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EFFECT OF SUMMER-SEEDED GREEN MANURES ON SOIL STRUCTURE AND AVAILABILITY OF NITROGEN

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ON THE COVER—Figure 1. See page 8 for description

EFFECT OF SUMMER-SEEDED GREEN MANURES ON SOIL STRUCTURE AND AVAILABILITY OF NITROGEN

J. L. MORTENSEN and J. L. YOUNG[1]

INTRODUCTION

Green manuring has been practiced for many years in all parts of the world in an attempt to improve soil productivity. Beneficial effects have been attributed (16) to one or more of the following: (1) the addition and conservation of nitrogen, (2) the maintenance or buildup of soil organic matter, (3) the improvement of soil structure, (4) the conservation and subsequent release of nutrient elements other than nitrogen, (5) the physical protection of the soil against erosion and (6) increased water-holding capacity.

Green manuring, however, has not always resulted in increased yield of crops or improvement of soil fertility. Plice (17) and McVickar, et al., (9) found little or no benefit from the use of green manures. Other investigators (4, 7, 14), particularly App, et al., (3), however, have reported marked benefits from their use. Joffe (5) has indicated that such contradictory results can be accounted for if climatic conditions and soil type are taken into account.

Studies in Ohio (2) have generally shown that green manuring can be expected to increase the yield of crops. Such effects have been attributed to increased availability of nitrogen following leguminous green manures, or an improvement in soil structure as the result of the added organic matter. Information as to the relative contribution of each effect to crop yield has not been available.

The purpose of this study was to compare the relative effects of six summer-seeded green manures on nitrogen availability and soil structure in the field. These effects were evaluated in an independent manner by using a synthetic soil conditioner to eliminate the effect of poor structure and nitrogen fertilization to eliminate or equalize the contribution of nitrogen from the green manures.

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MATERIALS AND METHODS[2]

Experiment I

FIRST YEAR (1953–1954)—CORN

The study was established at the Northwestern Substation of the Ohio Agricultural Experiment Station located in the old lakebed area of Wood County in Northwestern Ohio. The soil (Hoytville silty clay, formerly classified as Brookston) which developed from fine-textured lake plain till requires drainage, is very heavy and exhibits characteristics of poor physical structure. Improvement of the structure of this soil and nitrogen fertilization have increased crop yields (13). Additional characteristics can be found in the series description (1) and Table 1.

TABLE 1.—Some chemical and physical properties of Hoytville silty clay

Readily soluble phosphorus (Truog)	380 lb/acre
Exchangeable potassium	740 lb/acre
Cation-exchange capacity	28 meq/100 gm
Organic matter	5.4 percent
pH	6.6
Moisturo equivalent	31.0 percent

The experimental design was a split-plot factorial with four replications, the main plots (14′ × 88′) consisted of summer-seeded green manures, the subplots (14′ × 44′) consisted of nitrogen fertilization and a soil-conditioner treatment. Statistical computations were performed by the Statistics Laboratory of the Ohio State University.

The experimental area (Field C, Lots 6 and 7) was plowed, disked and cultipacked before six crops to be used as green manures (Table 2) were band-seeded with 300 pounds/acre of 3-12-12 fertilizer on July 27, 1953. Ammonium nitrate at the rate of 100 pounds/acre of elemental nitrogen was applied over the growth of the green manures to appropriate plots on April 29, 1954. Yields of the green manures were estimated and the experimental area was plowed and disked on May 17, 1954. VAMA conditioner (a mixture of calcium hydroxide and a copolymer of vinyl acetate and the partial methyl ester of maleic acid)

[2]The experiment was originally designed by Dr. W. P. Martin* and Dr. J. L. Haynes of the Department of Agronomy. Their assistance and that of Dr. G. S. Taylor of the Department of Agronomy, and Don Herr, Manager of the Northwest Substation, is gratefully acknowledged.

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TABLE 2.—Seeding rate for summer-seeded green manures

Green manure	Seeding rate Lb/acre
Yellow sweet clover	10
Kenland red clover	10
Atlantic alfalfa	10
Hairy vetch	20
Ryegass*	6
Orchardgrass*	6

*Two parts of milorganite to one part of grass seed was used to improve drillability.

at the rate of 1000 pounds/acre (0.05%) was applied to appropriate plots and incorporated by disking and rotovation on May 27. Ohio K62 corn was planted in 42 inch rows with a 9 inch seed drop and 300 pounds/acre of 4-16-16 fertilizer on May 27. Weeds were controlled by a 2,4-D spray application on July 29 and by conventional methods of cultivation.

A modified Yoder wet-sieving method (11) was used to determine the percentage of water-stable aggregates in soil samples obtained several times throughout the growing season. Porosity and volume weight measurements were made by the method of Leamer and Shaw (6), 60 cm. of tension being used.

Stand counts and observations on growth characteristics of the corn were made several times during the growing season. Corn leaf tissue was obtained within a half-hour sampling period from the same position on each plant, oven-dried at 68° C. and subjected to nitrogen analysis by the Kjeldahl method. A stretch of 40 feet of the two center rows of each plot was harvested by hand on October 29. Moisture content of the kernels was determined by using a Tag-Heppenstall moisture meter and nitrogen content of the grain was determined by the Kjeldahl method.

Experiment Ia

SECOND YEAR (1955)—CORN

Following the corn harvest (stalks left on plots), all plots were disked and planted to wheat with 185 pounds/acre of 4-16-16 fertilizer. The wheat was plowed under in May, 1955 and the seedbed prepared for corn. Part of the experimental area was used in a row spacing study, the remainder being used for a row spacing intercrop study.[3]

[3]Designed and conducted by Dr. J. L. Haynes.

In the spacing study, 300 pounds/acre of 0-20-20 fertilizer and 100 pounds/acre of nitrogen as ammonium nitrate was broadcast on May 14, 1955. Ohio K62 corn was planted in rows 42 inches apart, 74 inches apart and in pairs of rows 10 inches apart with 74 inches between the 10 inch pairs, on May 19. Corn from the two center rows (40 foot stretch) was harvested by hand on October 31. In the spacing-intercrop study, 300 pounds/acre of nitrogen as ammonium sulfate was broadcast on May 14 and 17. Ohio K62 corn was planted with 140 pounds/acre of 10-10-10 fertilizer in 42 and in 62 inch rows on May 20. Ryegrass or alfalfa was sown between, or over and between the rows at the second cultivation. Corn was harvested from the center rows (40 foot stretch) of each plot on November 4.

