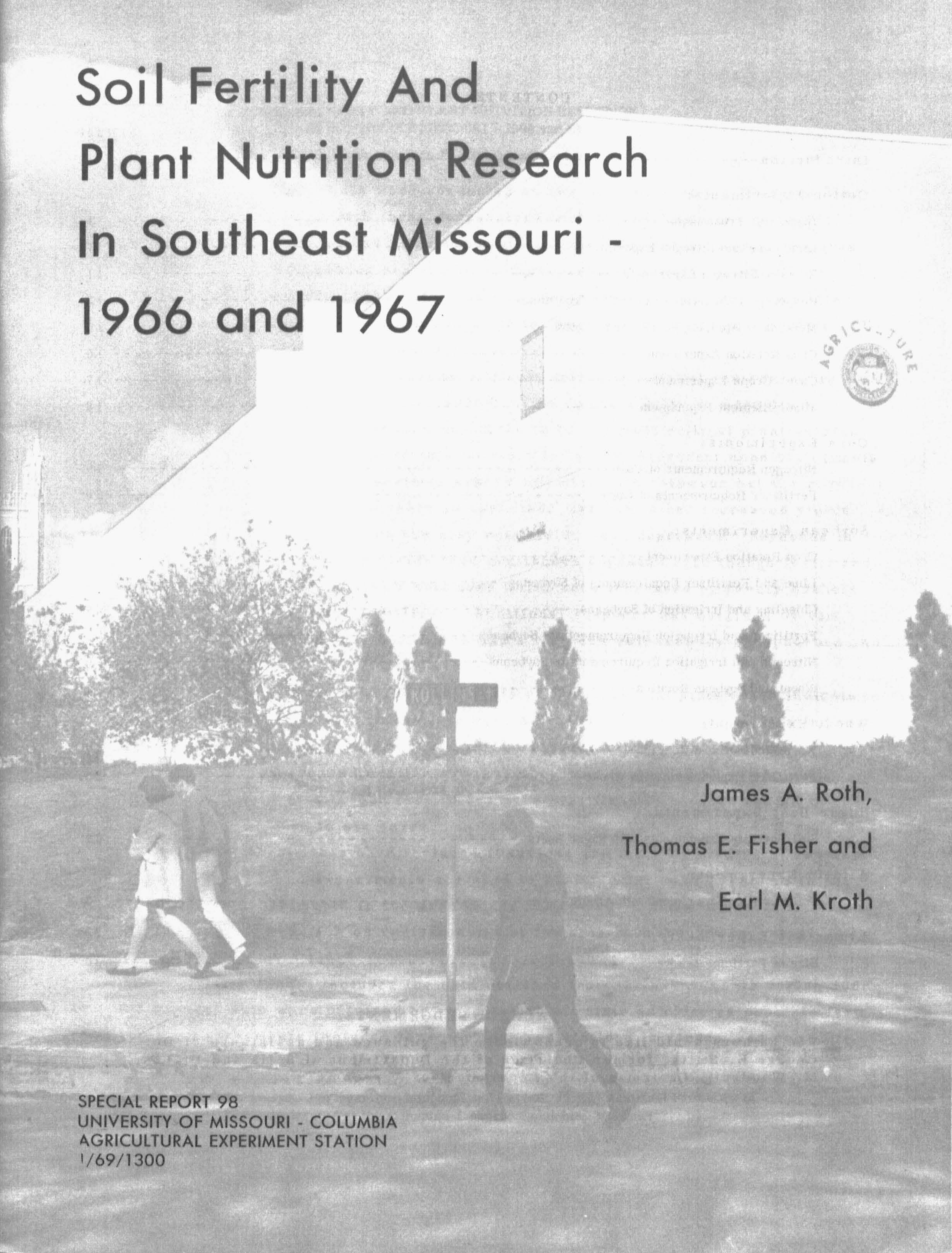

Soil Fertility And Plant Nutrition Research In Southeast Missouri - 1966 and 1967

James A. Roth,
Thomas E. Fisher and
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SPECIAL REPORT 98
UNIVERSITY OF MISSOURI - COLUMBIA
AGRICULTURAL EXPERIMENT STATION
1/69/1300

CONTENTS

ACKNOWLEDGEMENTS

The authors would like to acknowledge the guidance and assistance of Dr. George E. Smith, former Chairman of the Department of Soils and Dr. C. M. Woodruff, Chairman of the Department of Agronomy.

SOIL FERTILITY AND PLANT NUTRITION RESEARCH IN SOUTHEAST MISSOURI - 1966 and 1967

James A. Roth, Thomas E. Fisher and Earl M. Kroth(1)

Soil fertility experiments were conducted on two soil types at the Portageville Field, Clarkton Field, and with three cooperators in Southeast Missouri during 1966 and 1967. The various locations of experiments included the major soils of the area.

The 1966 and 1967 growing seasons were unfavorable for cotton production in Southeast Missouri with the 1967 production the lowest since 1909. The cold and wet seasons delayed planting and retarded maturity to the extent many fields of cotton in 1966 were not harvested after an early freeze.

The fertilization of cotton was very difficult during these past two years, as in many cases nitrogen fertilizers depressed yields due to a delay in maturity and failure of the bolls to open. Nitrogen continues to be the most critical plant nutrient in cotton production but response to this nutrient is largely dependent upon the climate.

Additional soil fertility experiments were initiated with soybeans but the response to fertilizer has not been as favorable as expected. Irrigation has increased yields on the loam and sandy soils but on the clay soil yields were depressed. Soybeans in a rotation have produced higher yields than continuous soybeans even though fertilized.

Yields of wheat on a silt loam soil near Qulin were increased by twenty bushels with the addition of phosphate fertilizer. Additional response was obtained by the application of limestone on this soil which had a very low soil test for phosphorous and a low pH.

Included in this report are 1967 soil tests of the individual plots which indicate the changes as a result of soil treatments over a period of years. These data indicate that the application of calcitic limestone has increased available phosphorous, decreased available potassium, decreased available magnesium, and increased pH of the soil. High application rates of nitrogen fertilizers have significantly reduced the pH of the soil over a period of five to six years.

Greenhouse experiments have included limestone and fertility studies of problem soils of the area. These experiments are used to hasten solution of problems in the field. Presently experiments in the greenhouse include rates and sources of limestone to determine rate of reaction on various soils of the area as measured by annual soil test.

The following report includes the data obtained from the experiments during 1966-67. All harvest data were obtained by machines to simulate as close as possible farm conditions. Experiments included three or four replications in randomized complete

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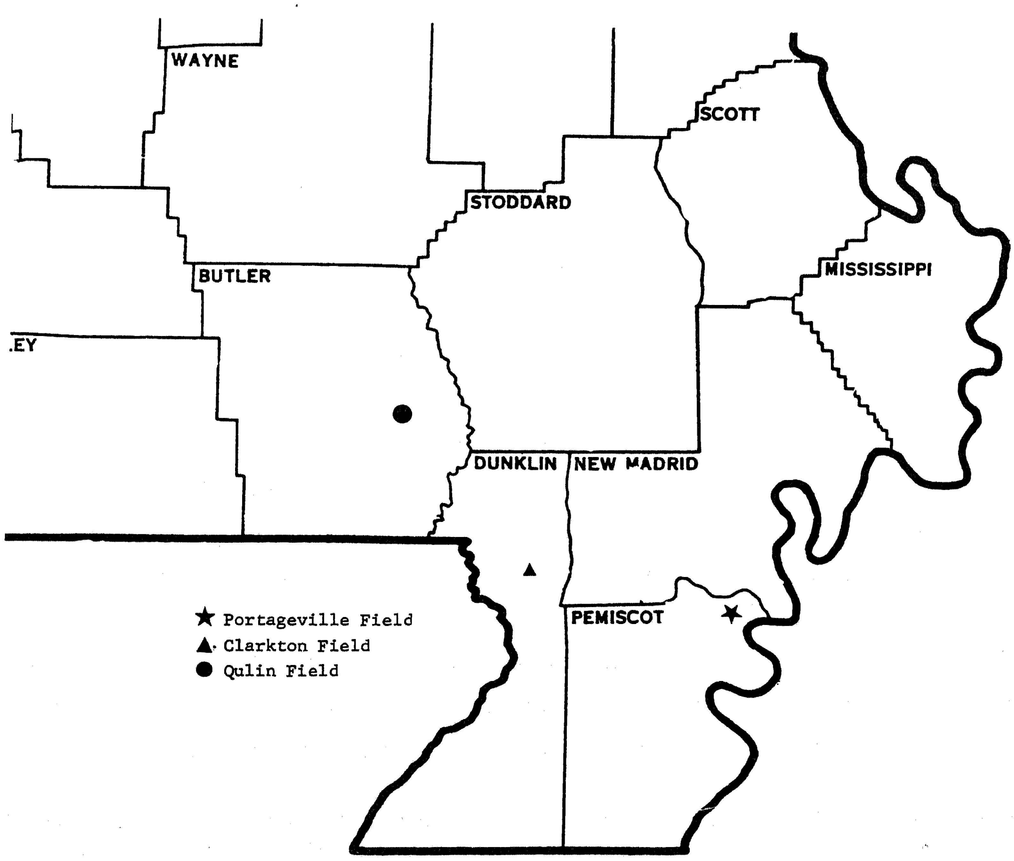
block design. Analysis of variance was calculated for each experiment and "L.S.D." or the "Duncan's Multiple Range Test" was used to determine significance at the 5% level.

These data are for only one year and no attempt has been made in this report to summarize over a period of years. In arriving at conclusions or practices to follow, the above fact must be considered. As experiments are terminated the data will be summarized and published in separate publications.

