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Legumes for Soil Improvement for Cotton and Corn

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SUMMARY

This bulletin reports the results of experiments conducted during 1949-55 on the Upland Farms, College Station; on the A&M Plantation located on bottomland near College Station; and Substation No. 6, Denton, to develop more practical systems of managing legumes for soil improvement.

Hairy vetch, Willamette vetch and Dixie Wonder peas as winter green-manure crops between annual corn corps produced only small increases in the corn yield on the Upland Farms at College Station during the 7 years. The legumes failed to produce larger increases in corn yield mainly because of inadequate soil moisture during the fruiting and ripening period of corn (May and June), when the corn was using maximum amounts of water. Rainfall in May and June influenced the yield of corn more than the treatments.

The spacing of corn plants 18, 24 and 30 inches apart in 40-inch rows had no significant effect on the corn yield. There was no differential response of plant spacing to irrigation. Irrigation produced a marked increase in the yield of corn in 1954.

Plowing under Hairy vetch, Willamette vetch, Dixie Wonder peas, Austrian Winter peas and Singletary peas preceding cotton in a 2-year rotation of cotton and corn had no significant effect on the average cotton yield on the Upland Farms for 7 years. However, Hairy vetch, Dixie Wonder peas and Austrian Winter peas produced larger yields of green matter and added more nitrogen to the soil than Singletary peas or Willamette vetch. The lack of rainfall was the first limiting factor in cotton production under these conditions. Legumes turned under for cotton had only a small residual effect on the yield of corn which followed the cotton. The application of 60 pounds of nitrogen per acre produced small but highly significant increases in the corn yield for 1950 and 1955 and in the average yield for the 6 years, 1950-55.

Continuous corn planted in every row and fertilized with 60 pounds of nitrogen per acre was the best treatment used at the A&M Plantation. This treatment produced the highest yields, 112.6 bushels of corn on 1 acre in 2 years, as compared with the next highest yield, 79.2 bushels, for corn in alternate pairs of rows in a 2-year rotation with Melilotus indica. There was no real difference between the 4-year average yield of unfertilized continuous corn grown in every row or grown in alternate pairs of rows.

Corn preceded by 1 year of fall-seeded Madrid sweetclover and corn preceded by 2 years of spring-seeded Madrid produced almost identical average yields on the A&M Plantation. Fall seeding was significantly better than spring seeding when Madrid sweetclover was used in a 2-year rotation with corn. In the 3-year rotations, 2 years of spring-seeded Madrid sweetclover for green manure produced a significantly higher average yield of corn than fall-seeded alfalfa for hay. This difference may have been caused partly by the superiority of Madrid in competing with Johnsongrass infestations and by the removal of the alfalfa as hay.

At Denton, Austrian Winter peas, Dixie Wonder peas, Hubam sweetclover and Madrid sweetclover in cropping systems with corn, with and without nitrogen, produced significantly lower average yields of corn than continuous corn. In fact, the cropping systems that included Hubam sweetclover for seed or Madrid sweetclover for green manure produced significantly lower average yields of corn than did continuous corn. Furthermore, the application of 60 pounds of nitrogen per acre to corn each year, in addition to the legumes, did not increase the average yield of corn. Deficiency of soil moisture was the chief limiting factor in corn yields at Denton during the period of these experiments.

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Legumes for Soil Improvement for Cotton and Corn

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THE UPLAND SOILS IN EAST TEXAS generally are low in organic matter, nitrogen, phosphorus and potash, and consequently are naturally low in productivity (1). These soils, however, respond to soil management practices, such as fertilizers and green manures, under favorable rainfall (2, 4, 5).

During the past 25 or 30 years, the Department of Agronomy has conducted experiments to determine the adaptation of legumes to Texas and to evaluate them for soil improvement for various crops. Some of this work (3) showed that Hairy vetch was one of the most dependable winter legumes for East Texas.

Other work (6) showed that plowing under Hairy Vetch increased the yield of cotton 40 percent over a period of 10 years, 1937-46, at College Station. Vetch increased the cotton yield 75 to 84 percent and practically doubled the corn yield at Tyler. Plowing under vetch also increased the cotton yield 75 percent at Nacogdoches.

Later, some new legumes, especially Dixie Wonder peas, Singletary peas and Willamette vetch, became available as forage and soil-improving crops. The work on soil and crop management was revised and expanded in 1948-49. Dixie Wonder peas, Willamette vetch, Austrian Winter peas and Singletary peas were included, along with Hairy vetch, in the revised work on the Upland Farms at College Station to evaluate them for soil improvement. The experiments on the A&M Plantation, near College Station, included Dixie Wonder peas, Hubam and Madrid sweetclovers, alfalfa and *Melilotus indica* in different cropping systems. Somewhat similar work was started at Denton in 1949 to ascertain the value of Austrian Winter peas, Dixie Wonder peas and Hubam and Madrid sweetclovers for soil improvement in various cropping systems with corn.

CORN ON THE UPLAND FARMS

Experiments were conducted with Hairy vetch, Willamette vetch and Dixie Wonder peas as soil-improving crops for corn on the Upland Farms at College Station during 1949-55. The legumes were grown during the fall and winter between annual corn crops. The main objectives of the work were: to determine the relative value of these legumes as soil-improving crops, to determine whether the legumes will furnish enough nitrogen for corn and to ascertain whether there is any differential response of spacing of corn plants to green manure and fertilizers.

Seed of the three legumes were inoculated and planted on well-prepared seedbeds as soon as practicable after the corn was harvested. The soil was fertilized with 0-60-60 fertilizer when the legumes were planted. This fertilizer is equivalent to 60 pounds of phosphoric acid (P_2O_5) and 60 pounds of potash (K_2O) per acre. The legumes were allowed to grow until about February 15, when they were plowed under. A recommended corn hybrid was planted on the land about March 15, the optimum planting date for corn in this part of Texas.

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Legumes and Fertility Treatments

The following legume and fertility treatments were used in the experiment:

1. Hairy vetch fertilized with 0-60-60.

2. Hairy vetch fertilized with 0-60-60; 30 pounds of nitrogen per acre were applied when the corn was planted and 60 pounds were applied as a sidedressing.

3. Willamette vetch fertilized with 0-60-60.

4. Willamette vetch fertilized with 0-60-60; 30 pounds of nitrogen per acre were applied when the corn was planted and 60 pounds were applied as a sidedressing.

5. Dixie Wonder peas fertilized with 0-60-60.

6. Dixie Wonder peas fertilized with 0-60-60; 30 pounds of nitrogen were applied when the corn was planted and 60 pounds were applied as a sidedressing.

7. 0-60-60 fertilizer applied to corn.

8. 90-60-60 applied to corn; all P_2O_5 and K_2O applied at planting; 30 pounds of nitrogen applied at planting and 60 pounds as a sidedressing.

Three spacings of corn plants, 18, 24 and 30 inches between plants in 40-inch rows, were included to determine the effects of spacing on the yield of corn. These spacings provided 8,700, 6,500 and 5,200 plants per acre, respectively.