Soil samples for aggregate analysis (modified Yoder method (11)) and leaf samples for nitrogen analysis were obtained in September within the 1954 plot boundaries. Yield, and moisture and nitrogen content of the corn grain was determined on samples from plots which had received conditioner or no conditioner in 1954. Nitrogen content of the leaf and grain samples was determined by the Kjeldahl method. Moisture content of the corn grain was determined by oven-drying at 105° C.

Experiment II

FIRST YEAR (1954–1955)—SUDAN

An experimental design identical to that described in Experiment I was used in establishing Experiment II on Field C, Lots 4 and 5 of the Northwest Substation. The crops to be used as green manures (Table 2) were band-seeded on July 12, 1954 with 300 pounds/acre of 4-16-16 fertilizer. Ammonium nitrate at the rate of 100 pounds/acre of nitrogen was applied over the growth of the green manures to appropriate plots on May 2, 1955. A 3 foot strip of the top growth from the green manure plots was removed by clipping on May 11, and weighed for determination of yield, a portion being retained for nitrogen analysis by the Kjeldahl method. The moisture percentage of the soil at the time of plowing was determined by oven-drying (105° C.). Soil samples were removed by an auger from a depth of 0 to 6 inches.

The experimental area was plowed, disked and cultipacked on May 18. VAMA conditioner at the rate of 1000 pounds/acre (0.05%) was applied to appropriate plots and incorporated by rotovation on May 21. Following a corn crop failure which had received 250 pounds/acre of 5-20-20 in the row, Sweet Sudan (36½ pounds/acre) was planted on July 11. Failure of the corn could be attributed to excessive drouth which inhibited germination in all plots.

Yield measurements were made on a 3 foot strip which had been clipped from the center of each plot on September 2. Samples of sudan for determination of nitrogen content (Kjeldahl method) and samples of soil for aggregate analysis (modified Yoder method (11)) were also obtained on September 2.

SECOND YEAR (1956)—CORN

The remaining sudan from the 1955 plots was clipped on September 2 and left on the surface of the soil. The experimental area was plowed, disked and cultipacked on May 24, 1956. Ohio K62 corn was planted in 42 inch rows with a 9 inch seed drop and 100 pounds/acre of 5-20-20 fertilizer on May 26.

Soil samples for aggregate analysis (modified Yoder method (11)) were obtained on July 5 and for aeration porosity (method of Leamer and Shaw (6) using 60 cm. of tension) on September 20. Corn leaves for nitrogen analysis were obtained on August 27 and the corn was harvested by hand from the two center rows (40 foot stretch) on October 31. Stand and ear counts were made at the time of harvest. Nitrogen percentage in the corn grain and leaf tissue was determined by the Kjeldahl method. Moisture percentage in the corn grain was determined by oven-drying at 105° C.

THIRD YEAR (1957)—OATS

The corn stalks were left on the plots and the experimental area was plowed on November 14, 1956. The plots were disked and harrowed in the spring and planted to Clintland oats (2 bu./acre) on April 30, 1957, with 320 pounds/acre of 5-20-20 fertilizer.

Soil and plant samples were obtained and analyzed in a manner similar to that described in the first two years of the experiment. Oat plants for nitrogen analysis were sampled in the heading stage, 20 plants being obtained from each plot. Borders were mowed from all plots and a center strip was harvested with a self-propelled combine on July 29. Moisture percentage of the oat grain was determined by oven-drying at 105° C.

RESULTS AND DISCUSSION

Experiment I and Ia

Green manures. Observations on the growth of the summer-seeded green manures indicated that the stand of alfalfa and hairy vetch was satisfactory. The poor stand of the other green manures resulted in low yields (Table 3). Considerable orchard grass and yellow sweet clover were killed by winter heaving. Maximum effects of green manuring on soil structure and availability of nitrogen therefore could not be expected from these crops.

TABLE 3.—Yield of green manures (roots and tops). Exp. I

Green manure	Pounds per acre*—total dry matter May 5, 1954
Yellow sweetclover	1000
Red clover	800
Alfalfa	800
Hairy vetch	1400
Ryegrass	600
Orchardgrass	100

*Estimates of yield made by Dr. J. L. Haynes.

Soil structure. VAMA significantly increased the percentage of water-stable aggregates and aeration porosity, and decreased the volume weight of Hoytville silty clay (Table 4 and 5). Although the conditioner was diluted with untreated soil by plowing, the improvement in aggregate stability was maintained through a second growing season of 1955 (Table 4).

The improved structure and amelioration of surface crusting as a result of VAMA treatment can be seen in Figure 1. The characteristic shrinking and cracking of this soil when dry was not apparent in the conditioner treated plots.

Green manuring had little effect on aggregate stability until sufficient time had elapsed for decomposition and concomitant synthesis of aggregate stabilizing materials (8, 10). This effect was quite transitory and could not be detected in the second growing season of 1955 (Table 4). Ryegrass and hairy vetch were primarily responsible for the increased aggregate stability noted in September of 1954. Aeration porosity and volume weight were not affected by green manuring (Table 5).

Composition and yield of corn in 1954. The expected (18) improvement in germination as a result of conditioner treatment was not noted. A rainfall of 1.5 inches three days after planting created

TABLE 4.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on stability of aggregates of Hoytville silty clay (> 0.25 mm). Exps. I and Ia

Treatment	None	Green manure						Aver.
		Yellow sweet clover	Red clover	Alfalfa	Hairy vetch	Rye grass	Orchard grass	
				June 16, 1954 (Exp. I)				
No conditioner								
Check	53	54	55	54	48	56	51	53
100 lb/acre nitrogen	52	51	56	54	53	60	49	54
Conditioner								
0.05 % VAMA	83	83	85	85	86	80	86	84
0.05 % VAMA and 100 lb/acre nitrogen	82	81	84	84	83	80	83	82
Average	67	67	70	70	68	69	67	68
				September 3, 1954 (Exp. I)				
No conditioner								
Check	56	61	55	57	65	61	53	58
100 lb/acre nitrogen	50	55	57	57	57	64	59	57
Conditioner								
0.05 % VAMA	83	85	85	87	84	87	85	85
0.05 % VAMA and 100 lb/acre nitrogen	82	84	85	84	86	83	84	84
Average	68	71	71	71	73	74	70	71
				September 1955 (Exp. Ia)				
No conditioner								
Check	63	61	57	62	55	60	66	61
100 lb/acre nitrogen	63	65	61	60	58	60	61	61
Conditioner								
0.05 % VAMA	69	67	72	73	70	81	75	71
0.05 % VAMA and 100 lb/acre nitrogen	72	73	73	69	69	73	73	72
Average	67	67	66	66	63	66	69	66

LSD (0.01)** (0.05)*	June 1954	Sept. 1954	Sept. 1955
Green manures	NS	2*	NS
Nitrogen	NS	1*	NS
Conditioner	2**	1**	5**
Green manures x nitrogen	NS	NS	NS
Green manures x conditioner	3*	2*	NS
Conditioner x nitrogen	NS	NS	NS
Green manures x nitrogen x conditioner	NS	17**	NS

almost ideal conditions for germination. Stand counts taken several times throughout the early growth period indicated some reduction in plant population as a result of VAMA treatment (Table 6).