This report is a contribution of the Department of Agronomy's research projects as follows:

267 Cotton Fertilization
486 Limestone Needs
357 Soybean Fertilization
358 Soil Treatments for Alfalfa and Birdsfoot Trefoil
117 Crop Sequences
168 Corn Fertilization
492 Fertilization of Sugar Beets



Basic Soil Treatments on Cotton
1966-67 -- Experimental Results

Clarkton and Portageville Fields Initial Soil Test:	OM	P_2O_5	K	Mg.	ca	pH	H	C.E.C.	Soil Type
Clarkton	0.8	141	230	80	500	4.1	3.0	5.0	Sand
Portageville	1.9	224+	310	940	6000	5.6	2.0	21.5	Sharkey Clay

Soil Treatment: ** Plowdown $N+P_2O_5+K_2O$	Soil Treatment: Banded Annually $N+P_2O_5+K_2O$	1966 Pounds Seed Cotton Per Acre: Clarkton First Pick	Clarkton Total	Portageville-Clay First Pick	Portageville-Clay Total	1967 Bushels of Soybeans: Clarkton	Portageville-Clay
Plowdown x Annual Treatment							
None	100+ 0+ 0	1130 h	1614 g	Not harvested in 1966		41.3 g	32.2 abcd
None	100+50+50	1418 bcdefg	2093 cdef			43.9 fg	31.2 bcd
0+ 200+ 0	100+ 0+ 0	1205 fgh	1841 fg			47.4 bcdef	30.4 cd
0+ 200+ 0	100+50+50	1484 abcde	2247 abcde			50.3 abc	32.3 abcd
0+ 0+200	100+ 0+ 0	1235 efgh	1978 ef			47.8 bcde	34.2 abcd
0+ 0+200	100+50+50	1271 defgh	2132 bcdef			49.0 abcd	35.0 abc
0+ 100+200	100+ 0+ 0	1156 gh	1959 ef			47.3 bcdef	37.5 a
0+ 100+200	100+50+50	1209 fgh	2057 cdef			50.6 abc	36.4 ab
0+ 200+200	100+ 0+ 0	1297 cdefgh	2099 cdef			50.0 abc	33.6 abcd
0+ 200+200	100+50+50	1516 abcd	2443 ab			52.0 a	34.3 abcd
0+ 400+200	100+ 0+ 0	1428 bcdef	2014 def			44.9 efg	32.7 abcd
0+ 400+200	100+50+50	1644 ab	2244 abcde			46.7 cdef	33.8 abcd
0+1000+200	100+ 0+ 0	1123 h	1946 ef			49.5 abcd	29.3 d
0+1000+200	100+50+50	1405 bcdefg	2309 abcd			51.0 ab	31.5 bcd
0+ 200+100	100+ 0+ 0	1195 fgh	1900 fg			47.3 bcdef	33.5 abcd
0+ 200+100	100+50+50	1543 abc	2375 abc			49.1 abcd	35.9 abc
0+ 200+400	100+ 0+ 0	1166 fgh	1972 ef			47.3 bcdef	37.2 a
0+ 200+400	100+50+50	1290 cdefgh	2158 bcdef			50.0 abc	36.7 ab
0+ 100+100	100+ 0+ 0	1277 cdefgh	1896 fg			46.0 def	36.0 ab
0+ 100+100	100+50+50	1706 a	2519 a			49.9 abc	35.8 abc
0+ 400+400	100+ 0+ 0	1385 bcdefgh	1942 ef			41.6 g	32.0 abcd
0+ 400+400	100+50+50	1742 a	2535 a			47.0 bcdef	34.3 abcd
Minimum Least Significant Range(L.S.D.)(.05)		231	281			3.3	4.6
Maximum Least Significant Range(.05)		274	333			4.0	5.7
Coefficient of Variation		10.1%	7.9%			4.2%	8.3%
SUMMARY OF PLOWDOWN TREATMENTS							
Plowdown Phosphorous							
None		1274 de	1854 c			42.6 e	31.7 bc
0+ 200+ 0		1344 cde	2044 abc			48.9 ab	31.4 bc
0+ 0+200		1253 de	2055 abc			48.4 ab	34.6 ab
0+ 100+200		1182 e	2008 bc			49.0 ab	37.0 a
0+ 200+200		1407 bcd	2271 a			51.1 a	33.9 abc
0+ 400+200		1536 ab	2129 ab			45.8 cd	33.2 abc
0+1000+200		1264 de	2127 ab			50.3 ab	30.4 c
Plowdown Potassium							
None		1274 de	1854 c			42.6 e	31.7 bc
0+200+ 0		1344 cde	2044 abc			48.9 ab	31.4 bc
0+200+100		1369 bcd	2137 ab			48.2 bc	34.7 ab
0+200+200		1407 bcd	2271 a			51.1 a	33.9 abc
0+200+400		1228 de	2065 abc			48.7 ab	36.9 a
0+100+100		1492 abc	2208 ab			48.0 bc	35.9 a
0+400+400		1564 a	2239 a			44.3 de	33.2 abc
Minimum Least Significant Range(L.S.D.)(.05)		163	199			2.3	3.4
Maximum Least Significant Range(.05)		188	229			2.7	3.8
SUMMARY OF ANNUAL BANDED TREATMENT							
100+ 0+ 0		1236 b	1924 b			46.4 b	33.5 a
100+50+50		1475 a	2283 a			49.1 a	34.3 a
Minimum Least Significant Range(L.S.D.)(.05)		70	85			1.0	1.5
Maximum Least Significant Range(.05)		70	85			1.0	1.5
Coefficient of Variation		10.1%	7.9%			4.2%	8.3%

COMPARISON OF ANNUALLY BANDED FERTILIZER TREATMENTS					
No Treatment	1369 ab	1736 b		45.0 abc	38.3 a
100+ 0+ 0	1130 b	1615 b		41.3 c	32.2 a
100+ 50+ 50	1418 ab	2093 ab		43.9 bc	31.2 a
50+ 50+ 50	1624 a	2505 a		49.6 ab	34.8 a
100+100+100	1258 ab	2231 ab		50.7 a	32.0 a
150+100+100	1425 ab	2378 a		49.0 ab	37.3 a
Minimum Least Significant Range(L.S.D.)(.05)	361	598		5.7	6.7
Maximum Least Significant Range(.05)	396	658		6.3	7.3
Coefficient of Variation	14.5%	15.7%		6.8%	10.7%
**Plowdown fertilizer applied:	Spring 1962		Spring 1961	Spring 1962	Spring 1961
Variety and date of planting:	Auburn M-May 5			Hill-May 5	Hill-May 23
Irrigated:	June 28, July 14 and 29			June 15, Aug 14, Sept 6	-
Limestone applied:	4 Tons Dolomitic 1962		None	4 Tons Dolomitic 1962	None

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

The above experiment was designed to determine if plowdown applications of phosphate and potash are sufficient as compared to annual application.

This experiment with cotton was terminated in 1966 but in 1967 soybeans were planted in the plots to determine residue effect on the soybeans.

The results indicate that annual applications of phosphate and potash increased yield of cotton and the soybeans following on the sandy soil at Clarkton. An increase in yield was obtained in the clay soil but the increase was not significant.

LIMESTONE AND NITROGEN
PORTAGEVILLE FIELD
1966-67 -- EXPERIMENTAL RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Topsoil: Sandy Loam	1.6	212	300	280	2500	4.9	3.0	11.0
Subsoil: Sandy Loam	1.5	157	210	360	2600	4.8	3.0	11.5