The work was conducted on Lufkin fine sandy loam soil, a planosol. This soil occurs in the southern parts of the East Texas Timberlands, mainly in the area known as the post oak strip. Lufkin soils occur to some extent in other parts of the region. They are gray and rest on dense, plastic clay subsoils. They have very slow drainage through the soil and on smooth flat areas the soils remain wet for long periods. Lufkin soils are drouthy. They are not naturally productive, but, with careful treatment, moderate yields of general farm crops are obtained if moisture conditions are favorable. The results obtained in this experiment at College Station should be applicable generally to Lufkin soils throughout the region.

Yield of Corn

The corn yield obtained during the 7 years of the experiment are shown in Table 1. Good yields were obtained only in 1955, when the average yield of all the treatments was about 51 bushels per acre. Low to medium yields in the other years were caused by deficient or poor distribution of rainfall, unavoidable lateness of planting or replanting necessitated by corn rootworm damage. In 1950 medium yields, averaging about 28 bushels for the several treatments, were caused by severe corn rootworm damage. In an adjoining experiment, which suffered little or no damage by the rootworm, the average yield was nearly 50 bushels per acre.

Table 2 shows that the rainfall was above the long-time average of 38 inches only in 1949 and 1953. Although apparently there was sufficient rainfall in June of 1949 and 1953, by the middle of June of each year there was not enough moisture in the soil to supply the needs of the corn during its critical period. In 1955 rains occurred in June at the time the corn plants were using maximum amounts of water. These timely rains account for the higher yields in 1955, although the total rainfall for the years was about 13 inches below the long-time average.

TABLE 1. YIELD OF CORN WHICH RECEIVED AND WHICH DID NOT RECEIVE NITROGEN FOLLOWING LEGUMES AT COLLEGE STATION, 1949-55

Treatment	Bushels shelled corn per acre							
	1949	1950	1951	1952	1953	1954	1955	Average
Hairy vetch plus N[1]	26.6	26.2	19.1	25.1	30.1	31.8	51.8	31.0
Hairy vetch	25.1	27.9	21.6	24.1	33.1	33.5	52.2	30.1
Average	25.8	27.1	20.3	24.6	31.6	32.7	52.0	30.5[2]
Willamette vetch plus N[1]	28.9	26.3	18.4	24.0	29.7	32.3	55.1	30.6
Willamette vetch	25.6	26.3	22.9	24.1	30.9	32.4	45.9	29.6
Average	27.3	26.3	20.7	24.1	30.3	32.3	50.5	30.1[2]
Dixie Wonder peas plus N[1]	29.7	31.2	18.5	24.6	29.2	31.5	52.2	31.2
Dixie Wonder peas	28.3	28.1	22.7	28.1	32.6	34.0	50.2	31.9
Average	29.0	29.7	20.6	26.3	30.9	32.7	51.2	31.5[2]
0-60-60 plus N[1]	27.4	34.8	18.5	24.0	30.1	31.9	55.0	31.6
0-60-60	24.5	22.5	23.1	21.6	30.0	30.1	45.8	28.5
Average	25.9	28.7	20.8	22.8	30.1	31.0	50.4	30.1[2]
Average with nitrogen	28.2	29.6	18.6	24.4	29.8	31.9	53.5	30.9
Average without nitrogen	25.9	26.2	22.6	24.5	31.7	32.5	48.5	30.3
L. S. D. for nitrogen: .05	NS	NS	2.6	NS	NS	NS	4.9	NS
L. S. D. for nitrogen: .01	NS	NS	NS	NS	NS	NS	8.0	NS

[1]These plots received 90 pounds of nitrogen per acre each year.
[2]The difference in the average yields of any two treatments must equal or exceed 1.1 bushels to give odds of 19 to 1 that such difference is real and not due to chance.

TABLE 2. RAINFALL IN INCHES AT COLLEGE STATION, 1949-55, AND AVERAGE FOR 65 YEARS

Month	1949	1950	1951	1952	1953	1954	1955	Average 1949-55	Average 65 years
January	6.05	1.30	.61	3.95	2.13	1.12	2.35	2.50	3.25
February	3.59	3.62	2.54	2.58	2.65	.83	5.56	3.05	2.92
March	3.05	2.84	5.44	1.57	2.44	.77	.37	2.35	2.81
April	6.19	5.26	1.38	5.19	6.93	3.71	3.80	4.64	3.73
May	.87	5.52	2.91	7.23	7.27	5.63	3.94	4.77	4.90
June	3.98	6.26	1.51	.49	3.58	.14	3.00	2.71	3.17
July	3.26	2.81	.52	1.20	2.00	2.89	1.32	2.00	2.54
August	.89	.73	.51	T	2.95	.14	.74	.85	2.32
September	3.31	2.15	4.53	1.88	3.03	.83	1.30	2.43	2.72
October	8.40	.33	.53	.00	4.46	4.69	.67	2.73	2.89
November	.06	.12	2.54	7.09	2.68	1.48	.60	2.08	3.29
December	7.35	.10	1.34	4.47	4.49	2.73	1.64	3.16	3.78
Total	47.00	31.04	24.36	35.65	44.61	24.96	25.19	33.27	38.32

Effect of Legumes and Fertilizer

The highest average yield of corn, 31.5 bushels per acre for the 7 years, was obtained by plowing under Dixie Wonder peas, Table 1. This yield was significantly larger than the average yields of corn from the treatments of Willamette vetch and 0-60-60.

The application of 90 pounds of nitrogen per acre produced a significant decrease in the corn yield for 1951 and an increase in yield for 1955. Nitrogen, however, had no appreciable effect on the average yield of corn for the 7 years, Table 1.

The effects of the legumes and nitrogen on the yield of corn were not enough to be of economic importance.

Effect of Spacing

The three spacings of plants, 18, 24 and 30 inches, produced almost identical average yields of corn for the 7 years, Table 3. In most years, however, moisture, not nitrogen or spacing, is the first limiting factor in yield of corn on this soil.

Apparently the soil in most years has furnished enough nitrogen for the population of plants provided by the spacings used. With adequate moisture and higher levels of nitrogen, however, the spacing of plants probably would have a greater influence on yield of corn.

Effect of Irrigation

Irrigation facilities became available in 1954 and two of the three blocks of corn in the experiment were irrigated June 14, 15 and 16, when the corn plants were showing great stress from lack of moisture. This irrigation was made several days too late to produce maximum yields; however, the irrigated land made an average yield of 36.8 bushels per acre and the nonirrigated land, 23.0 bushels, Table 4. Spacing and application of nitrogen had no appreciable effect on yield of corn under irrigation.