Plants growing in conditioner treated plots were taller throughout the growing season and exhibited less wilting during droughty periods than plants growing in untreated plots. With the exception of a nitrogen deficiency effect with ryegrass, green manuring and nitrogen fertili-

TABLE 5.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on volume weight and aeration porosity of Hoytville silty clay. Exp. I

Treatment	None	Green manure: Yellow sweet clover	Red clover	Alfalfa	Hairy vetch	Rye grass	Orchard grass	Aver.
		Volume weight (gms/c.c.)—September 3, 1954						
No conditioner								
Check	1.20	1.19	1.22	1.21	1.20	1.20	1.23	1.21
100 lb/acre nitrogen	1.20	1.18	1.22	1.20	1.19	1.20	1.25	1.21
Conditioner								
0.05% VAMA	1.16	1.13	1.15	1.21	1.16	1.14	1.16	1.16
0.05% VAMA and 100 lb/acre nitrogen	1.17	1.15	1.13	1.10	1.12	1.16	1.16	1.14
Average	1.18	1.16	1.18	1.18	1.17	1.18	1.20	1.18
		Percent aeration porosity—September 3, 1954						
No conditioner								
Check	14	17	14	14	14	12	11	14
100 lb/acre nitrogen	17	15	13	17	15	14	13	15
Conditioner								
0.05% VAMA	19	20	20	17	20	18	17	19
0.05% VAMA and 100 lb/acre nitrogen	18	19	18	22	21	18	19	19
Average	17	18	16	18	18	15	15	17

LSD
(0.01)**
(0.05)*

	Volume weight	Aeration porosity
Green manures	NS	NS
Nitrogen	NS	NS
Conditioner	.09**	2**
Green manure x nitrogen	NS	NS
Green manure x conditioner	NS	NS
Conditioner x nitrogen	NS	NS
Green manure x nitrogen x conditioner	NS	NS

TABLE 6.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on stand of corn. Exp. I

Treatment	None	Green manure: Yellow sweet clover	Red clover	Alfalfa	Hairy vetch	Rye grass	Orchard grass	Aver.
		Stand count—plants/plot—July 16, 1954						
No conditioner								
Check	93	91	87	91	89	90	89	90
100 lb/acre nitrogen	92	92	92	89	85	90	93	90
Conditioner								
0.05% VAMA	86	88	87	83	85	88	93	87
0.05% VAMA and 100 lb/acre nitrogen	93	88	88	85	84	89	91	88
Average	91	90	88	87	86	89	91	89

LSD	
(0.01)**	
(0.05)*	
Green manures	NS
Nitrogen	NS
Conditioners	2*
Green manures x nitrogen	NS
Green manures x conditioner	NS
Conditioner x nitrogen	NS
Green manures x nitrogen x conditioner	NS

zation had little effect on height and drouth resistance of the corn plants. It has been suggested (13) that the more extensive root growth in conditioner treated plots increased the volume of available soil moisture.

When compared to the check, nitrogen content of the corn leaves was significantly increased by nitrogen fertilization and significantly decreased by conditioner treatment (Table 7). This latter effect has been noted previously (13) and may have resulted from advanced maturity and subsequent translocation of nitrogen to the more rapidly developing ears on plants growing in conditioner treated plots. Ryegrass and orchard grass, especially in the presence of VAMA treatment, reduced the nitrogen content of the leaves. A reduction in leaf nitrogen below 2.90 percent has been shown to limit the yield of corn (19). Leguminous green manures generally increased the nitrogen content of the corn leaves.

In the absence of nitrogen fertilization, ryegrass and orchard grass reduced the weight per ear and yield of corn (Table 8). Leguminous green manures and VAMA had little effect on the yield of corn. Nitrogen fertilization significantly increased yield by increasing the number

TABLE 7.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on percent nitrogen in corn leaf tissue and corn grain and moisture content of corn grain. Exp. I

Treatment	None	Green manure: Yellow sweet clover	Red clover	Alfalfa	Hairy vetch	Rye grass	Orchard grass	Aver.
	Nitrogen content of leaf tissue (percent)—July 26, 1954							
No conditioner								
Check	2.83	2.98	2.95	2.95	3.07	2.85	2.85	2.93
100 lb/acre nitrogen	3.22	3.28	3.07	3.16	3.16	3.14	3.14	3.17
Conditioner								
0.05 % VAMA	2.87	2.82	2.92	2.83	2.94	2.51	2.73	2.80
0.05 % VAMA and 100 lb/acre nitrogen	3.10	3.08	3.04	2.85	3.08	2.98	3.09	3.03
Average	3.00	3.04	3.00	2.95	3.06	2.87	2.95	2.98
	Nitrogen content of grain (percent)—October 29, 1954							
No conditioner								
Check	1.29	1.44	1.45	1.36	1.48	1.29	1.27	1.37
100 lb/acre nitrogen	1.62	1.66	1.57	1.67	1.57	1.65	1.52	1.61
Conditioner								
0.05 % VAMA	1.23	1.45	1.40	1.42	1.37	1.26	1.17	1.33
0.05 % VAMA and 100 lb/acre nitrogen	1.61	1.58	1.66	1.61	1.61	1.47	1.52	1.58
Average	1.44	1.53	1.52	1.51	1.51	1.42	1.37	1.47
	Moisture content of grain (percent)—October 29, 1954							
No conditioner								
Check	24.1	24.9	24.8	25.0	25.0	24.5	24.5	24.7
100 lb/acre nitrogen	24.5	24.5	24.3	24.5	24.5	24.3	24.9	24.5
Conditioner								
0.05 % VAMA	24.4	23.9	24.8	25.1	24.0	24.7	25.0	24.5
0.05 % VAMA and 100 lb/acre nitrogen	24.6	25.1	24.3	24.2	25.2	24 3	24.7	24.6
Average	24.4	24.6	24.5	24.7	24.7	24.5	24.7	24.6