Soil Treatment		1966			1967		
*Limestone	Annual Fertilizer		Pounds Seed Cotton			Pounds Seed Cotton	
(Tons per Acre)	$N+P_2O_5+K_2O$	Soil pH	First Pick	Total	Soil pH	First Pick	Total
LIMESTONE X NITROGEN MEANS							
None	25+50+50	5.3 k	1544 abc	2171 abc	5.5 i	1819 ab	2309 bc
None	50+50+50	5.2 k	1236 fghi	2018 abcdefgh	5.2 j	1814 ab	2357 ab
None	100+50+50	5.2 k	1249 efghi	2046 abcdefgh	5.2 j	2324 a	2846 a
1 Fine Lime	25+50+50	5.5 hij	1564 ab	2184 abc	5.5 i	1817 ab	2280 bc
1 Fine Lime	50+50+50	5.5 hij	1220 ghi	1954 cdefgh	5.6 hi	1651 b	2196 bc
1 Fine Lime	100+50+50	5.4 j	1254 efghi	2077 abcdefg	5.4 ij	1666 b	2283 bc
2 Fine Lime	25+50+50	5.9 def	1506 abcd	2163 abc	5.8 gh	1779 ab	2168 bc
2 Fine Lime	50+50+50	5.8 efg	1152 hi	1847 gh	5.8 gh	1580 b	2013 bc
2 Fine Lime	100+50+50	5.7 fgh	1177 hi	1850 fgh	5.6 hi	1536 b	1906 bc
2 Agricultural	25+50+50	5.7 fgh	1593 a	2235 a	5.8 gh	1722 b	2370 ab
2 Agricultural	50+50+50	5.9 def	1470 abcdefg	2235 a	5.8 gh	1962 ab	2156 bc
2 Agricultural	100+50+50	5.7 fgh	1371 abcdefgh	2168 abc	5.5 ij	1740 b	2237 bc
4 Fine Lime	25+50+50	6.1 d	1580 a	2128 abcd	5.9 fg	1722 b	2010 bc
4 Fine Lime	50+50+50	6.0 de	1437 abcdefg	2061 abcdefgh	6.0 fg	1661 b	2005 bc
4 Fine Lime	100+50+50	6.0 de	1493 abcde	2179 abcdef	5.6 hi	1603 b	1918 bc
4 Agricultural	25+50+50	6.1 d	1475 abcdefg	2143 abcd	6.1 efg	1814 ab	2237 bc
4 Agricultural	50+50+50	6.1 d	1271 defghi	1924 defgh	6.0 fg	1796 ab	2273 bc
4 Agricultural	100+50+50	6.0 de	1157 hi	1888 efgh	6.0 fg	1575 b	2038 bc
8 Agricultural	25+50+50	6.6 abc	1358 abcdefgh	1965 cdefgh	6.7 bc	1514 b	1886 bc
8 Agricultural	50+50+50	6.5 bc	1279 defghi	1835 h	6.7 bc	1595 b	1906 bc
8 Agricultural	100+50+50	6.5 bc	1096 i	1600 i	6.5 cd	1432 b	1743 c
12 Agricultural	25+50+50	6.8 a	1350 abcdefgh	1982 bcdefgh	7.1 a	1559 b	1962 bc
12 Agricultural	50+50+50	6.8 a	1317 bcdefghi	2010 abcdefgh	7.0 a	1554 b	1967 bc
12 Agricultural	100+50+50	6.7 ab	1279 defghi	2079 abcdef	6.9 ab	1475 b	1855 bc
**1/4 Fine Lime Annually	25+50+50	6.0 de	1539 abc	2110 abcde	6.3 de	1725 b	2148 bc
**1/4 Fine Lime Annually	50+50+50	5.9 def	1353 abcdefgh	2158 abc	6.5 cd	1817 ab	2352 ab
**1/4 Fine Lime Annually	100+50+50	5.9 def	1302 cdefghi	2207 ab	6.2 e	1626 b	2194 bc
Minimum Least Significant Range(L.S.D.)(.05)		0.2	212	197	0.2	486	491
Maximum Least Significant Range(.05)		0.2	253	235	0.3	579	586
LIMESTONE MEANS							
No Treatment		5.2 g	1343 bc	2078 bcd	5.3 g	1986 a	2504 a
1 T Fine Lime		5.5 f	1346 bc	2072 bcd	5.5 f	1711 ab	2253 ab
2 T Fine Lime		5.8 e	1278 bc	1953 d	5.8 e	1632 b	2029 bcd
2 T Agricultural Lime		5.7 e	1478 a	2213 a	5.7 e	1808 ab	2234 abc
4 T Fine Lime		6.0 cd	1503 a	2122 abc	5.8 e	1662 b	1978 bcd
4 T Agricultural Lime		6.1 c	1301 bc	1985 d	6.0 d	1728 ab	1283 bc
8 T Agricultural Lime		6.5 b	1244 c	1800 e	6.6 b	1513 b	1845 d
12 T Agricultural Lime		6.8 a	1316 bc	2024 cd	7.0 a	1530 b	1928 cd
**1/4 Fine Lime Annually		5.9 d	1398 ab	2158 ab	6.3 c	1722 ab	2231 abc
Minimum Least Significant Range(L.S.D.)(.05)		0.11	122	113	0.1	280	284
Maximum Least Significant Range(.05)		0.13	142	131	0.2	324	328
NITROGEN MEANS							
25# Nitrogen Sidedress		6.0	1501 a	2120 a	6.1 a	1719 a	2131 a
50# Nitrogen Sidedress		6.0	1304 b	2004 b	6.1 a	1715 a	2160 a
100# Nitrogen Sidedress		5.9	1264 b	2010 b	5.9 b	1664 a	2104 a
Minimum Least Significant Range(L.S.D.)(.05)		0.06	71	66	0.1	162	164
Maximum Least Significant Range(.05)		0.07	74	69	0.1	170	172
Coefficient of Variance		1.9%	9.3%	5.7%	2.4%	17.0%	13.7%

Limestone applied on sandy loam soil in March, 1963.
* Calcium carbonate limestone
Fine lime from Ste. Genevieve, Missouri, of 200 mesh.
Agricultural limestone from Jonesboro, Illinois.
** Fine lime banded by the row annually.

Auburn M cotton planted May 7, 1966 and May 11, 1967 with 13+50+50 banded by the row at planting.
Additional nitrogen sidedressed July 8, 1966 and June 29, 1967.
Irrigated: July 2 and July 28, 1966. No irrigation required in 1967.

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

This experiment was designed to study the effect of limestone on the soils and what effect rate of nitrogen has on the effective duration of the limestone treatment. The limestones used were materials with 50% passing through a No. 40 screen and a fine lime with 100% passing a No. 100 sieve. In addition, annual applications of 500 pounds of fine lime banded by the row have also been made.

LIMESTONE AND NITROGEN
PORTAGEVILLE-LOAM
1967 SOIL TESTS RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Topsoil: Sandy Loam	1.6	212	300	280	2500	4.9	3.0	11.0
Subsoil: Sandy Loam	1.5	157	210	360	2600	4.8	3.0	11.5

Soil Treatment *Limestone (Tons per Acre)	Annual fertilizer $N+P_2O_5+K_2O$	O.M.	P_2O_5	K	Mg.	Ca	H	pH	C.E.C.
LIMESTONE X NITROGEN MEANS									
None	25+50+50	2.23 defg	331 ghijk	470 abcd	220 abc	3133 ghi	2.17 bcd	5.50 i	11.50 efg
None	50+50+50	2.27 cdef	348 fghijk	513 ab	233 ab	3167 ghi	2.83 a	5.23 j	12.33 abcdef
None	100+50+50	2.33 abcde	330 ijk	517 ab	240 a	3167 ghi	2.83 a	5.17 j	12.33 abcdef
1 Fine Lime	25+50+50	1.93 hi	324 k	447 cd	220 abc	3000 i	2.00 bcde	5.53 i	11.00 g
1 Fine Lime	50+50+50	2.13 efghi	343 ghijk	493 abcd	220 abc	3000 i	2.00 bcde	5.57 hi	11.17 fg
1 Fine Lime	100+50+50	2.03 fghi	350 fghijk	543 a	213 abc	2867 i	2.33 abc	5.40 ij	11.00 g
2 Fine Lime	25+50+50	1.90 hij	333 hijk	463 bcd	213 abc	3267 fghi	1.50 efg	5.83 gh	11.00 g
2 Fine Lime	50+50+50	1.97 ghi	431 ghijk	523 ab	207 bcd	3200 ghi	1.33 fgh	5.83 gh	10.83 g
2 Fine Lime	100+50+50	2.10 efghi	328 jk	530 ab	220 abc	3167 ghi	2.00 bcde	5.63 hi	11.50 efg
2 Agricultural	25+50+50	2.30 bcdef	358 defghijk	507 abc	240 a	3700 bcde	1.83 cdef	5.80 gh	12.67 abcde
2 Agricultural	50+50+50	2.30 bcdef	354 efghijk	530 ab	220 abc	3933 bcd	1.67 def	5.83 gh	13.00 abc
2 Agricultural	100+50+50	2.50 abcd	354 efghijk	517 ab	240 a	3533 defg	2.50 ab	5.47 ij	12.83 abcd
4 Fine Lime	25+50+50	2.17 efgh	367 bcdefgh	467 bcd	180 def	3467 efg	1.50 efg	5.93 fg	11.50 efg
4 Fine Lime	50+50+50	2.33 abcde	361 cdefghij	490 abcd	213 abc	3633 cdef	1.33 fgh	6.03 fg	11.83 cdefg
4 Fine Lime	100+50+50	2.37 abcde	388 abcde	503 abc	200 cde	3400 efgh	2.00 bcde	5.57 hi	11.83 cdefg
4 Agricultural	25+50+50	2.57 ab	382 abcdef	463 bcd	213 abc	4000 bc	1.33 fgh	6.07 efg	12.83 abcd
4 Agricultural	50+50+50	2.60 a	361 cdefghij	493 abcd	207 bcd	3933 bcd	1.50 efg	6.00 fg	12.83 abcd
4 Agricultural	100+50+50	2.57 ab	376 abcdefg	517 ab	200 cde	4000 bc	1.33 fgh	6.00 fg	13.00 abc
8 Agricultural	25+50+50	2.33 abcde	399 ab	467 bcd	173 ef	4567 a	0.50 ijkl	6.70 bc	13.17 ab
8 Agricultural	50+50+50	2.53 abc	406 a	510 abc	207 bcd	4700 a	0.33 jkl	6.67 bc	13.50 a
8 Agricultural	100+50+50	2.23 defg	395 abc	527 ab	173 ef	4500 a	0.67 ijk	6.50 cd	13.33 a
12 Agricultural	25+50+50	1.97 ghi	388 abcde	437 de	167 f	4867 a	0.00 l	7.07 a	13.33 a
12 Agricultural	50+50+50	1.97 ghi	393	470 bcd	167 f	4900 a	0.00 l	7.03 a	13.50 a
12 Agricultural	100+50+50	2.03 fghi	375 abcd	470 bcd	167 f	4500 a	0.17 kl	6.87 ab	12.67 abcde
**1/4 Fine Lime Annually	25+50+50	1.67 j	365 bcdefghi	373 f	207 bcd	3733 bcde	1.00 ghi	6.30 de	11.67 defg
**1/4 Fine Lime Annually	50+50+50	1.83 ij	326 jk	383 ef	200 cde	4067 b	0.50 ijkl	6.47 cd	12.00 bcdefg
**1/4 Fine Lime Annually	100+50+50	2.03 fghi	324 k	467 bcd	227 abc	3733 bcde	0.83 hij	6.20 e	11.67 defg
Minimum L.S.R.(L.S.D.)(.05)		.25	30	56	26	371	.47	.24	1.03
Maximum L.S.R.(.05)		.30	36	67	31	443	.56	.29	1.23
LIMESTONE MEANS									
None		2.28 b	336 e	500 a	231 a	3156 ef	2.6 a	5.3 g	12.0 b
1 T Fine Lime		2.03 c	339 de	494 a	218 ab	2956 f	2.1 b	5.5 f	11.0 c
2 T Fine Lime		1.99 cd	334 e	506 a	213 bc	3211 e	1.6 c	5.7 e	11.1 c
2 T Agricultural		2.37 b	356 cd	518 a	233 a	3722 c	2.0 b	5.7 e	12.8 a
4 T Fine Lime		2.29 b	372 bc	487 ab	198 cd	3500 d	1.6 c	5.8 e	11.7 b
4 T Agricultural		2.58 a	373 bc	491 ab	207 bc	3978 b	1.3 c	6.0 d	12.8 a
8 T Agricultural		2.37 b	400 a	501 a	184 d	4589 a	0.5 e	6.6 b	13.3 a
12 T Agricultural		1.99 cd	385 ab	459 b	167 e	4756 a	0.0 f	6.9 a	13.1 a
**1/4 Fine Lime Annually		1.84 d	338 de	408 c	211 bc	3844 bc	0.7 d	6.3 c	11.7 b
Minimum L.S.R.(L.S.D.)(.05)		.15	18	32	15	214	0.27	0.14	0.59
Maximum L.S.R.(.05)		.17	20	38	17	248	0.31	0.16	0.69
NITROGEN MEANS									
25# Nitrogen Sidedress		2.12 b	361 a	455 c	204 a	3748 ab	1.3 b	6.0 a	12.0 a
50# Nitrogen Sidedress		2.21 a	359 a	490 b	208 a	3837 a	1.2 b	6.0 a	12.3 a
100# Nitrogen Sidedress		2.24 a	358 a	510 a	209 a	3652 b	1.6 a	5.8 b	12.2 a
Minimun L.S.R.(L.S.D.)(.05)		.08	10	19	87	124	.16	.08	.34
Maximum L.S.R.(.05)		.09	11	20	91	130	.16	.08	.36
Coefficient of Variance		6.9%	5.0%	6.9%	7.5%	5.9%	19.7%	2.4%	5.0%

Duncan's Multiple Range Test: Results followed by same letters are not significantly different (.05).