TABLE 3. YIELD OF CORN IN DIFFERENT SPACINGS AT COLLEGE STATION, 1949-55

Spacing between plants, inches	Yield, bushels per acre 1949	1950	1951	1952	1953	1954	1955	Average
18	28.2	28.6	21.2	25.5	31.2	30.8	49.5	30.7
24	25.3	27.8	19.5	24.2	30.0	32.9	52.2	30.3
30	26.9	27.4	21.1	23.6	30.9	32.9	51.5	30.6

Yield and Nitrogen Content of Legumes

The yields of green and air-dry matter and nitrogen content of the legumes used in this work are given in Tables 5, 6, 7 and 8. Yields of green and air-dry matter (forage) were obtained if the legumes made sufficient growth. The winter of 1948-49 was unusually severe for Central Texas, with a minimum of −3° F. on January 31, 1949. As a result of this extremely low temperature, together with dry weather and enforced late planting, the legumes made very little growth. Only the Dixie Wonder peas made sufficient growth to estimate yields of green matter. Normally these peas would have been killed by this low temperature, but they were protected by a snow cover 6 to 8 inches deep. Yields were not obtained in 1951 and 1954 because the legumes made little growth as a result of the dry weather or severe freezes or both. Willamette vetch and Dixie Wonder peas produced low yields in 1953; Hairy vetch made scanty growth but not enough to determine yields. Fairly good yields were obtained for the three legumes in 1955. Yields were obtained from Dixie Wonder peas during 5 of the 7 years, from Willamette vetch, 4 years and from Hairy vetch, 3 years.

Dixie Wonder peas produced an average yield of 12,040 pounds of green matter per acre

TABLE 4. YIELD OF CORN IN DIFFERENT SPACINGS UNDER IRRIGATION AND ON DRYLAND AT COLLEGE STATION, 1954

Spacing, inches between plants in row	Bushels per acre Irrigated	Nonirrigated	Average
18	33.8	24.9	30.8
24	38.6	21.5	32.9
30	38.1	22.5	32.9
Average	36.8	23.0	

TABLE 5. YIELD OF GREEN AND AIR-DRY MATTER OF HAIRY VETCH, WILLAMETTE VETCH AND DIXIE WONDER PEAS AT COLLEGE STATION, 1949-1955

Variety	Yield, pounds per acre					
	1949	1950	1952	1953	1955	Average, 1950, 1952, 1955
			Green matter			
Hairy vetch		11,720	12,820		8,740	11,093
Willamette vetch		6,690	4,370	4,760	10,150	7,070
Dixie Wonder peas	3,260	7,340	14,470	5,740	14,310	12,040
			Air-dry matter			
Hairy vetch		2,250	2,440		2,250	2,313
Willamette vetch		950	960	690	2,260	1,390
Dixie Wonder peas	520	1,440	2,390	900	2,590	2,140

in 1950, 1952 and 1955; Hairy vetch yielded 11,093 pounds; and Willamette vetch made 7,070 pounds, Table 5.

In 1950, 1952 and 1955 Hairy vetch contained, on the average, 22.0 percent of air-dry matter; Willamette vetch, 21.5 percent; and Dixie Wonder peas, 18.1 percent, Table 6.

On the average, Hairy vetch had a slightly higher percentage of nitrogen than Willamette vetch or Dixie Wonder peas, Table 7.

These results possibly indicate that Dixie Wonder peas would be a more dependable soil-improving crop for corn than Hairy vetch or Willamette vetch because it was a more consistent yielder. But there are other factors to consider. During the 7 years of the experiment, Hairy vetch produced a total of 33,280 pounds of green matter per acre, Willamette vetch 25,970 pounds and Dixie Wonder peas 45,120 pounds. During the experiment the tops of Hairy vetch added 263 pounds of nitrogen per acre to the soil, Willamette vetch added 168 pounds and Dixie Wonder peas 261 pounds.

These data reveal the hazards and difficulties involved in the use of winter annual legumes as soil-improving crops for corn. The lack of rainfall in the fall frequently delays preparation of the land for seeding legumes. Freezing temperatures in the winter and lack of rainfall may result in low yields of green matter or a total failure. Rains occurring at the time the legumes should be turned under in late winter may delay turning, and consequently delay corn planting.

TABLE 6. PERCENTAGE OF AIR-DRY MATTER IN TOPS OF LEGUMES WHEN PLOWED UNDER AT COLLEGE STATION, 1949-55

Legume	1949	1950	1952	1953	1955	Average, 1950, 1952, 1955
Hairy vetch		21.4	19.0		25.7	22.0
Willamette vetch		20.4	22.0	14.5	22.2	21.5
Dixie Wonder peas	16.0	19.6	16.5	15.7	18.1	18.1

TABLE 7. PERCENTAGE OF NITROGEN IN AIR-DRY MATTER IN TOPS OF LEGUMES WHEN PLOWED UNDER AT COLLEGE STATION, 1949-55

Legume	1949	1950	1952	1953	1955	Average, 1950, 1952, 1955
Hairy vetch		4.01	3.75		3.63	3.80
Willamette vetch		3.89	3.20	4.55	3.04	3.38
Dixie Wonder peas	3.33	3.61	3.06	4.17	3.14	3.27

In this experiment the use of Hairy vetch, Willamette vetch and Dixie Wonder peas as green-manure crops for corn was not profitable or practical.

COTTON AND CORN IN ROTATION ON THE UPLAND FARMS

This experiment was conducted on the Upland Farms at College Station for 7 years, 1949-55. The objectives of the work were to determine the soil-building value of Austrian winter peas, Dixie Wonder peas, Singletary peas, Willamette vetch and Hairy vetch for cotton in a 2-year rotation of cotton and corn and to determine whether there is any residual effect of legumes and fertilizer on the yield of corn. The work was conducted on Lufkin fine sandy loam.

The work involved the growing of winter legumes preceding cotton in a 2-year rotation with corn in which the legume was grown each year. The legumes were inoculated and planted as early as possible each fall and 90 pounds of available phosphoric acid (P_2O_5) and 90 pounds of potash (K_2O) per acre were applied at planting (0-90-90). The legumes were plowed under in the spring and followed by cotton. Corn followed the cotton the second year and received only the residual effects of the legumes and fertilizer except where nitrogen was applied to the corn. The work was started in the fall of 1948, with legumes being planted on half of the land. The legumes were turned under in the spring of 1949 and cotton planted on the land. Corn was planted on the half of the land on which no legumes were planted.

To determine the residual effects of legumes and fertilizer on the yield of corn, two plots of each legume were established in each replication. Each plot received a 0-90-90 fertilizer per acre when the legumes were planted; in the second

TABLE 8. POUNDS OF NITROGEN PER ACRE IN TOPS OF LEGUMES WHEN PLOWED UNDER AT COLLEGE STATION, 1949-55

Legume	1949	1950	1952	1953	1955	Average, 1950, 1952, 1955
Hairy vetch		90	91		82	88
Willamette vetch		37	31	31	69	46
Dixie Wonder peas	17	52	73	38	81	69

year when the plots were planted to corn one plot received a total of 60 pounds of nitrogen per acre, 30 pounds at planting and 30 pounds as a sidedressing. The other plot received no nitrogen.

