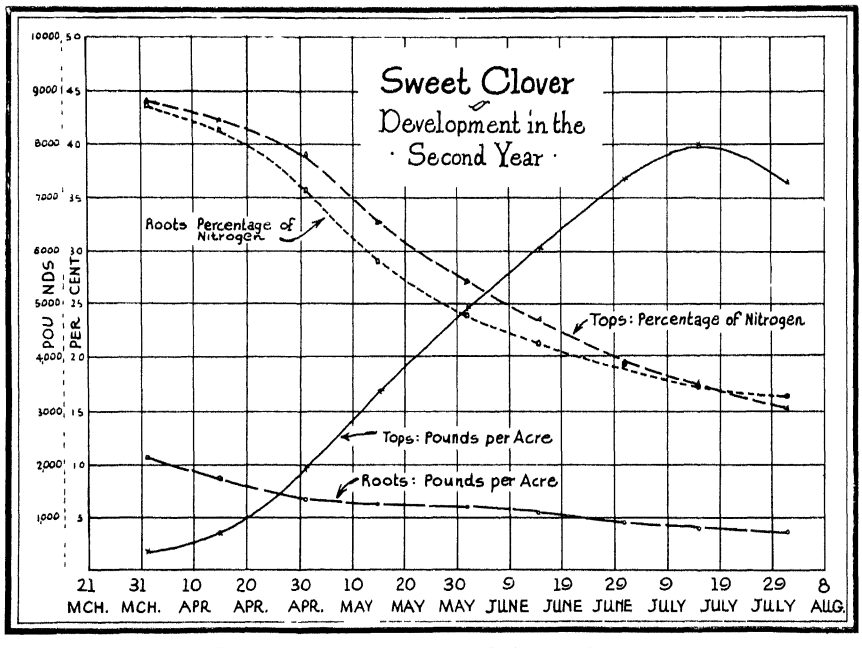


Fig. 6.—Life History of Sweetclover.

Top, development of sweetclover in the seeding year; bottom, development in the second year.

TABLE 12.—Yield and Composition of Tops and Roots of Sweetclover at Successive Dates in the Seeding Year and the Year After Seeding*

Sweetclover sown in early oats which were harvested for grain
Sweetclover not clipped or pastured after oats harvest

Date of sampling	Air-dry yield per acre		Nitrogen in		Nitrogen per acre			Plants per square yard
	Tops	Roots	Tops	Roots	Tops	Roots	Total	
	Lb.	Lb.	Pct.	Pct.	Lb.	Lb.	Lb.	No.
Development in the seeding year								
July 1†	512[2]	----	3.25[2]	----	--	--	----	----
July 15‡	588[5]	75[4]	2.85[4]	2.30[3]	16	2	18	----
August 1	659	182[5]	2.54[5]	2.53[5]	17	4	21	----
August 15	963	310[6]	2.89	2.90[5]	28	9	37	----
September 1	1431	577	2.88	3.02	41	18	59	----
September 15	1544	884	3.09	3.05	48	27	75	----
October 1	1881	1273	2.87	3.12	54	40	94	----
October 15	1714	1721	2.59	3.25	44	56	100	----
November 1	1616	2115	2.38	3.50	39	74	113	----
November 8-10	1397	2234	2.32	3.45	32	77	109	----
Development in the year after seeding								
April 1	420[2]	2130	4.35[2]	4.33	19	92	111	125
April 15	690	1750	4.21	4.15	29	73	102	125
May 1	1930	1360	3.90	3.57	75	49	114	117
May 15	3360	1280	3.27	2.90	110	37	147	102
June 1	4940	1200	2.70	2.38	133	39	162	92
June 15	6030	1110	2.35	2.14	142	24	166	82
July 1	7380	880	1.95	1.94	144	17	161	66
July 15	7990	790	1.77	1.72	141	14	155	50
August 1	7290[3]	760[3]	1.54[2]	1.64[2]	112	13	115	40

*Yields—first year, 7-year average; second-year, 4-year average, except as noted. Nitrogen analyses—first year, 6-year average, second year, 3-year average, except as noted.