LSD (0.01)** (0.05)*	% N in leaf tissues	% N in grain	Moisture in grain
Green manures	.35**	.09**	NS
Nitrogen	.06**	.05**	NS
Conditioner	.06**	NS	NS
Green manures x nitrogen	.49**	NS	NS
Green manures x conditioner	NS	NS	NS
Conditioner x nitrogen	NS	NS	NS
Green manures x nitrogen x conditioner	NS	NS	NS

TABLE 8.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on weight and number of ears and yield of corn. Exp. I

Treatment	None	Green manure: Yellow sweet clover	Red clover	Alfalfa	Hairy vetch	Rye grass	Orchard grass	Aver.
	Average weight of ears (lbs)—October 29, 1954							
No conditioner								
Check	.56	.53	.58	.54	.56	.48	.52	.54
100 lb/acre nitrogen	.60	.56	.58	.57	.58	.55	.56	.57
Conditioner								
0.05% VAMA	.54	.56	.53	.54	.56	.44	.49	.52
0.05% VAMA and 100 lb/acre nitrogen	.58	.58	.56	.58	.55	.56	.58	.57
Average	.57	.56	.56	.56	.56	.51	.54	.55
	Number of ears per plot—October 29, 1954							
No conditioner								
Check	89	92	83	94	90	83	90	89
100 lb/acre nitrogen	88	96	91	89	89	95	93	91
Conditioner								
0.05% VAMA	89	93	90	89	90	81	88	88
0.05% VAMA and 100 lb/acre nitrogen	97	90	95	89	92	91	89	92
Average	91	93	90	90	89	87	90	89
	Yield—Bu/acre at 15.5% moisture—October 29, 1954							
No conditioner								
Check	111	109	106	112	111	89	105	106
100 lb/acre nitrogen	117	119	117	112	114	117	115	116
Conditioner								
0.05% VAMA	106	116	106	107	109	79	97	103
0.05% VAMA and 100 lb/acre nitrogen	125	115	117	114	111	113	115	116
Average	115	115	112	111	111	100	108	110

LSD (0.01)** (0.05)*	**Wt. of ears**	**No. of ears**	**Yield**
Green manures	.02**	NS	5**
Nitrogen	.01**	3**	8**
Conditioner	.01*	NS	NS
Green manure x nitrogen	.02*	4*	22**
Green manures x conditioner	.02*	NS	NS
Conditioner x nitrogen	NS	NS	NS
Green manures x nitrogen x conditioner	NS	NS	6*

and weight of the ears. There was a significant interaction between green manures and nitrogen fertilization on weight and number of ears, nitrogen content of the leaf tissue and yield. Nitrogen fertilization at the rate of 100 pounds per acre was evidently insufficient to offset the unfavorable carbon/nitrogen ratio of the grasses and supply the nitrogen requirements of the corn crop.

Maturity, as determined by the moisture content of the grain, was not affected by the treatments. Leguminous green manures and nitrogen fertilization significantly increased, but VAMA had no effect on the nitrogen content of the corn grain (Table 7).

Table 9 indicates that there was a positive correlation between aggregation and aeration porosity and a negative correlation between aggregation and content of nitrogen in the corn leaves. Nitrogen content of the leaves, and weight and number of ears were interrelated and positively correlated with yield. Since aggregation and porosity as indices of soil structure had little effect on the parameters having maximum effect on yield (number and weight of ears), yield apparently was

TABLE 9.—Coefficients of correlation and regression (1954 corn, Exp. I)

Coefficients of correlation

	Aggregation % > .25 mm	Aeration porosity %	Nitrogen in leaves %	Ears/plot number	Wt./ear lb.	Yield bu/A
	X_1	X_2	X_3	X_4	X_5	Y
X_1		.7963**	−.4197*	.0103	−.2045	−.1481
X_2			−.1341	.0682	.1352	.1027
X_3				.5578**	.7349**	.7717**
X_4					.4384*	.7925**
X_5						.8899**

Standard regression coefficients

X_1	X_2	X_3	X_4	X_5
.0044	−.0294	−.0138	.5019**	.6847**

Multiple regression

$Y = -99.8620 + .0029\, X_1 - .0942\, X_2 - .77644\, X_3 + 1.2532^{**}\, X_4 + 182.7411^{**}\, X_5$

$R = .9964$

*Significant at 5 % level.
**Significant at 1 % level.

influenced to a greater extent by nitrogen availability than by physical properties of the soil. If soil structure was a limiting factor in the yield of corn, it could not be detected by such gross measurements as aggregate stability and aeration porosity.

Composition and yield of corn in 1955. Corn growing in plots which had been treated with VAMA the previous year was strikingly taller and more mature than corn growing in untreated plots. This difference in maturity apparently caused a reduction in nitrogen content of the leaf tissue (Table 10) and moisture content of the grain 'Table 11).

The placement of a dissimilar design over the original plots prevented a study of treatment effects other than that of VAMA, but striking increases in the number of ears and yield resulted from this treatment (Table 11). It will be noted from Table 21 that rainfall was

TABLE 10.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on percentage of nitrogen in corn leaves. Exp. Ia

		Green manure						
Treatment	None	Yellow sweet clover	Red clover	Alfalfa	Hairy vetch	Rye grass	Orchard grass	Aver.
				September, 1955				
No conditioner								
Check	2.29	2.19	2.36	2.11	2.32	2.09	2.17	2.22
100 lb/acre nitrogen	2.11	2.20	2.14	2.19	2.20	2.04	2.04	2.13
Conditioner								
0.05% VAMA	1.66	1.57	1.75	1.53	1.59	1.62	1.62	1.62
0.05% VAMA and 100 lb/acre nitrogen	1.70	1.71	1.44	1.56	1.45	1.60	1.63	1.58
Average	1.94	1.92	1.92	1.85	1.89	1.84	1.87	1.89

LSD
(0.01)**
(0.05)*

Green manures	NS
Nitrogen	NS
Conditioners	.19**
Green manures x nitrogen	NS
Green manures x conditioner	NS
Conditioner x nitrogen	NS
Green manures x nitrogen x conditioner	NS

TABLE 11.—Effect of soil conditioner, spacing and interplanting on moisture percentage in grain, number of ears and yield of corn. Exp. Ia