The above data from soil tests obtained in 1967 which is four years after the limestone was applied. This soil required 12 tons of agricultural limestone to neutralize the acidity or raise the pH from 4.9 to 7.0. One hundred pounds of nitrogen applied annually to cotton has significantly reduced the pH and increased hydrogen content of the soil.

LIMESTONE AND NITROGEN
PORTAGEVILLE FIELD
1966-67 -- EXPERIMENTAL RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Topsoil: Sharkey Clay	1.3	224+	480	940	6000	5.5	2.5	22.0

Soil Treatment		1966			1967		
*Limestone	Annual Fertilizer	Pounds Seed Cotton			Pounds Seed Cotton		
(Tons per Acre)	$N+P_2O_5+K_2O$	pH	First Pick	Total	pH	First Pick	Total
LIMESTONE X FERTILIZER MEANS							
None	25+50+50	Not Harvested in 1966			5.7 l	669 abc	669 abc
None	50+50+50				5.7 l	825 abc	825 abc
None	100+50+50				5.8 kl	841 abc	841 abc
2 Agricultural	25+50+50				6.1 ijk	806 abc	806 abc
2 Agricultural	50+50+50				6.2 hij	723 abc	723 abc
2 Agricultural	100+50+50				6.1 jk	768 abc	768 abc
4 Agricultural	25+50+50				6.4 fghi	671 abc	671 abc
4 Agricultural	50+50+50				6.5 efgh	760 abc	760 abc
4 Agricultural	100+50+50				6.2 hij	830 abc	830 abc
8 Agricultural	25+50+50				6.9 bcd	663 abc	663 abc
8 Agricultural	50+50+50				6.8 bcde	785 abc	785 abc
8 Agricultural	100+50+50				6.6 def	677 abc	677 abc
12 Agricultural	25+50+50				6.8 bcde	763 abc	763 abc
12 Agricultural	50+50+50				6.8 bcde	779 abc	779 abc
12 Agricultural	100+50+50				6.7 cdef	854 ab	854 ab
24 Agricultural	25+50+50				7.2 a	760 abc	760 abc
24 Agricultural	50+50+50				7.0 abc	607 c	607 c
24 Agricultural	100+50+50				7.1 ab	617 bc	617 bc
**1/4 Fine Lime	25+50+50				6.6 def	652 abc	652 abc
**1/4 Fine Lime	50+50+50				6.5 defg	687 abc	687 abc
**1/4 Fine Lime	100+50+50				6.3 ghij	895 a	895 a
LIMESTONE MEANS							
No Treatment					5.7 e	778 ab	778 ab
2 T Agricultural Lime					6.1 d	766 ab	766 ab
4 T Agricultural Lime					6.4 c	754 ab	754 ab
8 T Agricultural Lime					6.8 b	708 ab	708 ab
12 T Agricultural Lime					6.8 b	799 a	799 a
24 T Agricultural Lime					7.1 a	661 b	661 b
1/4 T Fine Lime (Annually)					6.5 c	745 ab	745 ab
Minimum Least Significant Range(L. S. D.)(.05)					0.2	118	118
Maximum Least Significant Range(.05)					0.2	134	134
NITROGEN MEANS							
25# Nitrogen Sidedress					6.5 a	712 a	712 a
50# Nitrogen Sidedress					6.5 a	738 a	738 a
100# Nitrogen Sidedress					6.4 b	783 a	783 a
Minimum Least Significant Range(L. S. D.)(.05)					0.1	77	77
Maximum Least Significant Range(.05)					0.1	81	81
Coefficient of Variance					2.7%	16.4%	16.4%

Duncan's Multiple Range Test: Yields followed by the same letter are not significantly different (.05).
Limestone applied in March, 1961.
* Calcium carbonate limestone
Fine lime from Ste. Genevieve, Missouri, of 200 mesh.
Agricultural limestone from Jonesboro, Illinois.
** Fine lime banded by the row annually.
Auburn M cotton planted May 23, 1967 with 13+50+50 additional nitrogen sidedressed July 11, 1967.
Irrigated: None in 1967.

This experiment was designed to study the effect of limestone on the soils and what effect rate of nitrogen has on the effective duration of the limestone treatment. The limestones used were materials with 50% passing through a No. 40 screen and a fine lime with 100% passing a No. 100 sieve. In addition, annual applications of 500 pounds of fine lime banded by the row have also been made.

Plots were not harvested in 1966 due to late maturity and an early freeze which prevented the cotton bolls from opening. Unfavorable weather in 1967 resulted in very low yields on this soil.

LIMESTONE AND NITROGEN
PORTAGEVILLE FIELD
1967 SOIL TEST RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	H	pH	C.E.C.
Topsoil: Sharkey Clay	1.3	224+	480	940	6000	5.5	2.5	22.0

Soil Treatment: *Limestone (Tons per Acre)	Annual Fertilizer $N+P_2O_5+K_2O$	O.M.	P_2O_5	K	Mg.	Ca	H	pH	C.E.C.
LIMESTONE X NITROGEN MEANS									
None	25+50+50	1.83 cde	361 cd	410 abcd	980 ab	5500 gh	3.67 a	5.70 l	22.00 a
None	50+50+50	1.83 cde	365 cd	407 abcde	1027 a	5533 fgh	3.67 a	5.67 l	22.17 a
None	100+50+50	2.00 bcde	348 d	390 bcde	987 ab	5467 h	3.33 a	5.80 kl	21.50 ab
2 Agricultural	25+50+50	2.03 abcde	427 ab	460 a	973 ab	5700 efgh	2.00 bc	6.10 ijk	20.83 bc
2 Agricultural	50+50+50	2.10 abc	412 abc	433 abc	973 ab	5733 defg	1.83 bcd	6.20 hij	20.83 bc
2 Agricultural	100+50+50	2.17 ab	408 abc	437 abc	967 ab	5767 def	2.33 b	6.07 jk	21.33 ab
4 Agricultural	25+50+50	2.03 abcde	439 ab	420 abcd	907 bc	5833 de	1.33 cde	6.40 fghi	20.17 cdef
4 Agricultural	50+50+50	1.93 bcde	403 abc	390 bcde	927 abc	5867 de	1.17 cde	6.50 efgh	20.17 cdef
4 Agricultural	100+50+50	2.00 bcde	439 ab	443 ab	980 ab	5900 cde	2.00 bc	6.20 hij	21.50 ab
8 Agricultural	25+50+50	2.13 ab	444 a	423 abcd	880 bc	6133 abc	0.00 f	6.87 bcd	19.50 def
8 Agricultural	50+50+50	2.00 bcde	418 ab	410 abcd	893 bc	6167 ab	0.50 ef	6.83 bcde	20.00 cdef
8 Agricultural	100+50+50	2.07 abcd	435 ab	423 abcd	900 bc	5867 de	0.83 def	6.60 def	19.83 cdef
12 Agricultural	25+50+50	1.97 bcde	418 ab	400 bcde	953 abc	5967 bcd	0.33 ef	6.77 bcde	19.67 def
12 Agricultural	50+50+50	2.10 abc	439 ab	407 abcde	920 abc	5967 bcd	0.00 f	6.83 bcde	19.17 f
12 Agricultural	100+50+50	2.30 a	427 ab	383 cde	887 bc	5900 cde	0.50 ef	6.70 cdef	19.33 ef
24 Agricultural	25+50+50	1.80 de	412 abc	377 de	933 abc	6300 a	0.00 f	7.20 a	20.17 cdef
24 Agricultural	50+50+50	1.77 e	390 bcd	353 e	840 c	6167 ab	0.33 ef	6.97 abc	19.67 def
24 Agricultural	100+50+50	1.90 bcde	409 abc	353 e	887 bc	6200 ab	0.00 f	7.07 ab	19.50 def
**1/4 Fine Lime	25+50+50	2.03 abcde	423 ab	410 abcd	927 abc	5800 de	1.17 cde	6.57 defg	20.17 cdef
**1/4 Fine Lime	50+50+50	1.90 bcde	435 ab	430 abcd	953 abc	5867 de	1.17 cde	6.53 defg	20.33 cde
**1/4 Fine Lime	100+50+50	2.00 bcde	393 abcd	417 abcd	940 abc	5767 def	1.67 bcd	6.27 ghij	20.50 bcd
Minimum L.S.R.(L.S.D.)(.05)		.23	44	47	96	217	0.88	0.29	0.90
Maximum L.S.R.(.05)		.28	53	56	115	260	1.05	0.35	1.07
LIMESTONE MEANS									
No Treatment		1.88 bc	358 b	402 b	998 a	5500 f	3.56 a	5.72 e	21.89 a
2 T Agricultural Lime		2.10 a	415 a	443 a	971 ab	5733 e	2.06 b	6.12 d	21.00 b
4 T Agricultural Lime		1.99 ab	427 a	418 ab	938 abc	5867 cd	1.50 c	6.37 c	20.61 b
8 T Agricultural Lime		2.07 a	432 a	419 ab	891 c	6056 b	0.44 d	6.77 b	19.78 d
12 T Agricultural Lime		2.12 a	428 a	397 b	920 bc	5944 bc	0.28 d	6.77 b	19.39 d
24 T Agricultural Lime		1.82 c	404 a	361 c	887 c	6222 a	0.11 d	7.08 a	19.78 d
**1/4 T Fine Lime (Annually)		1.98 ab	417 a	419 ab	940 abc	5811 de	1.33 c	6.46 c	20.33 c
Minimum L.S.R.(L.S.D.)(.05)		.14	26	27	56	125	0.51	0.17	0.52
Maximum L.S.R.(.05)		.15	29	31	63	143	0.58	0.19	0.59
NITROGEN MEANS									
25# Nitrogen Sidedress		1.98 ab	418 a	414 a	936 a	5890 a	1.21 a	6.51 a	20.36 a
50# Nitrogen Sidedress		1.95 b	409 a	404 a	933 a	5900 a	1.24 a	6.50 a	20.33 a
100# Nitrogen Sidedress		2.06 a	408 a	407 a	935 a	5838 a	1.52 a	6.39 b	20.50 a
Minimum L.S.R.(L.S.D.)(.05)		0.09	17	18	36	82	0.33	0.11	0.34
Maximum L.S.R.(.05)		0.09	18	19	38	86	0.35	0.12	0.36
Coefficient of Variance		7.0%	6.5%	6.8%	6.2%	2.2%	4.0%	2.7%	2.6%