The following legume and fertility treatments were used:

1. Hairy vetch fertilized with 0-90-90.
2. Hairy vetch fertilized with 0-90-90; 60 pounds of nitrogen per acre applied to corn the second year.
3. Austrian Winter peas fertilized with 0-90-90.
4. Austrian Winter peas fertilized with 0-90-90; 60 pounds of nitrogen per acre applied to corn the second year.
5. Willamette vetch fertilized with 0-90-90.
6. Willamette vetch fertilized with 0-90-90; 60 pounds of nitrogen per acre applied to corn the second year.
7. Dixie Wonder peas fertilized with 0-90-90.
8. Dixie Wonder peas fertilized with 0-90-90; 60 pounds of nitrogen applied to corn the second year.
9. Singletary peas fertilized with 0-90-90.
10. Singletary peas fertilized with 0-90-90; 60 pounds of nitrogen applied to corn the second year.
11. Fertilizer, 60-90-90 applied to cotton.
12. Fertilizer, 60-90-90 applied to cotton; 60 pounds of nitrogen per acre applied to corn the second year.
13. Check, 0-90-90 applied to cotton.
14. Check, 0-90-90 applied to cotton; 60 pounds of nitrogen per acre applied to corn as sidedressing the second year.

Yield of Cotton

The results obtained with cotton during 1949-55 are given in Table 9. Excellent yields for Lufkin soil were reported only in 1955, when the average yield for the seven treatments was 631 pounds of lint per acre. This high yield was due partially to the two irrigations of 2 inches each, applied July 11 and August 8. Good yields, averaging more than 400 pounds of lint per acre, were obtained in 1949, 1953 and 1954. The lowest yields were reported in 1951-52.

Moisture was the first limiting factor in yields in 1951-52 as indicated by the low rainfall in June, July and August, Table 2. Moisture also probably restricted yields in 1950, 1953 and 1954. Two irrigations were applied in 1954, but irrigation facilities did not become available until the cotton was wilting.

Barely significant differences in yields between treatments were found only in 1949 and 1953. No significant differences in the average yields of the several treatments were found for the 7 years. Highly significant differences in yields, however, occurred between years.

From these results it is difficult to reach definite conclusions regarding the relative value of the several treatments, especially the legumes. The results seem to indicate that the legumes furnished enough nitrogen for cotton yields up to 1 bale per acre (500 pounds of lint). The 60-90-90 treatment produced the highest average yield, 387 pounds of lint per acre, or only 22 pounds more than the low yield of 365 pounds for the 0-90-90 treatment. This small difference in yield would hardly justify the cost of purchasing and applying 60 pounds of nitrogen.

Since there were no untreated check plots in the experiment, it is not possible to determine the real effect of the 0-90-90 fertilizer, which was the basic treatment on every plot. Previous work on the same soil, however, showed that the soil responded to applications of nitrogen, phosphorus and potash for cotton.

Yield of Corn

The yields of corn in this experiment were erratic and varied from year to year, depending on the amount and distribution of rainfall during the fruiting and ripening periods. The yields ranged from about 50 bushels per acre in 1950 to

TABLE 9. YIELD OF COTTON FOLLOWING LEGUMES FOR SOIL IMPROVEMENT AT COLLEGE STATION, 1949-55

Treatment	Pounds of lint per acre							
	1949	1950	1951	1952	1953	1954	1955	Average
Hairy vetch	452	265	278	202	397	380	671	378
Willamette vetch	389	262	254	192	399	395	615	356
Austrian Winter peas	407	295	254	197	398	390	656	371
Dixie Wonder peas	391	282	251	194	404	380	613	359
Singletary peas	449	277	274	199	413	404	684	386
60-90-90	392	288	266	202	485	444	631	387
0-90-90	387	300	251	201	440	425	548	365
Average	410	281	261	198	419	403	631	372
L.S.D.: .05	51	NS	NS	NS	82	NS	NS	NS
.01	70	NS	NS	NS	150	NS	NS	NS

TABLE 10. YIELD OF CORN GROWN IN ROTATION WITH COTTON FOLLOWING LEGUMES AT COLLEGE STATION, 1950-55

Treatment	Yield bushels per acre						
	1950	1951	1952	1953	1954	1955	Average
Hairy vetch[1]	53.2	8.0	6.0	20.6	5.2	42.6	22.6
Hairy vetch	39.1	9.4	12.0	19.6	8.9	42.6	21.9
Willamette vetch[1]	47.6	5.1	4.5	16.6	9.9	45.5	21.5
Willamette vetch	33.2	8.7	17.1	19.3	10.6	35.1	20.7
Austrian Winter peas[1]	47.8	7.0	9.9	16.8	5.7	44.7	22.0
Austrian Winter peas	32.4	7.4	9.3	18.1	9.0	41.9	19.7
Dixie Wonder peas[1]	47.1	7.0	9.2	20.4	8.0	45.0	22.8
Dixie Wonder peas	30.2	11.3	10.2	18.7	8.8	40.5	20.0
Singletary peas[1]	51.1	6.2	9.5	19.6	5.9	42.9	22.5
Singletary peas	34.8	8.4	8.9	20.3	8.0	43.4	20.6
60-90-90[1]	45.4	9.0	13.9	16.0	11.1	42.9	23.0
60-90-90	40.6	6.3	8.1	17.1	6.4	46.1	20.8
0-90-90[1]	55.2	7.2	10.8	17.9	9.4	45.3	24.3
0-90-90	33.2	8.7	12.6	18.2	9.3	29.1	18.5
Average							
Nitrogen	49.6	7.1	9.1	18.3	7.9	44.1	22.7
No nitrogen	34.8	8.6	11.2	18.8	8.7	39.8	20.3
L.S.D. for nitrogen: .05	4.9	NS	NS	NS	NS	2.41	1.45
.01	7.4	NS	NS	NS	NS	3.30	1.95

[1]These plots received 60 pounds of nitrogen per acre, 30 pounds at planting and 30 pounds as a sidedressing.

5 bushels in 1951, Table 10. A yield of 50 bushels per acre is excellent and unusual on Lufkin soil. The good yields in 1950 resulted from fairly adequate and well-distributed rainfall in April, May, June and July. Some individual plots produced yields of about 70 bushels per acre. The yield in 1950 might have been limited by the amount of nitrogen and not by moisture.

The low yields in 1951-52 were caused by deficient rainfall in June and July, when the corn needed large amounts of water. The low rainfall and the low water-holding capacity of the Lufkin fine sandy loam emphasize the difficulties of producing satisfactory yields of corn on this soil. About normal yields for Lufkin soil were obtained in 1953 and low yields resulted in 1954. An average yield of about 42 bushels per acre was obtained in 1955.

Effect of Nitrogen

The application of 60 pounds of nitrogen per acre produced highly significant increases in yield of corn in 1950 and 1955 and the average yield during 1950-55. In 1951-54 the corn that received nitrogen produced slightly lower yields than the corn that did not receive nitrogen. Thus, nitrogen actually reduced the yield of corn because it produced larger vegetative growth, which depleted the small amount of available water in the soil more rapidly than the corn which did not receive nitrogen. This small margin of water in the soil on the plots that did not receive nitrogen resulted in a slightly higher yield on these plots.

The results obtained during 1950-55 show that nitrogen increased the yield of corn in years of favorable rainfall, but not in years of deficient rainfall.

Effect of Legumes and Fertilizer

Significant differences in yield of corn among the legume and fertilizer treatments occurred only in 1950 and 1955, Table 10. There were, however, marked differences in yields among years.