Spacing	Percent moisture in corn grain		Number of ears per acre		Yield—Bu/acre at 15.5% moisture	
	Conditioner	No conditioner	Conditioner	No conditioner	Conditioner	No conditioner
42 inches	22.3	27.1	12,400	9,800	95	86
74 inches	23.5	27.3	13,000	11,300	93	87
10 inches between paired rows, 74 inches between pairs	22.6	27.5	11,200	9,700	85	75
Average	22.8	27.3	12,200	10,300	91	83
Spacing and Intercrop						
63 inch rows—ryegrass between and over rows			14,200	12,100	84	73
63 inch rows—alfalfa between and over rows			13,100	11,200	73	68
63 inch rows—ryegrass between rows			13,600	11,400	84	73
63 inch rows—alfalfa between rows			12,800	11,100	82	73
42 inch rows—ryegrass between rows			12,900	11,400	89	78
Average			13,300	11,400	82	73

LSD		Moisture in grain	Number of ears	Yield
(0.01)**	Spacing	NS	900**	11**
(0.05)*	Conditioner	1.2**	700**	8**
	Spacing × conditioner	NS	NS	NS
	Spacing × intercrop	----	NS	6**
	Conditioner	----	980**	3**
	Spacing and intercrop × conditioner	----	NS	NS

deficient during the 1955 season. Since the maximum effect of improved structure in increasing yield has been noted in dry years (13, 18), the increase in yield was apparently related to plant population and the availability of soil moisture. Improvement of soil structure by conditioner treatment has not altered the field capacity or wilting point values of surface soil (13, 15) but the increase in root volume and subsequent increase in size of the available moisture reservoir may account for such observations. Greater infiltration in treated plots may have resulted in increased availability of moisture below the treated surface soil.

Experiment II

Green manures. With the exception of hairy vetch, excellent stands of summer seeded green manures were obtained in 1954-1955. Hairy vetch winter killed and data from plots with this green manure are not included in this report. There were no significant differences in the yield of the above ground portion of the green manures, but the nitrogen content of the grasses was considerably below that of the legumes (Table 12). No attempt was made to determine the amount of root growth, but root growth of the grasses was probably more extensive than that of the legumes (2).

Moisture content of the soil at the time of plowing had been considerably reduced as the result of transpiration by the green manure crops (Table 12). The use of summer-seeded green manures should

TABLE 12.—Yield and nitrogen content of green manures (above ground portion) and their effect on moisture content of Hoytville silty clay at plowing time. Exp. II

Green manure	Yield (lb/A) May 11, 1955	Percent nitrogen May 11, 1955	Moisture content of soil (0-6") May 18, 1955
None	----	----	28.1
Yellow sweetclover	1790	3.80	22.9
Red clover	2080	3.68	23.8
Alfalfa	1970	3.74	23.1
Ryegrass	2230	1.75	22.3
Orchardgrass	2170	1.94	23.1
LSD (0.01)** (0.05)*	NS	.54**	4.0**

therefore permit earlier plowing on heavy soils such as Hoytville silty clay. Some difficulty was experienced in obtaining good coverage of the grasses, but the condition of the seedbed was thought to be satisfactory for corn. Drouthy conditions prevented adequate germination in all plots, however, and sudan grass was later seeded for the assay crop.

Soil structure. Aggregates were generally more stable in plots containing the grasses (Table 13), but green manures had no significant effect on aggregation following their incorporation in 1955 or in subsequent cropping years (1956 and 1957). Transitory effects probably occurred but went undetected because of an insufficient number of sampling dates. Although confounded by season and time effects, there is an indication that the growing crop markedly affected aggregation, sudan grass having a greater effect than oats or corn (Table 13). VAMA significantly increased water stability of the aggregates throughout the three cropping seasons. The empirical nature of the wet-sieving method, and the effect of moisture and tillage operations on aggregate stability, however, prevent a quantitative comparison between sampling dates.

Alfalfa green manure and VAMA significantly reduced the volume weight and increased aeration porosity of Hoytville silty clay during the second growing season following treatment (Table 14). This was not due to a simple mechanical effect since the alfalfa had been decomposing for over a year.

Composition and yield of sudan grass (1955), corn (1956) and oats (1957). Leguminous green manures slightly increased the nitrogen content of the plant tissues while the grasses significantly reduced nitrogen content of the sudan grass and corn tissue (Table 15). Nitrogen fertilization significantly increased nitrogen content of the sudan grass and corn tissue but the 100 pounds per acre was insufficient to entirely offset the unfavorable carbon/nitrogen ratio of the grasses. Improved structure as the result of VAMA treatment probably reduced available nitrogen by immobilization and leaching (12, 13) and thus reduced the nitrogen content of the plant tissues. Increased rate of maturation as the result of conditioner treatment was less marked than noted in the 1955 corn (Experiment Ia).

Yellow sweet clover and red clover green manures increased the yield of corn but the grasses decreased the yield of sudan grass and corn (Table 16). Nitrogen fertilization in 1955 had little effect on sudan grass or oat yield but significantly increased the yield of corn in 1956. It will be noted from Table 16 that the green manures did not supply sufficient nitrogen for maximum yield. Nitrogen fertilization increased

TABLE 13.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on stability of aggregates of Hoytville silty clay (> 0.25 mm). Exp. II

Treatment	None	Green manure: Yellow sweet clover	Red clover	Alfalfa	Rye grass	Orchard grass	Aver.
		Sudan—September 2, 1955					
No conditioner							
Check	69	73	70	65	75	70	70
100 lb/acre nitrogen	72	64	68	67	74	79	71
Conditioner							
0.05 % VAMA	86	85	87	90	91	89	88
0.05 % VAMA and 100 lb/acre nitrogen	79	80	87	83	87	87	84
Average	77	76	78	76	82	81	78
		(No sudan grass = 63)					
		Corn—July 5, 1956					
No conditioner							
Check	37	52	55	54	49	57	51
100 lb/acre nitrogen	54	61	70	56	58	55	59
Conditioner							
0.05 % VAMA	69	70	58	70	71	74	69
0.05 % VAMA and 100 lb/acre nitrogen	63	66	67	63	68	65	65
Average	56	62	63	61	62	63	61
		Oats—June 25, 1957					
No conditioner							
Check	63	61	63	61	67	64	63
100 lb/acre nitrogen	61	61	60	58	65	61	62
Conditioner							
0.05 % VAMA	74	78	69	74	74	72	73
0.05 % VAMA and 100 lb/acre nitrogen	72	69	74	72	71	71	71
Average	68	67	67	66	69	67	67

LSD
(0.01)**
(0.05)*

	1955	1956	1957
Green manures	NS	NS	NS
Nitrogen	NS	NS	NS
Conditioner	7**	2**	3**
Green manures x nitrogen	NS	6*	NS
Green manures x conditioner	NS	6**	NS
Conditioner x nitrogen	NS	3**	NS
Green manures x nitrogen x conditioner	NS	NS	NS

yield in the green manure plots but did not adequately compensate for the unfavorable carbon/nitrogen ratio in the grass plots. VAMA treatment increased the yield of sudan grass in 1955 and corn in 1956. Improved structure would be expected to increase yield under the low rainfall conditions of these two growing seasons.