Duncan's Multiple Range Test: Results followed by the same letters are not significantly different (.05)

LIMESTONE AND NITROGEN
CLARKTON FIELD
1966-67 -- EXPERIMENTAL RESULTS

Clarkton Field
Soil Type: Sand

Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Topsoil:	1.0	131	350	40	600	4.0	2.5	4.5
Subsoil:	1.0	52	310	40	600	4.0	2.5	4.5

Soil Treatment		1966			1967		
		Pounds Seed Cotton Per Acre			Pounds Seed Cotton Per Acre		
*Limestone (Tons per Acre)	Annual Fertilizer $N+P_2O_5+K_2O$	pH	First Pick	Total	pH	First Pick	Total
None	25+50+50	4.4 jk	1323 efg	1841 cd	4.8 fghi	816 e	1114 f
None	50+50+50	4.3 k	1130 gh	1634 de	4.5 hi	603 e	868 f
None	100+50+50	4.1 k	875 h	1428 e	4.4 i	596 e	858 f
2 T Dolomitic	25+50+50	5.1 efgh	1834 ab	2280 ab	5.1 efghi	1268 cd	1598 cde
2 T Dolomitic	50+50+50	4.9 fghi	1742 abcd	2276 ab	5.0 efghi	1369 abcd	1765 abcde
2 T Dolomitic	100+50+50	5.0 efghi	1602 abcdef	2332 a	4.8 fghi	1258 cd	1664 bcde
2 T Calcium Carbonate	25+50+50	4.9 fghi	1834 ab	2312 ab	5.2 efghi	1428 abcd	1687 abcde
2 T Calcium Carbonate	50+50+50	4.8 hi	1674 abcd	2270 ab	4.7 ghi	1536 abc	1864 abcd
2 T Calcium Carbonate	100+50+50	4.8 hi	1654 abcde	2322 a	4.7 ghi	1634 a	2001 ab
4 T Dolomitic	25+50+50	5.4 cd	1818 ab	2224 ab	5.3 defgh	1369 abcd	1723 abcde
4 T Dolomitic	50+50+50	5.6 bc	1883 a	2384 a	5.6 bcdef	1290 bcd	1775 abcde
4 T Dolomitic	100+50+50	5.2 defg	1700 abcd	2358 a	5.0 efghi	1543 abc	1975 abc
4 T Calcium Carbonate	25+50+50	5.4 cd	1877 a	2335 a	5.7 abcde	1431 abcd	1706 abcde
4 T Calcium Carbonate	50+50+50	5.5 cd	1572 abcdef	2175 abc	5.4 defg	1389 abcd	1729 abcde
4 T Calcium Carbonate	100+50+50	5.3 def	1680 abcd	2339 a	5.5 cdefg	1516 abc	1877 abcd
8 T Dolomitic	25+50+50	6.1 a	1526 bcdef	2054 abc	6.1 abc	1297 bcd	1549 de
8 T Dolomitic	50+50+50	5.9 ab	1471 cdef	2086 abc	6.2 abc	1533 abc	1854 abcde
8 T Dolomitic	100+50+50	5.9 ab	1297 fg	2099 abc	5.8 abcd	1454 abcd	1801 abcde
8 T Calcium Carbonate	25+50+50	6.2 a	1628 abcdef	2204 ab	6.3 ab	1523 abc	1890 abcde
8 T Calcium Carbonate	50+50+50	6.1 a	1458 cdefg	2185 abc	6.2 abc	1549 abc	1916 abcd
8 T Calcium Carbonate	100+50+50	6.1 a	1556 abcdef	2371 a	6.0 abcd	1608 ab	2070 a
12 T Dolomitic	25+50+50	6.2 a	1490 bcdef	2145 abc	6.2 abc	1471 abc	1851 abcde
12 T Dolomitic	50+50+50	6.2 a	1539 abcdef	2316 ab	6.5 a	1608 ab	2021 ab
12 T Dolomitic	100+50+50	6.1 a	1412 defg	2289 ab	6.2 abc	1503 abc	2034 ab
**1/4 T Calcium Carbonate	25+50+50	4.7 hi	1546 abcdef	1949 bcd	5.2 efgh	1146 d	1471 e
**1/4 T Calcium Carbonate	50+50+50	4.7 hij	1785 abc	2283 ab	5.2 efgh	1379 abcd	1762 abcde
**1/4 T Calcium Carbonate	100+50+50	4.7 ij	1441 cdefg	2047 abc	4.9 fghi	1372 abcd	1788 abcde
Minimum Least Significant Range(L.S.D.)(.05)		0.3	292	313		273	325
Maximum Least Significant Range(.05)		0.4	348	373		325	388
LIMESTONE MEANS							
None		4.3 f	1109 d	1634 d	4.6 e	671 c	947 c
2 T Dolomitic		5.0 d	1726 ab	2296 a	5.0 de	1298 b	1676 b
2 T Calcium Carbonate		4.9 de	1721 ab	2301 a	4.9 de	1533 a	1851 ab
4 T Dolomitic		5.4 c	1800 a	2322 a	5.3 cd	1401 ab	1824 ab
4 T Calcium Carbonate		5.4 c	1710 ab	2283 ab	5.5 bc	1446 ab	1771 ab
8 T Dolomitic		5.9 b	1431 c	2080 c	5.7 b	1428 ab	1735 b
8 T Calcium Carbonate		6.1 a	1547 bc	2253 abc	6.2 a	1560 a	1959 a
12 T Dolomitic		6.2 a	1480 c	2250 abc	6.3 a	1527 a	1968 a
**1/4 T Fine Lime (Annually)		4.7 e	1591 b	2093 bc	5.1 d	1299 b	1674 b
Minimum Least Significant Range(L.S.D.)(.05)		0.2	169	180	0.4	157	188
Maximum Least Significant Range(.05)		0.2	195	209	0.5	182	217
NITROGEN APPLICATION MEANS							
25# Nitrogen Sidedress		5.4 a	1653 a	2149 a	5.6 a	1305 a	1621 b
50# Nitrogen Sidedress		5.3 ab	1584 a	2179 a	5.5 a	1361 a	1728 ab
100# Nitrogen Sidedress		5.2 b	1468 b	2176 a	5.2 b	1387 a	1785 a
Minimum Least Significant Range(L.S.D.)(.05)		0.1	97	104	0.2	91	108
Maximum Least Significant Range(.20)		0.1	102	110	0.2	96	114
Coefficient of Variance		3.6%	11.1%	8.6%		12.0%	11.3%

* Calcium Carbonate fine lime from Ste. Genevieve, Missouri Dolomitic limestone from Piedmont, Missouri. Applied broadcast and plowed down March 1962.

** Fine lime (200 mesh) calcium carbonate from Ste. Genevieve, Missouri banded by row annually.

	1966	1967
Cotton irrigated:	June 27, July 12 & 27	June 15, August 14 & September 5
Cotton sprayed for insects as needed.		
Cotton planted:	Auburn M May 5-Replanted May 19	Auburn M May 5
Fertilizer applied at planting:	13+50+50	13+50+50
Nitrogen sidedressed	June 5	June 26

The above experiment was designed to measure effectiveness of Kind, Source, and rates of limestone application on a sandy soil with an initial pH of 4.0. Rates of nitrogen were also included in the experiment to determine the effect of this element on duration of limestone treatments.