TABLE 11. YIELD IN POUNDS PER ACRE OF GREEN AND AIR-DRY MATTER OF LEGUMES AT COLLEGE STATION, 1949-54[1]

Variety	1949	1950	1952	1953	1954	Average 1949-54	Average 5 years[2]
				Green matter			
Hairy vetch	7,240	12,990	14,410	16,970	8,110	9,953	11,944
Willamette vetch	4,830	8,020	5,280	14,410	6,080	6,437	7,724
Austrian Winter peas	8,530	12,400	13,280	21,000	8,260	10,578	12,694
Dixie Wonder peas	6,470	9,340	12,340	22,920	8,190	9,877	11,852
Singletary peas	4,480	14,000	9,430	7,590	4,370	6,645	7,974
				Air-dry matter			
Hairy vetch	1,670	2,780	3,530	2,730	1,650	2,060	2,472
Willamette vetch	990	1,630	1,160	2,090	1,480	1,225	1,470
Austrian Winter peas	1,450	2,200	1,930	2,770	1,510	1,643	1,972
Dixie Wonder peas	1,050	1,840	2,040	3,600	1,500	1,672	2,006
Singletary peas	840	2,430	1,910	1,200	850	1,205	1,446

[1]The legumes did not make enough growth in the winter of 1950-51 to obtain yields. Yields are given to the nearest 10 pounds.
[2]Average for 1949, 1950, 1952, 1953 and 1954.

TABLE 12. PERCENTAGE OF AIR-DRY MATTER IN THE TOP GROWTH OF LEGUMES AT COLLEGE STATION, 1949-54

Legume	1949	1950	1952	1953	1954	Average
Hairy vetch	23.1	21.4	24.5	16.1	20.3	21.1
Willamette vetch	20.4	20.4	22.0	14.5	24.3	20.3
Austrian Winter peas	17.0	17.7	14.5	13.2	18.3	16.1
Dixie Wonder peas	16.2	19.7	16.5	15.7	18.3	17.3
Singletary peas	18.8	17.4	20.3	15.8	19.5	18.4

Yield and Nitrogen Content of Legumes

Good yields of forage were obtained in only 3 of the 7 years, 1950, 1952 and 1953. Medium to low yields were obtained in 1949 and 1954. The legumes did not make enough growth in the fall and winter of 1950-51 to determine yield. They made fair growth in 1955, but through uncontrollable circumstances, yields of forage were not obtained.

Austrian Winter peas made the highest average yield of green matter, 12,694 pounds per acre, for the 5 years in which yields were obtained, Table 11. Hairy vetch and Dixie Wonder peas ranked next in yield of green matter.

Hairy vetch made the highest average yield of air-dry matter, 2,472 pounds, as compared with 2,006 pounds of Dixie Wonder peas, Table 11.

The percentage of air-dry matter varied widely among the five legumes and from year to year, Table 12. Hairy vetch had the highest average percentage for the period, 21.1. Austrian Winter peas had the lowest percentage, 16.1.

The percentage of nitrogen also varied considerably among the legumes and in different years, Table 13. During 1949-54, Hairy vetch had the highest average nitrogen content, 4.06 percent of nitrogen in the air-dry tops. Dixie Wonder peas had the lowest percentage of nitrogen, 3.51.

Hairy vetch supplied more nitrogen per acre than the other legumes because of its good yield of green matter, high percentage of air-dry matter and high percentage of nitrogen, Table 14. For the 5 years, its tops contained, on the average, 101 pounds of nitrogen per acre. Willamette vetch and Singletary peas each supplied the lowest amount of nitrogen, 57 pounds per acre.

This experiment as a whole, including the yield of cotton and the yields and nitrogen content of the legumes, indicates that Hairy vetch, Dixie

TABLE 13. PERCENTAGE OF NITROGEN IN AIR-DRY MATTER IN TOP GROWTH OF LEGUMES AT COLLEGE STATION, 1949-54

Legume	1949	1950	1952	1953	1954	Average
Hairy vetch	3.68	4.01	4.05	4.51	4.06	4.06
Willamette vetch	3.38	3.89	3.20	4.55	3.78	3.76
Austrian Winter peas	3.06	4.05	4.80	4.44	3.62	3.99
Dixie Wonder peas	3.36	3.61	3.06	4.17	3.37	3.51
Singletary peas	3.71	3.62	4.21	4.28	3.66	3.90

TABLE 14. POUNDS OF NITROGEN PER ACRE IN TOPS OF LEGUMES AT COLLEGE STATION, 1949-54

Legume	1949	1950	1952	1953	1954	Average
Hairy vetch	62	112	143	123	67	101
Willamette vetch	33	64	37	95	56	57
Austrian Winter peas	44	89	92	123	55	81
Dixie Wonder peas	35	68	62	150	51	73
Singletary peas	31	92	81	51	31	57

Wonder peas and Austrian Winter peas are more dependable soil-improving crops for cotton on Lufkin and similar soils than Singletary peas and Willamette vetch.

CORN ON THE A&M PLANTATION

Two experiments with legumes in several cropping systems with corn were conducted on the A&M Plantation near College Station during 1950-53. One experiment involved continuous corn, corn and Dixie Wonder peas, and corn in rotation with *Melilotus indica*, Hubam and Madrid sweetclovers, and alfalfa. In the other experiment, continuous corn, with and without nitrogen, and corn in a 2-year rotation with *Melilotus indica*, with and without nitrogen applied to the corn at planting, were tested in two separate row systems.

Dixie Wonder peas, *Melilotus indica*, Hubam and Madrid sweetclovers, used as fall-seeded annuals were planted during the last week in September, or as soon thereafter as weather conditions permitted. Dixie Wonder peas were planted in a drill on each side of the bed as the land was bedded in the fall. The peas were turned under as green manure in the spring at the time the corn was planted. Ordinarily, no previous treatment of the pea vines was necessary to prepare them for being turned under.

The fall-seeded sweetclovers were close-drilled on flatland and were turned under the following spring as they reached the early bloom stage. For *Melilotus indica*, this was about the middle of April, for Hubam the first week in May and for Madrid about the middle of May. However, it was not unusual for Hubam and fall-

TABLE 15. RAINFALL IN INCHES AT THE A&M PLANTATION NEAR COLLEGE STATION, 1950-53, AND 16-YEAR AVERAGE

Month	1950	1951	1952	1953	Average 1950-53	Average 1941-56
January	1.30	0.82	3.17	1.86	1.79	2.71
February	4.23	2.20	4.20	2.77	3.35	2.97
March	2.24	4.91	1.71	2.43	2.82	2.92
April	6.96	.86	4.95	8.15	5.23	3.63
May	5.11	3.60	8.14	10.87	6.93	5.54
June	6.22	1.95	.54	4.44	3.29	3.67
July	4.42	1.40	2.74	3.04	2.90	2.71
August	.06	1.50	0.0	3.28	1.21	2.97
September	2.80	6.72	2.06	3.12	3.67	2.75
October	.50	.92	0.0	5.55	1.74	2.32
November	.39	2.35	8.48	2.39	3.40	2.92
December	.21	1.28	5.53	4.66	2.92	3.27
Total	34.44	28.51	41.52	52.56	39.26	38.39

seeded Madrid to be turned under at the same time.