TABLE 14.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on volume weight and aeration porosity of Hoytville silty clay. Exp. II

Treatment	None	Green manure: Yellow sweet clover	Red clover	Alfalfa	Rye grass	Orchard grass	Aver.
	Volume weight (gms/c.c.) September 20, 1956						
No conditioner							
Check	1.23	1.21	1.16	1.13	1.21	1.27	1.19
100 lb/acre nitrogen	1.28	1.22	1.23	1.19	1.15	1.26	1.20
Conditioner							
0.05% VAMA	1.12	1.20	1.10	1.06	1.18	1.14	1.12
0.05% VAMA and 100 lb/acre nitrogen	1.18	1.14	1.14	1.10	1.07	1.13	1.13
Average	1.20	1.19	1.16	1.12	1.15	1.20	1.17
	Percent aeration porosity—September 20, 1956						
No conditioner							
Check	15	11	14	15	12	9	13
100 lb/acre nitrogen	12	13	10	14	13	12	12
Conditioner							
0.05% VAMA	16	13	18	18	15	15	16
0.05% VAMA and 100 lb/acre nitrogen	15	16	16	18	19	15	16
Average	15	13	15	16	15	13	14

LSD
(0.01)**
(0.05)*

	Volume weight	Aeration porosity
Green manures	.04**	2*
Nitrogen	NS	NS
Conditioner	.02**	1**
Green manures x nitrogen	.06*	2*
Green manures x conditioner	NS	NS
Conditioner x nitrogen	NS	NS
Green manures x nitrogen x conditioner	NS	NS

TABLE 15.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on nitrogen content of plant tissue. Exp. II

Treatment	None	Green manure: Yellow sweet clover	Red clover	Alfalfa	Rye grass	Orchard grass	Aver.
		Sudan grass plants—September 2, 1955					
No conditioner							
Check	1.95	2.14	2.03	2.16	1.48	1.46	1.87
100 lb/acre nitrogen	2.36	2.52	2.23	2.29	1.91	2.30	2.27
Conditioner							
0.05% VAMA	1.72	2.24	2.18	1.93	1.17	1.41	1.78
0.05% VAMA and 100 lb/acre nitrogen	2.29	2.33	2.17	2.21	1.80	1.97	2.13
Average	2.08	2.31	2.15	2.15	1.59	1.79	2.01
		Corn leaves—August 27, 1956					
No conditioner							
Check	2.36	2.63	2.47	2.65	2.16	2.47	2.46
100 lb/acre nitrogen	2.71	2.94	3.04	2.83	2.57	2.51	2.77
Conditioner							
0.05% VAMA	2.20	2.26	2.35	2.18	1.76	2.00	2.13
0.05% VAMA and 100 lb/acre nitrogen	2.46	2.72	2.65	2.44	2.30	2.18	2.46
Average	2.43	2.64	2.63	2.53	2.20	2.29	2.46
		Oat plants—June 26, 1957					
No conditioner							
Check	1.84	1.83	2.03	1.94	1.99	1.95	1.93
100 lb/acre nitrogen	1.94	2.02	2.05	2.16	2.16	1.91	2.04
Conditioner							
0.05% VAMA	1.63	1.68	1.78	1.69	1.77	1.72	1.71
0.05% VAMA and 100 lb/acre nitrogen	1.64	1.71	1.65	1.88	1.84	1.65	1.73
Average	1.76	1.81	1.88	1.92	1.94	1.81	1.85

LSD
(0.01)**
(0.05)*

	Sudan grass	Corn leaves	Oat plants
Green manures	.27**	.22**	NS
Nitrogen	.24**	.12**	NS
Conditioner	NS	.12**	.07**
Green manures x nitrogen	NS	NS	NS
Green manures x conditioner	NS	NS	NS
Conditioner x nitrogen	NS	NS	NS
Green manures x nitrogen x conditioner	NS	NS	NS

TABLE 16.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on yield of crops. Exp. II

Treatment	None	Green manure: Yellow sweet clover	Red clover	Alfalfa	Rye grass	Orchard grass	Aver.
	1955 Sudan grass—Pounds/acre (Oven-dry weight)						
No conditioner							
Check	2760	3380	2530	3150	2080	2080	2660
100 lb/acre nitrogen	3140	3080	3150	3120	3060	2520	3010
Conditioner							
0.05% VAMA	3340	3230	3360	3650	2360	3020	3160
0.05% VAMA and 100 lb/acre nitrogen	3340	3430	3490	3380	3230	3040	3320
Average	3145	3280	3130	3330	2680	2670	
	1956 Corn—Bushels/acre (15.5% moisture)						
No conditioner							
Check	66	78	62	71	49	57	64
100 lb/acre nitrogen	74	84	82	78	75	74	78
Conditioner							
0.05% VAMA	78	86	81	84	63	69	77
0.05% VAMA and 100 lb/acre nitrogen	82	98	92	84	80	82	86
Average	75	87	79	79	67	75	
	1957 Oats—Bushels/acre (12.5% moisture)						
No conditioner							
Check	41	53	50	49	36	39	45
100 lb/acre nitrogen	43	58	57	39	55	43	49
Conditioner							
0.05% VAMA	51	53	49	50	40	42	48
0.05% VAMA and 100 lb/acre nitrogen	46	44	56	42	46	45	47
Average	45	52	53	45	44	42	

LSD
(0.01)**
(0.05)*

	Sudan grass	Corn	Oats
Green manures	430*	8**	NS
Nitrogen	NS	4**	NS
Conditioner	500**	4**	NS
Green manures x nitrogen	NS	NS	NS
Green manures x conditioner	NS	NS	NS
Conditioner x nitrogen	NS	NS	NS
Green manures x nitrogen x conditioner	NS	NS	NS

TABLE 17.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on stand count, number of ears and weight per ear of corn. Exp. II