†Oats not yet harvested.

‡Average date of harvesting oats.

[2], [3], [4], [5], [6]—number of years averaged.

When growth starts the second year, the growth until May 1st is little more than a transfer of materials from roots into the tops. After this the tops grow rapidly and both roots and tops diminish in percentage of nitrogen rapidly. The maximum nitrogen in tops and roots is reached about June 15 and the maximum total dry matter about July 15.

Clipping sweetclover or cutting for hay in the seeding year. In the seeding year sweetclover grows much like an annual plant. It produces only one stem at the crown. If this stem is cut by a combine, binder or mowing machine, or by pasturing, new growth starts immediately below the cut, not at the crown, as alfalfa and red clover seedlings. Furthermore, sweetclover is very slow to recover and when cut after the middle of August it does not recover at all, but simply remains until the following spring with whatever growth it had when cut. As an 8-year average at Columbus, cutting sweetclover for hay September 15 to 28 reduced the amount of nitrogen in the crop to plow under the next April from 99 pounds per acre in the uncut sweetclover to 45 pounds per acre in that cut for hay.

Again, like an annual crop, the most vigorous buds are near the top of the plant, so if it is necessary to clip sweetclover in the seeding year, it should be clipped as high as possible. The importance of this is shown in Table 13. In this two-year experiment well-grown sweetclover in oats was clipped in July two inches above the ground, as a mowing machine might, and six to eight inches and 14 to 16 inches above the ground, as a combine might. Additional plots were left unclipped, the oats being allowed to fall to the ground (Figure 7). As a two-year average the unclipped sweetclover produced 3600 pounds dry weight of roots containing 127 pounds of nitrogen, while the plots cut two to three inches high in July and allowed to grow without pasturing or mowing after that produced only 1100 pounds of roots containing 37 pounds of nitrogen.

TABLE 13.—Set the Combine High Over Sweetclover.
Oats sown to sweetclover and cut at various heights in July.
Nothing more done thereafter.

Height clipped in July	2-year average, harvested on November 1. Columbus						
	Yield per acre		Nitrogen in		Nitrogen per acre		
	Tops	Roots	Tops	Roots	Tops	Roots	Total
In.	Lb.	Lb.	Pct.	Pct.	Lb.	Lb.	Lb.
Not cut*	2940	3630	1 6	3 5	47	127	174
14-16	1900	2760	2 1	3 6	40	99	139
7-8	1130	1830	2 2	3 7	25	68	93
2-3	630	1090	2 2	3 4	14	37	51

*Oats crop with which seeding was made was not harvested.

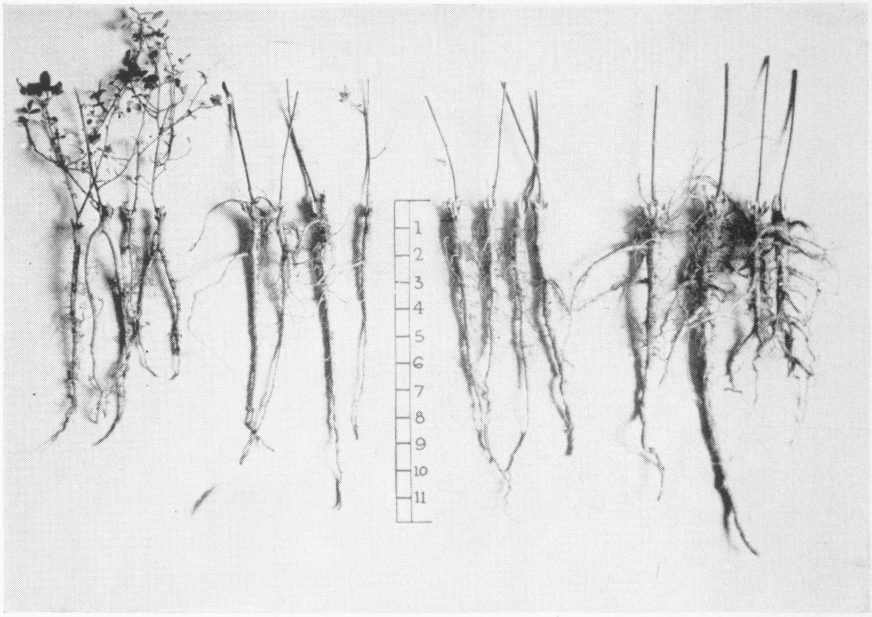


Fig. 7.—Set the Combine or Binder High When Sweetclover is Sown in Grain.