Spring-seeded Madrid, used as an annual, was planted in close drills on flatland during late February or early March and was turned under for green manure the following September. Spring-seeded Madrid, used as a biennial, was left to grow through the second spring and was turned under for green manure when it reached the early bloom stage.

Alfalfa was close-drilled in the fall on plowed land and was harvested for hay for two summers; then the residue was plowed under early in the second September.

The legumes were seeded at the rate of 30 pounds of inoculated seed per acre and were fertilized with 60 pounds of phosphoric acid (P_2O_5) in 300 pounds per acre of 20 percent superphosphate in a band to the side and slightly below the seed drill at planting.

Texas 24 corn was planted as near March 10 each year as the weather permitted. Nitrogen was used as an experimental variable. It was applied in a band 3 to 5 inches to the side and 2 to 3 inches below the corn at planting. Sixty pounds of nitrogen in the form of ammonium nitrate were used. The southern corn rootworm was controlled by applying 5 pounds per acre of 40 percent chlordane dust in the corn seed-furrow.

Light infestations of Johnsongrass, typical of fields of Miller clay soil in the vicinity of College Station, occurred on the area at the start of the tests. These infestations increased in the various cropping systems under test. Usually, the longer the soil-improving crop was left on the land before it was turned under, the more the Johnsongrass spread. Alfalfa for hay was a poor competitor with Johnsongrass. Apparently, the spread of Johnsongrass interfered with the maximum soil-improving effects of alfalfa in cropping systems in which this crop was grown.

Soils and Rainfall

This work was conducted on Miller clay soil, an extensive alluvial soil in the Brazos River bottom. Miller clay is very productive when well drained. Although cotton is the main crop grown, the soil is well adapted to many other crops, such as corn, alfalfa and sweetclovers. Previous work has shown that this soil is relatively low in nitrogen and responds to applications of nitrogen. The results of these experiments should be applicable to Miller and associated soils in the Brazos River bottom from Waco southward and probably to the same soils along the Colorado River east of Austin.

Monthly rainfall during the 4 years of the experiments, 1950-53, and the average for the 16 years, 1941-56, are given in Table 15. The average rainfall for these two periods is practically the same as the 65-year average at the Upland Farms, College Station.

Yield of Corn in Different Cropping Systems

The soil-improving crops used in this test were Dixie Wonder peas as winter green manure between annual crops of corn; fall-seeded *Melilotus indica,* Hubam and Madrid sweetclovers in separate 2-year rotations with corn; and fall-seeded alfalfa and spring-seeded Madrid in separate 3-year rotations with corn. Table 16 shows the cropping systems, the average yields of green manure preceding the corn crop and corn yields obtained.

Dixie Wonder peas as a winter green-manure crop between annual crops of corn increased the 3-year average yield of corn for 1951-53 approximately 24 percent above that of continuous corn not preceded by a legume.

Fall-seeded *Melilotus indica,* Hubam and Madrid sweetclovers in 2-year rotations with corn increased the 3-year average yield of corn 67, 73 and 85 percent, respectively, above that of continuous corn not preceded by a legume. Fall seeding was significantly superior to spring seeding when Madrid sweetclover was used in a 2-year rotation with corn.

Corn preceded by 2 years of Madrid sweetclover yielded 86 percent more per acre than continuous corn not preceded by a legume during

TABLE 16. YIELD OF SHELLED CORN PER ACRE IN CROPPING SYSTEMS WITH LEGUMES AT THE A. & M. PLANTATION NEAR COLLEGE STATION, 1950-53

Cropping system	Average pounds green tops turned under, 1951-52	Bushels per acre				Average	
		1950	1951	1952	1953	1950-53	1951-53
Continuous corn after							
No green manure		27.9	41.5	40.7	26.5	34.1	36.2
Dixie Wonder peas	9,236	43.3	47.9	47.6	39.3	44.5	44.9
2-year rotation, corn after 1 year of							
Fall-seeded Melilotus indica	38,539	78.1	62.4	65.2	54.0	64.9	60.5
Fall-seeded Hubam sweetclover	56,525	73.4	70.1	72.1	45.5	65.3	62.6
Spring-seeded Madrid sweetclover	24,943	70.9	58.2	67.1	43.3	59.9	56.2
Fall-seeded Madrid sweetclover	37,022	74.1	70.6	78.7	52.0	68.8	67.1
3-year rotation, corn after 2 years of							
Spring-seeded Madrid sweetclover	35,940		80.6	74.0	47.8		67.5
Fall-seeded alfalfa for hay	10,481		67.2	63.4	50.3		60.3
L.S.D.: .05		12.2	13.4	13.1	11.5	5.6	6.4
.01		16.9	18.5	17.8	15.6	7.5	8.5

the 3-year period 1951-53. It also significantly outyielded corn preceded by winter peas and 2 years of alfalfa for hay.

Corn preceded by 2 years of alfalfa for hay produced 66.6 percent more than continuous corn not preceded by a legume during 1951-53. It also outyielded corn preceded by winter peas, but did not produce a significantly greater yield than the other legume cropping systems.

The advantage of 2 years of Madrid sweetclover over 2 years of alfalfa for hay in increasing corn yields may have been due partly to the superiority of Madrid in competing with Johnsongrass infestations.

Effect of Row Systems on Yield of Corn

Two systems of rows were used in growing corn. Every row was planted to corn in one system, which is the row system used for growing corn in most sections of Texas. Alternate pairs of rows were planted to corn in the other system. These were rotated with the adjacent pair of rows from one season to another. Continuous corn and corn in a 2-year rotation with *Melilotus indica* were studied in each row system. Half of each plot planted to corn each year was fertilized with 60 pounds of nitrogen per acre and the other half of the plot received no nitrogen. Table 17 shows the treatments used, the 3-year average yield of green manure preceding the corn and the yield of corn obtained.

All the land devoted to each of the cropping systems in this test contributed to the yield of corn each year except for the 2-year corn-*indica* rotation in which all corn rows were planted. Two years were required for all the land in this rotation to produce a corn crop. For this reason the yield of corn for a 2-year period, as given in the last column of Table 17, is used to show the relative merit of the various corn-producing systems. On this basis, the highest yield was obtained by planting corn on every row and fertilizing it with 60 pounds of nitrogen per acre. This system produced a total of 112.6 bushels on an acre in 2 years. The next highest yield was 79.2 bushels obtained from corn planted in alternate pairs of rows in the corn-*indica* rotation without nitrogen fertilization.

Rotating alternate pairs of corn rows with *Melilotus indica* produced approximately the same yield as fertilizing alternate pairs of corn rows with 60 pounds of nitrogen per acre. The use of nitrogen fertilizer in rotations of corn with *Melilotus indica* did not increase the average yield of corn, irrespective of the row system used. This indicates that *Melilotus indica* furnished enough nitrogen for corn or brought about other favorable conditions for good yields.

CORN AT DENTON

Previous work conducted with several legumes at Denton showed that sweetclovers were well adapted for forage and soil improvement in the area. The work was revised and expanded in 1949 to evaluate more fully the sweetclovers and winter peas as soil-improving crops for corn.