Treatment	Green manure: None	Yellow sweet clover	Red clover	Alfalfa	Rye grass	Orchard grass	Aver.
	Plants per acre—October 31, 1956						
No conditioner							
Check	11100	13000	11600	12600	9700	9800	11100
100 lb/acre nitrogen	10400	12100	12220	11500	11600	11800	11600
Conditioner							
0.05% VAMA	13600	16000	13600	14500	12100	13100	13800
0.05% VAMA and 100 lb/acre nitrogen	13100	16100	15300	14800	13800	13800	14200
Average	12100	14300	13200	13400	11800	12100	12700
	Number of ears per acre—October 31, 1956						
No conditioner							
Check	8900	10200	9400	9800	8200	8100	8900
100 lb/acre nitrogen	9500	10000	9800	10000	9900	9800	9800
Conditioner							
0.05% VAMA	10800	11500	11000	10800	9900	11100	10800
0.05% VAMA and 100 lb/acre nitrogen	10000	11000	9900	10500	9700	10000	10200
Average	10000	11000	9900	10500	9700	10000	10200

TABLE 17.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on stand count, number of ears and weight per ear of corn. Exp. II—Continued

Treatment	Green manure: None	Yellow sweet clover	Red clover	Alfalfa	Rye grass	Orchard grass	Aver.
No conditioner			Weight per ear—pounds—October 31, 1956				
Check	.51	.52	.47	.50	.41	.48	.48
100 lb/acre nitrogen	.54	.58	.58	.54	.53	.53	.55
Conditioner							
0.05% VAMA	.51	.52	.52	.54	.45	.44	.49
0.05% VAMA and 100 lb/acre nitrogen	.55	.55	.53	.51	.52	.53	.54
Average	.53	.54	.53	.52	.48	.50	.52

LSD (0.01)** (0.05)*	Stand count	No. of ears	Weight per ear
Green manures	1350*	770*	NS
Nitrogen	NS	410*	.02**
Conditioner	720**	410**	NS
Green manures x nitrogen	NS	NS	NS
Green manures x conditioner	NS	NS	NS
Conditioner x nitrogen	NS	NS	NS
Green manures x nitrogen x conditioner	NS	NS	NS

Leguminous green manures, especially yellow sweet clover, increased the number of plants and ears of corn in 1956 (Table 17). Nitrogen fertilization had little effect on stand but significantly increased the number and weight of ears. VAMA increased the stand and number of ears. Stand and ear counts are obviously related but it appears that improved soil structure increased yield by enhancing germination, plant population and ear formation.

TABLE 18.—Effect of summer-seeded green manures, nitrogen fertilization and soil conditioner on nitrogen content of corn and oat grain. Exp. II

Treatment	None	Green manure: Yellow sweet clover	Red clover	Alfalfa	Rye grass	Orchard grass	Aver.
		Corn grain—October 31, 1956					
No conditioner							
Check	1.41	1.61	1.61	1.45	1.43	1.38	1.48
100 lb/acre nitrogen	1.47	1.71	1.67	1.60	1.53	1.51	1.58
Conditioner							
0.05% VAMA	1.28	1.42	1.37	1.43	1.29	1.77	1.43
0.05% VAMA and 100 lb/acre nitroen	1.43	1.57	1.59	1.55	1.46	1.36	1.49
Average	1.40	1.58	1.56	1.51	1.43	1.51	
		Oat grain—July 29, 1957					
No conditioner							
Check	2.41	2.46	2.51	2.45	2.51	2.41	2.46
100 lb/acre nitrogen	2.44	2.34	2.39	2.31	2.54	2.43	2.41
Conditioner							
0.05% VAMA	2.50	2.44	2.31	2.51	2.55	2.46	2.46
0.05% VAMA and 100 lb/acre nitrogen	2.39	2.39	2.45	2.43	2.47	2.34	2.41
Average	2.44	2.41	2.42	2.43	2.52	2.41	

LSD
(0.01)**
(0.05)*

	Corn grain	Oat grain
Green manures	.08**	NS
Nitrogen	.04**	NS
Conditioner	.04**	NS
Green manures x nitrogen	NS	NS
Green manures x conditioner	NS	NS
Conditioner x nitrogen	NS	NS
Green manures x nitrogen x conditioner	NS	NS

Leguminous green manures and nitrogen fertilization significantly increased, but VAMA decreased the nitrogen content of the corn grain (Table18). This would seem to indicate that factors other than nitrogen availability were involved in the improvement of yield as the result of VAMA treatment. Additional nitrogen is apparently required, however, when plants are growing in soils of improved structure. Except for the effect of VAMA on nitrogen content of the plant tissue, residual effects of the treatments on nitrogen availability during the third cropping season (oats in 1957) were not apparent.

Tables 19 and 20 show a negative correlation between aggregation and nitrogen content of the plant tissues. Stand, ear count and yield of corn were positively correlated with aggregation and aeration porosity. Nitrogen content of the leaves was positively correlated with weight per ear. Stand, ear count and weight per ear were positively correlated with yield. Practically all the yield of corn in 1954 and 1956 could be accounted for by the measured parameters (Tables 9 and 20). In both years the number and weight of ears made the greatest contribution to

TABLE 19.—Coefficients of correlation and regression (1955 Sudan grass and 1957 oats, Exp. II)

Coefficients of correlation

	1955 Sudan Grass				1957 Oats		
	Aggregation > .25 mm %	N in plants %	Yield Lb/A		Aggregation > .25 mm %	N in plants %	Yield Bu/A
	X_1	X_2	Y		X_1	X_2	Y
X_1		–.3794	.2718	X_1		–.7915**	.0193
X_2			.5557**	X_2			.0264

Standard regression coefficients

1955 X_1	1955 X_2	1957 X_1	1957 X_2
.5638**	.7696**	–.0044	–.0299

Multiple regression

1955 Sudan grass: $Y = -1044.6211 + 27.5999^{**} X_1 + 957.219^{**} X_2$, $R = .7622$

1957 oats: $Y = 49.4043 - .0048 X_1 - 1.1476 X_2$, $R = .0266$

*Significant at 5% level.
**Significant at 1% level

TABLE 20.—Coefficients of correlation and regression (1956 corn, Exp. II)