LIMESTONE AND NITROGEN
CLARKTON FIELD
1967 - SOIL TEST RESULTS

Clarkton Field - Soil Type: Sand Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Topsoil:	1.0	131	350	40	600	4.0	2.5	4.5
Subsoil:	1.0	52	310	40	600	4.0	2.5	4.5

Soil Treatment *Limestone (Tons per Acre)	Annual Fertilizer $N+P_2O_5+K_2O$	O.M.	P_2O_5	K	Mg.	Ca	H	pH	C.E.C.
None	25+50+50	0.4	263	200	100	633	2.8	4.8	5.0
None	50+50+50	0.5	253	183	47	500	3.3	4.5	4.8
None	100+50+50	0.6	258	207	60	500	3.8	4.4	5.5
2 T Dolomitic	25+50+50	0.6	292	230	133	767	2.5	5.1	5.3
2 T Dolomitic	50+50+50	0.8	269	230	133	800	2.8	5.0	5.7
2 T Dolomitic	100+50+50	0.8	289	220	113	633	3.3	4.8	5.7
2 T Calcium Carbonate	25+50+50	0.9	279	233	80	900	2.5	5.2	5.3
2 T Calcium Carbonate	50+50+50	0.7	245	197	53	500	3.0	4.7	4.5
2 T Calcium Carbonate	100+50+50	0.8	282	217	40	700	3.2	4.7	5.3
4 T Dolomitic	25+50+50	0.7	302	227	160	667	2.3	5.3	5.0
4 T Dolomitic	50+50+50	0.8	300	230	173	733	2.0	5.6	4.8
4 T Dolomitic	100+50+50	0.8	322	230	147	667	2.5	5.0	5.2
4 T Calcium Carbonate	25+50+50	0.6	263	203	87	1167	1.8	5.7	5.3
4 T Calcium Carbonate	50+50+50	0.7	305	203	67	1100	2.2	5.4	5.5
4 T Calcium Carbonate	100+50+50	0.6	274	220	73	1333	2.0	5.5	6.0
8 T Dolomitic	25+50+50	0.6	222	187	220	1100	1.0	6.1	4.8
8 T Dolomitic	50+50+50	0.6	223	193	220	1033	1.2	6.2	5.0
8 T Dolomitic	100+50+50	0.6	224	207	187	933	1.5	5.8	4.8
8 T Calcium Carbonate	25+50+50	0.6	348	203	67	1400	0.8	6.3	4.8
8 T Calcium Carbonate	50+50+50	0.6	271	233	67	1400	0.8	6.2	4.8
8 T Calcium Carbonate	100+50+50	0.8	258	227	53	1600	1.3	6.0	5.8
12 T Dolomitic	25+50+50	0.7	262	197	233	1200	1.0	6.2	5.3
12 T Dolomitic	50+50+50	0.7	248	213	227	1400	0.8	6.5	5.5
12 T Dolomitic	100+50+50	0.7	218	203	220	1167	1.0	6.2	5.2
**1/4 T Calcium Carbonate	25+50+50	0.7	294	210	33	1500	2.5	5.2	6.7
**1/4 T Calcium Carbonate	50+50+50	0.7	310	200	33	1100	2.7	5.2	5.8
**1/4 T Calcium Carbonate	100+50+50	0.7	311	203	33	833	3.2	4.9	5.5
L.S.D. (.05)		0.06	70	27	36	399	0.7	0.7	0.9
LIMESTONE									
None		0.51 e	258 bcd	197 c	69 d	544 c	3.3 a	4.56 e	5.1 bcd
2 T Dolomitic		0.74 abc	283 abc	227 a	127 c	733 c	2.9 b	4.97 de	5.5 abc
2 T Calcium Carbonate		0.82 abc	269 abc	216 ab	58 d	700 c	2.9 b	4.90 de	5.1 bcd
4 T Dolomitic		0.76 ab	308 a	229 a	160 b	689 c	2.3 e	5.29 cd	5.0 cd
4 T Calcium Carbonate		0.63 cd	281 abc	209 bc	76 d	1200 b	2.0 c	5.52 bc	5.6 ab
8 T Dolomitic		0.60 de	223 d	196 c	209 a	1022 b	1.2 d	5.71 b	4.9 d
8 T Calcium Carbonate		0.68 bcd	292 ab	221 ab	62 d	1467 a	1.0 d	6.18 a	5.2 bcd
12 T Dolomitic		0.71 bcd	243 cd	204 bc	227 a	1256 ab	0.9 d	6.30 a	5.3 bcd
**1/4 T Fine Lime (Annually)		0.70 bcd	305 a	204 bc	33 e	1144 b	2.8 b	5.09 d	6.0 a
Minimum L.S.R.		0.10	40	15	21	230	0.38	0.39	0.5
Maximum L.S.R.		0.12	47	18	24	266	0.44	0.45	0.6
NITROGEN									
25# Nitrogen Sidedress		0.66 a	281 a	210 a	124 a	1037 a	1.9 b	5.55 a	5.3 a
50# Nitrogen Sidedress		0.68 a	269 a	209 a	113 ab	952 a	2.1 b	5.47 a	5.2 a
100# Nitrogen Sidedress		0.71 a	271 a	215 a	103 b	930 a	2.4 a	5.15 b	5.4 a
Minimum L.S.R.		0.6	23	9	12	133	0.22	0.23	0.3
Maximum L.S.R.		0.6	24	9	13	140	0.23	0.24	0.3
Coefficient of Variance			15.2%	7.5%	19.0%	24.4%	18.5%	7.5%	10.4%

Duncan's Multiple Range Test: Results followed by the same letters are not significantly different (.05).

RATES OF NITROGEN
1966-67-- EXPERIMENTAL RESULTS

Portageville Field Initial Soil Tests:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Sandy Loam Soil	1.7	224+	440	260	2500	4.8	3.0	11.0
Clay Soil	2.4	189	455	940	6500	5.5	4.0	24.8

Soil Treatment		1966						1967			
		Pounds Seed Cotton Per Acre						Bushels Soybeans Per Acre			
		Sandy Loam Soil				Clay Soil		Sandy Loam Soil		Clay Soil	
				Carryover Nitrogen							
At Planting $N+P_2O_5+K_2O$	Nitrogen Sidedress	First Pick	Total	First Pick	Total	First Pick	Total	(1)	(2)	(1)	(2)
12+48+48	None	1750 ab	2096 b	1890 a	2284 b	Not harvested in 1966		39.4 a	44.9 a	38.4 a	36.0 a
12+48+48	25	1791 a	2416 a	1970 a	2423 b			41.4 a	41.6 b	38.3 a	34.8 a
12+48+48	50	1686 ab	2444 a	1970 a	2414 b			42.8 a	41.5 b	33.6 b	32.1 ab
12+48+48	75	1674 ab	2480 a	1924 a	2381 b			41.4 a	40.8 b	34.8 ab	32.4 ab
12+48+48	100	1661 ab	2549 a	1975 a	2482 ab			39.7 a	38.4 bc	37.0 ab	34.1 a
12+48+48	125	1601 ab	2470 a	2066 a	2683 a			44.1 a	36.9 c	33.1 b	32.9 ab
12+48+48	150	1525 b	2417 a	2058 a	2717 a			43.9 a	40.7 b	34.0 ab	28.9 b
Minimum L.S.R.(L.S.D.)(.05)		208	247	190	246			5.0	3.1	4.2	4.3
Maximum L.S.R.(.05)		235	278	214	277			5.7	3.5	4.7	4.8
Coefficient of Variance		8.4%	6.9%	6.5%	6.7%			8.1%	5.1%	7.9%	8.8%
Planted		Replanted May 21		Replanted May 21				May 11	May 11	May 23	May 23
Nitrogen Sidedress		July 7		-				-	-	-	-
*Nitrogen sidedress in 1965 but none in 1966											
Irrigated		June 30		June 30				-	-	-	-

2 Tons Limestone applied 1963

(1) Nitrogen applied to cotton plots in 1965 but none to soybeans in 1967.

(2) Nitrogen applied to cotton plots in 1966 but none to soybeans in 1967.

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

These experiments on the two soil types at the Portageville Field were designed to measure the effectiveness of sidedressing different rates of nitrogen on cotton. Also yields were obtained from the area on which nitrogen was applied in 1965 but not in 1966 - to determine if nitrogen will carry over from one year to the next.

The cotton experiment was terminated in 1966 and in 1967 Hill soybeans were planted in the plots to determine what effect the previous soil treatments would have on soybean yields.

In 1966 a total of 37 pounds of nitrogen appeared to be ample for maximum cotton yields on the sandy loam soils. On the residue (Carryover) area 125 and 150 pounds of nitrogen applied in 1965 produced highest yields.

Cotton on the clay soil in 1966 was late and an early freeze prevented harvesting these plots.

Soybean yields in 1967 were irratic and difficult to draw conclusions as to effect of previous soil treatments.

RATES OF NITROGEN
1966-67 -- EXPERIMENTAL RESULTS

Clarkton Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Topsoil:	1.3	212	330	40	600	4.1	2.0	4.0	Sand
Subsoil:	0.8	80	300	40	600	4.0	2.0	4.5	Sand

Soil Treatment		1966 Pounds Seed Cotton Per Acre				1967 Bushels Soybeans Per Acre	
				*"Residue"			
At Planting	Sidedress	First Pick	Total	First Pick	Total	(1)	(2)
No Treatment		1342 b	1529 e	1868 c	2042 d	40.5 abc	45.2 a
13+50+50	None	1810 ab	2024 d	2375 ab	2617 abc	39.4 abc	44.4 a
13+50+50	25+ 0+0	2063 a	2452 bc	2225 abc	2519 abc	40.2 abc	47.2 a
13+50+50	50+ 0+0	2057 a	2605 abc	2329 ab	2605 abc	41.9 ab	45.7 a
13+50+50	75+ 0+0	1950 a	2491 abc	2369 ab	2632 abc	43.8 a	45.6 a
13+50+50	100+ 0+0	2048 a	2678 ab	2522 a	2809 a	40.3 abc	45.9 a
13+50+50	125+ 0+0	2149 a	2791 a	2357 ab	2705 ab	41.3 abc	44.4 a
13+50+50	150+ 0+0	1895 ab	2543 abc	2369 ab	2739 a	40.7 abc	46.3 a
13+50+50	25+ 8+0	2140 a	2464 bc	2219 abc	2495 abc	39.4 abc	47.4 a
13+50+50	50+16+0	2005 a	2501 abc	2036 bc	2268 bcd	40.1 abc	43.4 a
13+50+50	75+24+0	2094 a	2684 ab	2161 abc	2427 abcd	39.4 abc	44.6 a
13+50+50	100+33+0	1929 ab	2510 abc	2320 ab	2641 ab	39.8 abc	46.2 a
13+ 0+ 0	50+ 0+0	1843 ab	2326 c	2253 abc	2580 abc	38.4 bc	46.5 a
13+ 0+ 0	100+ 0+0	1883 ab	2366 c	2339 ab	2650 ab	36.9 c	46.9 a
Minimum Least Significant Range(L.S.D.)(.05)		293	261	374	397	3.8	3.5
Maximum Least Significant Range(.05)		346	308	441	468	4.4	4.2
Coefficient of Variance		9.1%	6.5%	10.0%	9.4%	5.6%	4.6%

Two tons dolomitic limestone applied in 1961 and two tons in 1962.
* Sidedress in 1965, none in 1966.
Auburn M cotton planted May 3, 1966, 1967 Hill soybeans planted May 5, 1967.
1966 irrigated June 27, July 12 and 27, 1967 irrigated June 15, August 14 and September 5.

** Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05)

This experiment was designed to determine the optimum rate of nitrogen for cotton on this sandy soil, and to measure any value in the addition of phosphate to the sidedress application of nitrogen. In 1967 the cotton experiment was terminated, and soybeans planted in the plots to measure the effects of previous soil treatments on soybean yields. No fertilizer was applied to the soybeans in 1967.

(1) Yields of soybeans on plots on which nitrogen was applied in 1966.
(2) Yields of soybeans on plots on which nitrogen was applied in 1965.

RESPONSE OF VARIETIES TO FERTILITY TREATMENTS
1966 -- EXPERIMENTAL RESULTS

Clarkton and Portageville Fields Initial Soil Tests:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Clarkton	1.0	131	350	40	600	4.1	2.5	4.5	Sand
Portageville-Loam	1.7	224+	440	260	2500	4.8	3.0	11.0	Sandy Loam
Portageville-Clay	2.4	189	455	940	6500	5.5	4.0	24.7	Sharkey Clay

Variety	Pounds Seed Cotton Per Acre						1967 Bushels Soybeans Per Acre	
Soil Treatment	Clarkton		Portageville-Loam		Portageville-Clay		Portageville	
$N+P_2O_5+K_2O$	First Pick	Total	First Pick	Total	First Pick	Total	Loam (1)	Clay (1)
Auburn M								
50+50+50	1271 bcd	1507 cde	1896 a	2416 ab	-	-	41.7 ab	-
100+50+50	1510 ab	1873 ab	1677 abc	2433 ab	-	-	37.5 abc	-
150+50+50	1611 a	2027 a	1766 ab	2596 a	-	-	47.0 a	-
Rex SL								
50+50+50	1294 bc	1530 bcde	1373 def	2193 bc	731 ab	1098 c	40.0 ab	40.8 a
100+50+50	1438 abc	1749 abc	1024 gh	2059 cd	869 ab	1449 ab	41.3 ab	38.8 ab
150+50+50	1379 abc	1677 abcd	899 h	1880 cd	809 ab	1478 a	37.8 abc	40.3 ab
Deltapine 45								
50+50+50	576 gh	793 g	1605 bcd	2181 bc	837 ab	1093 c	43.1 ab	38.1 ab
100+50+50	462 h	704 g	1488 cde	2189 bc	894 a	1368 abc	46.7 a	37.6 ab
150+50+50	619 gh	917 fg	1338 def	2010 cd	901 a	1391 abc	43.8 ab	36.9 b
Missouri 470								
50+50+50	943 ef	1290 e	1447 cde	2143 bc	798 ab	1073 c	44.0 ab	40.4 ab
100+50+50	983 def	1376 de	1241 efg	2087 c	720 ab	1132 bc	39.7 ab	38.5 ab
150+50+50	1202 cde	1687 abcd	1134 fgh	2008 cd	619 b	1157 abc	33.5 bc	40.6 ab
Stoneville 213								
50+50+50	953 ef	1218 ef	1312 ef	1970 cd	963 a	1293 abc	34.6 bc	38.8 ab
100+50+50	845 fg	1225 ef	1136 fgh	1763 d	933 a	1474 a	28.8 c	39.9 ab
150+50+50	1146 cde	1543 bcde	1037 gh	1773 d	809 ab	1359 abc	40.6 ab	39.3 ab
Minimum L.S.R.(L.S.D.)(.05)	270	323	245	276	235	301	9.3	3.3
Maximum L.S.R.(.05)	314	376	285	321	269	345	10.8	3.7
VARIETY MEANS								
Auburn M	1464 a	1803 a	1779 a	2482 a	-	-	42.1 a	-
Rex SL	1370 a	1652 a	1099 d	2044 b	803 ab	1342 a	39.7 ab	39.9 a
Deltapine 45	552 c	805 c	1477 b	2127 b	877 a	1284 ab	44.5 a	37.6 b
Missouri 470	1043 b	1451 b	1274 c	2079 b	712 b	1121 b	39.1 ab	39.8 a
Stoneville 213	982 b	1329 b	1162 c	1835 c	902 a	1375 a	34.7 b	39.3 ab
Minimum L.S.R.(L.S.D.)(.05)	156	187	141	159	135	174	5.4	1.9
Maximum L.S.R.(.05)	172	206	156	176	146	187	5.9	2.1
SOIL TREATMENT MEANS								
50+50+50	1007 b	1268 b	1527 a	2181 a	832 a	1139 b	40.7 a	39.5 a
100+50+50	1047 b	1385 b	1313 b	2106 a	854 a	1356 a	38.8 a	38.7 a
150+50+50	1192 a	1570 a	1235 b	2054 a	784 a	1347 a	40.5 a	39.3 a
Minimum L.S.R.(L.S.D.)(.05)	121	145	109	124	117	150	4.2	1.7
Maximum L.S.R.(.05)	127	152	115	130	123	158	4.4	1.7
Coefficient of Variance	14.7%	13.5%	10.6%	7.7%	16.5%	13.6%	13.7%	4.8%
Planting date	May 19		May 22 (replanted)		May 11		May 11	May 23
Irrigated	June 27-July 12,27		June 30		June 28-July 13		-	-

50+50+50 banded at planting with additional nitrogen sidedress at bloom stage.
* Yields for Auburn M on Portageville-clay from rate of nitrogen test and not included in statistical analysis.
Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

The above experiments were designed to measure the response of five recommended varieties to varying rates of nitrogen on three soil types.

RESPONSE OF VARIETIES TO FERTILITY TREATMENTS
1966 -- EXPERIMENTAL RESULTS
"RESIDUE NITROGEN"

Clarkton and Portageville Fields Initial Soil Tests:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Clarkton	1.0	131	350	40	600	4.1	2.5	4.5	Sand
Portageville-Loam	1.7	224+	440	260	2500	4.8	3.0	11.0	Sandy Loam
Portageville-Clay	2.4	189	455	940	6500	5.5	4.0	24.7	Sharkey Clay

Variety ***Soil Treatment $N+P_2O_5+K_2O$	1966 Pounds Seed Cotton Per Acre						1967 Bushels Soybeans Per Acre		
	Clarkton		Portageville-Loam		Portageville-Clay		Clarkton (1)	Portageville	
	First Pick	Total	First Pick	Total	First Pick	Total		Loam (1)	Clay (1)
Auburn M									
50+50+50	1474 ab	1959 abcde	1794 abcde	2072 def	-	-	40.1 cd	40.7 a	-
100+50+50	1464 ab	2175 a	1812 abcd	2224 abcd	-	-	44.0 abc	41.8 a	-
150+50+50	1333 abc	2136 ab	1947 ab	2446 ab	-	-	45.2 a	41.3 a	-
Rex SL									
50+50+50	1625 a	2106 abc	1593 def	2181 bcde	108 e	220 e	43.6 abc	41.4 a	39.9 ab
100+50+50	1392 ab	2027 abcd	1524 ef	2217 abcd	115 de	227 e	44.7 ab	37.6 ab	37.3 abcde
150+50+50	1379 ab	2008 abcd	1391 f	2839 abcd	344 b	509 b	44.2 abc	41.8 a	39.6 abc
Deltapine 45									
50+50+50	1205 bcde	1628 def	1814 abcd	2153 cde	98 e	222 e	38.5 d	43.0 a	37.9 abcde
100+50+50	875 ef	1405 f	1936 ab	2339 abcd	211 cd	364 d	43.1 abc	43.6 a	36.7 bcde
150+50+50	842 f	1415 f	2013 a	2456 a	316 bc	490 bc	43.5 abc	43.0 a	36.1 cde
Missouri 470									
50+50+50	1268 bcd	1880 abcde	1649 cdef	1949 ef	289 bc	399 cd	43.4 abc	39.2 ab	40.6 a
100+50+50	924 def	1569 ef	1468 f	1868 f	309 bc	419 bcd	44.8 ab	33.5 b	39.3 abc
150+50+50	1012 cdef	1720 cdef	1906 abc	2375 ab	495 a	637 a	41.3 abcd	39.3 ab	38.7 abcd
Stoneville 213									
50+50+50	1205 bcde	1752 bcdef	1700 bcde	2158 cde	238 bc	378 d	40.2 bcd	44.4 a	37.7 abcde
100+50+50	989 cdef	1759 bcdef	1786 abcde	2357 abc	264 bc	413 cd	42.1 abcd	44.2 a	35.4 de
150+50+50	838 f	1569 ef	1562 def	2235 abcd	337 b	511 b	44.0 abc	42.8 a	34.7 e
Minimum L.S.R. (L.S.D.) (.05)	309	356	239	237	98	89	4.0	6.3	3.2
Maximum L.S.R. (.05)	360	414	278	275	112	102	4.6	7.3	3.6
VARIETY MEANS									
Auburn M	1424 a	2090 a	1850 a	2247 a	-	-	43.1 a	41.2 a	-
Rex SL	1465 a	2047 a	1502 c	2246 a	189 c	319 b	44.2 a	40.3 ab	38.9 a
Deltapine 45	974 b	1483 c	1921 a	2316 a	209 c	359 b	41.7 a	43.2 a	36.9 a
Missouri 470	1068 b	1723 b	1674 b	2064 b	364 a	485 a	43.2 a	37.4 b	39.5 b
Stoneville 213	1011 b	1693 b	1683 b	2250 a	280 b	434 a	42.1 a	43.8 a	35.9 b
Minimum L.S.R. (L.S.D.) (.05)	179	206	138	137	56	51	2.3	3.6	1.9
Maximum L.S.R. (.05)	197	227	152	151	61	55	2.5	4.0	2.0
SOIL TREATMENT MEANS									
50+50+50	1355 a	1865 a	1710 a	2103 b	183 b	305 c	41.2 b	41.8 a	39.0 a
100+50+50	1129 b	1787 a	1705 a	2201 b	225 b	356 b	43.7 a	40.1 a	37.2 b
150+50+50	1081 b	1769 a	1764 a	2370 a	373 a	537 a	43.6 a	41.6 a	37.3 b
Min. L.S.R. (L.S.D.) (.05)	138	159	107	105	49	45	1.8	2.8	1.6
Max. L.S.R. (.05)	145	167	112	111	51	47	1.9	2.9	1.7
Coefficient of Variance	15.3%	11.6%	8.1%	6.3%	21.6%	12.9%	5.5%	9.0%	4.8%
Planting date	May 19		May 22 (replant)		May 11		May 5	May 11	May 23
Irrigated	June 27-July 12, 27		June 30		June 38-July 13		June 15, Aug. 14, Sept. 5	-	-