Cropping Systems

The experiment included Austrian Winter peas, Dixie Wonder peas, Hubam sweetclover and Madrid sweetclover in several cropping systems with corn. The following cropping systems were used:

1. Corn every year.
2. Corn every year with Austrian Winter peas for green manure.
3. Corn every year with Dixie Wonder peas for green manure.
4. Corn in a 2-year rotation with Hubam sweetclover for green manure.

TABLE 17. YIELD OF CORN PLANTED IN EVERY ROW AND IN ALTERNATE PAIRS OF ROWS IN CROPPING SYSTEMS ON MILLER CLAY SOIL AT THE A&M PLANTATION NEAR COLLEGE STATION, 1950-53

Treatments				Bushels, shelled corn per acre					
Rows in corn	Crops	Pounds, nitrogen per acre	Average pounds green tops turned under, 1950-52	1950	1951	1952	1953	Average	Bushels of corn produced on an acre in 2 years[1]
Every row	Corn	None		39.0	33.5	39.9	23.3	33.9	67.8
	Corn	60		73.7	57.1	54.1	40.3	56.3	112.6
	Corn-indica	None	32,834	92.2	70.4	62.1	45.3	67.5	67.5
	Corn-indica	60	33,269	92.6	64.7	64.4	44.0	66.4	66.4
Alternate pairs	Corn	None		37.6	37.3	31.7	18.9	31.4	62.8
	Corn	60		52.1	40.2	38.4	25.3	39.0	78.0
	Corn-indica	None	16,901	55.6	39.5	39.6	23.6	39.6	79.2
	Corn-indica	60	17,530	48.0	42.8	39.2	25.1	38.8	77.6
L.S.D.: .05				7.1	8.0	7.9	4.8	3.4	
.01				9.7	10.9	10.8	6.6	4.6	

[1]Calculated by multiplying the average yields for 1950-53 by 2, except the yield for the corn-indica rotation where every row was planted.

5. Corn in a 2-year rotation with Hubam sweetclover for seed.

6. Corn in a 2-year rotation with Madrid sweetclover for green manure.

7. Corn in a 3-year rotation with Madrid sweetclover for seed.

Each crop in each cropping system appeared every year. In systems 2 and 3 the legumes were planted in the fall and turned under in late winter preceding corn. In systems 4 and 6, Hubam and Madrid sweetclovers were allowed to grow for 1 year and then turned under as green manure preceding corn. In systems 5 and 7 Hubam and Madrid sweetclovers were allowed to mature seed, which was harvested. The stubble was then turned under for soil improvement for corn.

Beginning in 1951, 60 pounds of nitrogen per acre was applied to one-half of each plot of corn to determine the effect of additional nitrogen on the yield of corn. Since legumes add nitrogen to the soil and may condition it, this treatment was included to evaluate the source of legume benefits.

The treatments were laid out in randomized blocks and replicated four times.

Soils and Rainfall

The work was conducted on Denton clay at Substation No. 6, Denton, in the Grand Prairie. Denton soils, where the surface layers are deep, are moderately productive. These soils are drouthy, especially on the shallow and more steeply sloping areas, where runoff is rapid. On such areas the thin subsoil layers do not afford a large storage of moisture. Denton clay is well suited to cotton, corn, small grains, sorghums, sweetclovers and a few other crops. Good yields of these crops are obtained under favorable moisture conditions. The results of the work conducted on Denton clay at Denton should be applicable generally to this soil and similar soils throughout the Grand Prairie.

The monthly rainfall at Denton for the 7 years, 1949-55, and the monthly average rainfall for 43 years are given in Table 18. The rainfall for 5 of the 7 years was considerably below the 43-year average. April, May and June have more rainfall than the other months.

Yield of Corn

The yield of corn fluctuated from year to year, depending largely on the amount of rainfall in May, June and July. The yields in Table 19 and the rainfall data in Table 18 indicate that the amount of rainfall in June probably was the most decisive factor in corn production. Corn usually was flowering and fruiting in June and used large amounts of soil moisture. The highest yields were obtained in 1950 and 1955 when good rains came in May and June. Distribution of rainfall apparently was a more critical factor than total rainfall.

The total rainfall in 1950 was slightly above the 43-year average of 32.25 inches, Table 18. The rainfall during the other 5 years ranged from about 3 to 10 inches below the 43-year average.

Effect of Legumes and Cropping Systems

There were no significant differences in the average yields of corn among the seven cropping systems during 1950-55, Table 19. Omitting 1950 and using 1951-55, the systems of Madrid sweetclover for green manure and Hubam sweetclover for seed produced significantly smaller average yields of corn than continuous corn. It would appear that the differences in plow-up dates of the legumes brought about these differences in yield. Significant differences also occurred among the yields of corn in the other five cropping systems.

The yields of corn given in Table 19 indicate that Denton clay without any legume or fertilizer treatment is capable of producing about 48 bushels of corn per acre with adequate moisture and other favorable growing conditions. Hubam and Madrid sweetclovers increased the yield from

TABLE 18. MONTHLY AND YEARLY RAINFALL IN INCHES AT SUBSTATION NO. 6, DENTON

Month	1949	1950	1951	1952	1953	1954	1955	Average 1949-55	Average 43 years
January	5.11	4.54	.59	.54	.34	1.92	1.23	2.04	2.05
February	3.05	2.20	2.29	2.00	1.07	.20	1.76	1.80	2.20
March	2.76	.96	.81	2.41	2.86	.73	1.47	1.71	2.27
April	.92	4.09	1.67	6.46	4.59	2.82	1.83	3.20	3.76
May	7.50	5.95	3.28	4.30	4.73	3.93	5.53	5.03	4.62
June	3.85	4.45	5.82	.30	2.09	3.11	5.66	3.61	3.14
July	2.44	5.83	1.60	1.69	2.66	.68	1.10	2.29	2.03
August	2.41	2.36	.64	.34	1.78	1.59	.84	1.42	2.33
September	4.88	3.98	2.49	.27	1.15	1.83	2.36	2.42	2.42
October	6.11	.14	2.06	.08	3.76	3.07	.76	2.28	2.98
November	.00	.05	1.17	5.07	3.15	.78	.10	1.47	2.13
December	1.84	.04	.36	2.18	1.07	1.86	.70	1.15	2.32
Total	40.87	34.59	22.78	25.64	29.25	22.52	23.34	28.42	32.25

about 47 bushels to 57 or 63 bushels per acre in 1950; under those particular conditions the legumes added enough nitrogen or brought about other conditions in the soil that increased the yield 10 to 15 bushels per acre. During the other 5 years of the experiment the conditions were not favorable enough to produce 48 bushels of corn per acre. Moisture and not nitrogen was the first limiting factor in corn yields. Three of the legume cropping systems apparently reduced the yield of corn, as compared with the yield of continuous corn.

Two factors apparently influenced the failure of legumes to increase the corn yield. First, winter legumes usually must be turned under to prepare a seedbed before they produce sufficient organic matter and nitrogen to have a significant effect on yield of corn. Second, legumes deplete the moisture reserves in the soil to such an extent that the yield of corn is depressed or is not affected in years having below average rainfall. Further, the difficulty of establishing good stands of legumes, the high seed cost and low corn yields following the legumes in this experiment do not justify the use of legumes solely as soil-improving crops on the soils of the Denton series.