Nov. 10. Four typical roots each from plots cut on July 20 (left to right) 2 inches high, 8 inches high, 14 inches high and not at all. Nothing was done after July—the differences are due to the different heights of cutting.

Sweetclover for green manure should never be clipped in the seeding year under any circumstances (13). Others (1) (9) have repeatedly confirmed this. This is rule No. 1 in managing sweetclover for green manure, but many never learn it. Even many experiment station results with sweetclover have been vitiated by "tidying up" the plots by clipping.

Obviously, it is also a serious defect of the sweetclover for green manure rotation that it inevitably pollutes the soil with seed of many annual weeds.

The worst time to clip sweetclover in the latitude of Parallel 40° is from September 1 to October 1. After these dates there is at least a reasonable amount of root reserves already accumulated. Before these dates the tops will recover sufficiently to store some reserves. The comparative vigor of sweetclover plants clipped at different dates in the preceding year is illustrated in Figures 8 and 9. If one wishes to destroy volunteer sweetclover in an alfalfa, red clover or alsike clover

Fig. 8.—Don't Clip Sweetclover in the Seeding Year!

May 12. Three typical large plants from plots clipped (left to right) Aug. 1, Aug. 15, Sept. 1, Sept. 15, Oct. 1, Oct. 15, and Nov. 1 of the previous year, and not clipped in the seeding year. The percentages of plants heaved during the winter in this test were, respectively, 51, 67, 66, 89, 82, 61, 51, and 41.

Fig. 9.—Clipping or Pasturing Sweetclover in the Seeding Year Reduces Yields the Next Year.

Sweetclover from equal areas on May 26 from plots clipped (left to right) Aug. 1, Sept. 15, Nov. 1, and not cut, in the seeding year.

field, it should be clipped about September 1. A high proportion of the sweetclover plants will be so small that they will heave out over winter, and the few that remain will be so weak that they will give a minimum of competition to the other forages. The other forages will recover from the crown and have time to harden normally for winter.

SUMMARY AND CONCLUSIONS

1. Numerous experiments on a variety of soil types in Ohio have shown that when conditions are or can be made favorable for sweetclover the 2-year rotation of corn followed by a small grain seeded to a sweetclover catch crop will maintain the productivity of a productive soil nearly or quite as well as a 3- or 4-year rotation with one year of mixed hay including red clover and alfalfa.

2. On soils which are highly deficient in organic matter, this rotation will increase the productivity of the soil.

3. Sweetclover, in this rotation, will produce as high yields of corn as are obtained by plowing under six tons of manure per acre or applying commercial nitrogen up to, at times, as much as 100 pounds per acre.

4. Sweetclover may be plowed under any time from November to the first of May in the latitude of Ohio, the most favorable time depending on the soil type and not the sweetclover. Despite the fact that somewhat more nitrogen is obtained, there is no advantage in delaying plowing after May 1, and in many seasons, it may be disadvantageous.

5. The soil improving value of the rotation is increased when the straw and stover from the grain crops are not removed but are plowed down with the sweetclover.

6. Factors in the successful use of sweetclover in this rotation are: (a) spring seeding; summer seedings alone or in corn are much less effective and are quite likely to be unprofitable (b) do not harvest a companion crop with a mowing machine (c) do not clip the stubble of the companion crop or cut the sweetclover for hay at any time during the seeding year.

7. Because of its unique life history properly grown sweetclover will accumulate much more nitrogen per acre in the roots in the fall of the seeding year than any other legume. Alfalfa is next in this respect and preferable if the field must be clipped.