Coefficients of correlation

	Aggregation % > .25 mm	Aeration porosity %	N in leaves %	Stand plants/A	Ear count No./A	Wt./ear lb.	Yield Bu/A
	X_1	X_2	X_3	X_4	X_5	X_6	Y
X_1		.3072	–.2490	.6121**	.6350**	.1289	.4698*
X_2			–.3728	.6056**	.6065**	.0207	.4089*
X_3				–.0896	–.0263	.6993**	.3785
$+_4$					.9448**	.3277	.8217**
X_5						.3611	.8607**
X_6							.7747**

Standard regression coefficients

X_1	X_2	X_3	X_4	X_5	X_6
–.0216	–.0025	.0693	.1834**	.5316**	.4767**

Multiple regression

$Y = -66.0552 - .0275\ X_1 - .0109\ X_2 + 2.5733^{*}\ X_3 + .0012^{**}\ X_4 + .0055^{**}\ X_5 + 129.7349^{**}\ X_6$

$R = .9967$

*Significant at 5 % level.
**Significant at 1 % level.

yield. The size and number of ears was also positively correlated. It appears that any treatment which will improve soil structure (in dry years only), or nitrogen availability will increase plant population leading to an increase in the yield of corn. When adequate germination and plant population is attained, nitrogen availability appears to be more important than the structural status of Hoytville silty clay. Other fertility factors such as phosphorus and potassium appear to be adequate in this soil (13).

TABLE 21.—Rainfall data (inches)

	1954	1955	1956	1957
April	2.53	2.72	2.66	6.15
May	1.06	1.73	5.41	3.98
June	2.87	1.79	3.24	4.94
July	4.13	3.46	3.63	2.82
August	4.09	2.81	3.97	.93
September	1.24	1.26	1.15	4.54
October	6.19	4.16	.91	4.51
Total	22.11	17.93	20.97	27.87

SUMMARY AND CONCLUSIONS

Two field experiments were established on Hoytville silty clay to determine whether the major contribution of summer-seeded green manures was associated with improvement of soil structure or increased availability of nitrogen. VAMA soil conditioner (0.05%) and nitrogen fertilization (100 pounds per acre) were used for comparative purposes in studying structure and nitrogen effects in an independent manner. Six summer-seeded green manures were used in a split-plot factorial design with corn (1954) followed by corn (1955) in Experiment I, and sudan grass (1955), corn (1956) and oats (1957) in succession in Experiment II being the assay crops.

Stability of aggregates, aeration porosity and volume weight were used as indices of soil structure. Determination of plant population, nitrogen content of plant tissue and grain, number and weight of corn ears and yield was made to ascertain the effect of the various treatments on the assay crop.

The following conclusions can be made from the results of this study:

1. Some difficulty was experienced in obtaining consistently good stands of summer-seeded green manures. Planting rates could possibly have been higher because poor germination and winter killing accounted for most of the loss in stand in 1953-1954. Hairy vetch winter killed in 1954-1955 but good stands of other green manures were obtained. There was no significant difference in the yield of the above ground portion of yellow sweet clover, red clover, alfalfa, ryegrass or orchardgrass, but the nitrogen content of the grasses was low enough to cause immobilization of nitrogen in the soil.

2. Moisture content of the soil at plowing time was considerably reduced by transpiration of the green manures. Earlier plowing and/or better seedbed preparation could be expected if green manures were grown on heavy soils where moisture content at time of plowing influences the quality of the seedbed. Some difficulty was experienced in obtaining good coverage of the grasses during plowing.

3. VAMA soil conditioner significantly increased aeration porosity and aggregate stability, and reduced volume weight of the soil. This improvement in soil structure was maintained through three growing seasons.

Decomposition of the plant tissues and microbial synthesis of aggregate stabilizing materials was necessary before green manuring had any effect in improving aggregate stability. The effect was transitory and was detected at only two sampling dates. Probably as the result of their fibrous root systems, the grasses were generally more effective in improving aggregate stability than were the legumes. The gross measurements used in this study were probably inadequate, however, to detect all effects of green manures on soil structure.

4. Nitrogen content of the plant tissue and grain was significantly increased by nitrogen fertilization, and in some cases, by leguminous green manures. This effect was noted through a second growing season following nitrogen fertilization and/or green manuring. The grasses, and improved aggregation as the result of VAMA treatment, significantly reduced nitrogen content of the plant tissues. Part of the VAMA effect on corn was probably due to the increased rate of maturation and translocation of nitrogen from the leaves to the developing ear. Additional nitrogen is apparently required when soil structure is improved by conditioner treatment.

   Nitrogen fertilization at the rate of 100 pounds per acre was insufficient to offset the unfavorable carbon/nitrogen ratio of the orchard grass and ryegrass.

5. Nitrogen fertilization increased the yield of the first and second assay crops but did not affect yield of the assay crop the third year after application. Leguminous green manures did not supply sufficient nitrogen for maximum crop yields.

6. During years of comparatively low rainfall, assay plants growing in conditioner treated plots matured more rapidly and yielded better than plants growing in untreated plots. In spite of the reduction in nitrogen availability, improvement in soil structure was positively correlated with increased yield in these years. Conditioner treatment has been shown to have little effect on moisture equivalent, water-holding capacity or field moisture content of the surface 6 inches of Hoytville silty clay (13). Since nutrients other than nitrogen do not limit yield on this soil (13), the improved soil structure probably increased yield in dry years by increasing the size of the available water reservoir. This could have resulted from increased root extension and volume and/or increased infiltration of water into the subsoil.

7. Statistical analysis indicated that the components which affected corn yield most significantly were weight and number of ears. In

dry years, improved soil structure increased plant population, and thus, the number and weight of ears. Nitrogen fertilization consistently increased these components of yield.

Since leguminous green manures increased yield in some years, but had little effect on soil structure, it appears that the major effect of green manures on Hoytville silty clay with its present structural status was their contribution to the availability of nitrogen. Yellow sweet clover appears to be of maximum benefit.

Unless legumes can be sown in standing corn or drilled with spring grains, nitrogen could be more profitably applied in fertilizer form. If additional nitrogen were applied to offset the unfavorable carbon/nitrogen ratio, the grasses would probably be a better green manure since they generally improved soil structure to a greater extent than did the legumes. This nitrogen would eventually become available to crops following decomposition of the grasses.

8. The present price of synthetic soil conditioners prevents their use in general field applications for the improvement of soil structure. The use of summer-seeded green manures might be expected to have some favorable effect on the components of yield on fine textured soils if they were used prior to each cropping season. The immediate and residual effects on moisture content at time of plowing, and some improvement in soil structure and nitrogen availability would probably result in a better seedbed, improved stand and increased yield, especially in dry years.

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