Effect of Nitrogen

The application of 60 pounds of nitrogen per acre had no appreciable effect on the average yields of corn in the several cropping systems during 1951-55. The plots that received nitrogen made an average yield of 21.2 bushels and the plots that did not receive nitrogen produced 20.4 bushels, Table 19. In 1951, however, nitrogen produced a marked increase in the yield of corn. This indicates that in years with good rainfall in May, June and July, application of nitrogen probably would be beneficial.

DISCUSSION OF RESULTS

The results of these experiments show the limitations of using legumes as green-manure crops under limited rainfall and the relation of corn yields to the amount and distribution of rainfall. The lack of adequate soil moisture was the most critical or decisive factor in corn and cotton yields at College Station and corn yields at Denton. The distribution of rainfall during the fruiting and ripening period had more influence on yield of corn than total yearly rainfall.

The intensity of rainfall also is an important factor, especially on the Lufkin soils. The surface of the Lufkin soil seals over under high rainfall intensities and slows down the infiltration rate. This causes large amounts of water to be lost as surface runoff. At lower intensities runoff may occur as a result of the low infiltration rate.

The legume cropping systems increased the average yield of corn 24 to 86 percent above that of continuous unfertilized corn at the A&M Plantation. Their use, however, could hardly be justified in view of the good yields obtained by fertilizing continuous corn with 60 pounds of nitrogen per acre each year.

Legumes used for green manure consume large amounts of water in their growth. Where soil moisture is a limiting factor in plant growth, legumes will use some water that otherwise would be available for corn and cotton. This leaves the soil dry at planting time and the corn or cotton

TABLE 19. YIELD OF CORN IN CROPPING SYSTEMS AT DENTON, 1950-55

Cropping system	Bushels per acre[1]						Average	
	1950[2]	1951	1952	1953	1954	1955	1950-55	1951-55[1]
Corn continuously	47.6	26.4	7.2	6.0	33.6	34.7	25.8	21.6
Corn and Austrian Winter peas	49.1	25.6	7.9	7.8	32.9	40.1	26.2	22.8
Corn and Dixie Wonder peas	47.2	20.8	5.1	5.6	31.0	35.7	23.7	19.6
Corn and Hubam sweetclover for green manure	57.4	30.6	12.4	8.9	33.0	31.3	29.1	23.2
Corn and Hubam sweetclover for seed	55.4	27.1	3.4	3.5	28.1	30.0	24.3	18.4
Corn and Madrid sweetclover for green manure	63.2	26.4	2.7	2.6	25.6	29.6	24.1	17.3
Corn and Madrid sweetclover for seed	57.1	34.8	8.1	5.7	30.9	34.0	28.8	22.7
L.S.D. for above treatments:								
.05 level	9.8	6.5	5.5	4.7	NS	6.1	NS	3.2
.01 level	13.5	8.6	7.4	6.4	NS	8.2	NS	4.9
Average yield for								
Nitrogen[3]		30.2	6.2	5.8	30.6	33.1		21.2
No nitrogen		24.6	7.1	5.6	30.7	34.0		20.4
L.S.D.: .05		2.4	NS	NS	NS	NS		NS
.01		3.2	NS	NS	NS	NS		NS

[1]Average of all treatments including nitrogen and no nitrogen for the cropping system.
[2]Nitrogen treatments were not made in 1950.
[3]Average of the 60-pound nitrogen treatment applied to all plots.

must depend entirely on the soil moisture made available through rainfall during the growing season. With the planting dates used at College Station and Denton, June was the most critical period in the growth of corn.

The effect of the green-manure crops on the chemical and physical properties of soil also should be considered. Chemical and physical studies were made in 1953-54 on the plots in the experiments on the Upland Farms at College Station. The legumes did not seem to influence materially the physical properties of the soil.[1] The plowing under of legumes, however, increased significantly the total nitrogen and nitrifying power of the soil.[2] The legume plots also contained significantly more available phosphoric acid than the plots receiving only fertilizer. Similar results were obtained in other work conducted on the same soil type at College Station during 1937-41 (7).

[1]Unpublished thesis entitled, "The Effect of Green Manuring with Winter Legumes on some Physical and Chemical Properties of Lufkin Fine Sandy Loam," Sibte Mehdi Naqvi, submitted to the Graduate School of the A. & M. College of Texas in partial fulfillment of the degree of Master of Science, January 1954.

[2]Unpublished thesis entitled, "Effect of Winter Annual Legumes on Certain Chemical Properties of Lufkin Fine Sandy Loam and on the Yield of Cotton," Jose Dula-Navarrete, submitted to the Graduate School of the A. & M. College of Texas in partial fulfillment of the requirements for the degree of Master of Science, January 1955.

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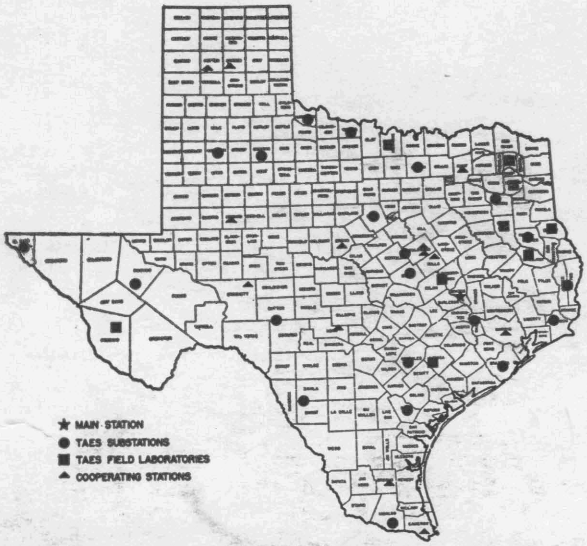

Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

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The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of ten parts of the Texas A&M College System

ORGANIZATION

IN THE MAIN STATION, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

OPERATION

THE TEXAS STATION is conducting about 400 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

- Conservation and improvement of soil
- Conservation and use of water
- Grasses and legumes
- Grain crops
- Cotton and other fiber crops
- Vegetable crops
- Citrus and other subtropical fruits
- Fruits and nuts
- Oil seed crops
- Ornamental plants
- Brush and weeds
- Insects
- Beef cattle
- Dairy cattle
- Sheep and goats
- Swine
- Chickens and turkeys
- Animal diseases and parasites
- Fish and game
- Farm and ranch engineering
- Farm and ranch business
- Marketing agricultural products
- Rural home economics
- Rural agricultural economics
- Plant diseases

Two additional programs are maintenance and upkeep, and central services.

Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service

AGRICULTURAL RESEARCH seeks the WHATS, the WHYS, the WHENS, the WHERES and the HOWS of hundreds of problems which confront operators of farms and ranches, and the many industries depending on or serving agriculture. Workers of the Main Station and the field units of the Texas Agricultural Experiment Station seek diligently to find solutions to these problems.

Today's Research Is Tomorrow's Progress