***Soil fertility treatment in 1965. None applied in 1966.

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

METHODS OF APPLYING FERTILIZER TO COTTON
1966-67 -- EXPERIMENTAL RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Topsoil:	2.5	208	350	980	5300	5.4	6.5	24.3	
Subsoil	2.2	179	380	1020	7000	5.5	6.0	28.5	Sharkey Clay

Soil Treatment			1966 Pounds Seed Cotton Per Acre				1967 Pounds seed cotton per acre	
					*"Residue"			**"Residue"
Preplant $N+P_2O_5+K_2O$	Band at Planting $N+P_2O_5+K_2O$	Sidedress $N+P_2O_5+K_2O$	First Pick	Total	First Pick	Total	Total (1)	Total (1)
No Treatment			754 e	1011 b	630 a	860 a	518 e	669 c
50+ 50+ 50 Broadcast and bed			1029 cd	1611 a	351 a	516 a	871 d	713 bc
75+ 75+ 75 Broadcast and bed			1136 abcd	1824 a	474 a	662 a	1112 bcd	843 abc
100+100+100 Broadcast and bed			1102 bcd	1866 a	390 a	571 a	1151 abcd	717 bc
50+ 50+ 50 Band under bed			1387 a	1944 a	584 a	795 a	1176 abcd	598 c
100+100+100 Band under bed			1238 abc	2028 a	543 a	793 a	1517 a	793 abc
	50+ 50+50		1293 ab	1792 a	530 a	738 a	1245 abcd	591 d
	100+100+100		1018 cd	1797 a	486 a	1096 a	1485 ab	846 abc
	13+ 50+ 50	37+0+0	970 de	1620 a	500 a	701 a	1068 cd	656 c
	13+ 50+ 50	87+0+0	940 de	1737 a	676 a	946 a	1318 abc	1043 a
	100+ 0+ 0		1054 bcd	1882 a	710 a	962 a	1513 a	967 ab
50+ 0+ 0 Broadcast and bed			1169 abcd	1857 a	678 a	979 a	1148 abcd	869 abc
100+ 0+ 0 Broadcast and bed			1031 cd	1776 a	504 a	704 a	1247 abcd	999 a
Minimum Least Significant Range(L.S.D.)(.05)			227	361	416	634	332	245
Maximum Least Significant Range(L.S.D.)(.05)			264	420	484	737	386	284
Coefficient of Variance			12.4%	12.2%	45.5%	47.3%	16.6%	18.3%
Preplant fertilizer applied			May 10		-		April 4	
Cotton Planted			May 11		May 11		May 22-Auburn M-May 22	
Irrigated			June 28-July 14		June 28-July 14		-	
Sidedress			July 5		-		July 3	

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

* Fertilizer applied to plots in 1965 but none applied in 1966.
** Fertilizer applied in 1966 but none in 1967.
(1) Due to late maturity only one picking was made in 1967.

The above experiment was designed to determine the most efficient method of applying fertilizer. Banding the fertilizer under the bed or near the seed has been more productive as compared to broadcasting the same amount.

CROP ROTATION EXPERIMENT
1966-67 -- EXPERIMENTAL RESULTS

Portageville Field

Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Sandy Loam	1.4	224+	540	160	1700	4.8	2.5	8.1
Clay	3.2	160	500	940	7000+	5.3	3.8	22.1

Crop Sequence			Pounds Seed Cotton Per Acre					
			Sandy Loam Soil				(1) Clay Soil	
			1966		1967		1967	
First Year	Second Year	Third Year	First Pick	Total	First Pick	Total	First Pick	Total
Cotton	Soybeans	Corn	2497 ab	2742 ab	2022 a	2416 a	1069 a	1069 a
Cotton	Soybeans	Wheat-Sudan	2651 a	2968 a	2083 a	2446 a	1036 a	1036 a
Cotton	Soybeans	Wheat-Soybeans	2649 a	2967 a	2136 a	2568 a	1089 a	1089 a
Cotton	Soybeans	Soybeans	2454 ab	2717 ab	2033 a	2456 a	1089 a	1089 a
Cotton	Fescue	Fescue	2394 ab	2702 ab	2207 a	2545 a	1088 a	1088 a
Cotton	Cotton	Cotton	2275 b	2526 b	2116 a	2373 a	1283 a	1283 a
Minimum Least Significant Range(L.S.D.)(.05)			275	245	300	302	305	305
Maximum Least Significant Range(.05)			302	269	330	332	335	335
Coefficient of Variance			6.1%	4.9%	7.9%	6.7%	15.1%	15.1%

	1966 Sandy Loam	1967 Sandy Loam	1967 Clay
Cotton Variety	Auburn M	Auburn M	Auburn M
Date of Planting	May 9	May 11	May 23
Fertilizer applied at planting	50+50+50	50+50+50	50+50+50
50 pounds nitrogen sidedressed	None	None	July 11
Irrigated	July 1,29		-

All crops in rotation fertilized at optimum rates.

(1) Cotton on clay soil was late in 1966 and due to early freeze the cotton was not harvested. Only one picking in 1967.

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

On the loam soil continuous cotton has depressed yields in 1966 and 67 as compared to cotton grown in rotation.

These experiments were designed to determine the benefit of crop rotation in cotton production as compared to continuous cotton.

COVER CROP EXPERIMENT
1966-67 -- EXPERIMENTAL RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Sandy Loam	1.3	224+	520	160	1700	4.9	2.0	7.8
Clay	2.8	176	530	948	6300	6.0	4.0	24.4

	Pounds Seed Cotton Per Acre					
	Sandy Loam Soil				(1) Clay Soil	
	1966		1967		1967	
Cover Crop	First Pick	Total	First Pick	Total	First Pick	Total
None	1660 a	2300 abc	1387 bc	1763 abc	904 ab	904 ab
Rye	1787 a	2412 ab	1669 a	2079 a	826 b	826 b
Rye and Vetch	999 b	1786 d	1196 c	1647 bc	1170 a	1170 a
Dixie Crimson Clover	1214 b	2082 bcd	1264 c	1664 bc	1002 ab	1002 ab
Austrian Winter Peas	1142 b	1930 cd	1218 c	1609 c	926 ab	926 ab
Field Brome	1907 a	2500 a	1578 ab	1977 ab	886 ab	886 ab
Rye Grass	1739 a	2294 abc	1427 bc	1762 abc	884 ab	884 ab
Minimum Least Significant Range(L.S.D.)(.05)	286	377	223	303	298	298
Maximum Least Significant Range(.05)	318	418	248	336	331	331
Coefficient of Variance	10.8%	9.7%	9.0%	9.5%	17.8%	17.8%

	Sandy Loam 1966	Sandy Loam 1967	Clay 1967
Cover Crops Planted	September 20, 1965	September 16, 1966	September 16, 1966
Cotton Planted	Auburn M-May 21	Auburn M-May 11	Auburn M-May 24
Fertilizer applied			
Starter	50+50+50	50+50+50	50+50+50
Sidedress	None	None	50# N July 11
Irrigated	June 20-July 29	None	None

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

(1) Cotton on the clay soil was late in 1966 and 1967. Due to early freeze the cotton was not harvested in 1966. In 1967 the season delayed cotton maturity and only one picking was made.

On the sandy loam soil in 1966 and 1967 the non-legume cover crops produced higher yields than the legumes. The additional nitrogen provided by the legumes probably resulted in an excess supply of nitrogen.

On the clay soil in 1967 the legumes increased yields over the non-legume cover crops.

This experiment was designed to determine the effect of winter-cover crops on the organic matter content of the soil over a period of years. Considerable difficulty has been encountered in the establishment of stands of these winter crops. If crops are allowed to grow too late in the spring, considerable work is required in preparing the seedbed for cotton.

MINOR ELEMENT EXPERIMENT
1966-67 -- EXPERIMENTAL RESULTS

Clarkton Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Topsoil:	0.7	202	130	160	1300	4.9	2.0	6.0	Sand
Subsoil:	0.6	90	130	140	1700	4.2	2.0	7.0	Sand

	1966				1967			
	Pounds Seed Cotton Per Acre				Pounds Seed Cotton Per Acre			
*Soil Treatment	**No Fine Lime		**4T Fine Lime 1964		**No Fine Lime		**4T Fine Lime 1964	
(Pounds per Acre)	First Pick	Total	First Pick	Total	First Pick	Total	First Pick	Total
No Trace Elements	1382 a	1851 a	760 a	1209 a	1163 a	1461 a	943 a	1202 a
0.5 Boron Banded	1706 a	2152 a	940 a	1441 a	1241 a	1494 a	1022 a	1245 a
0.5 Boron Broadcast	1667 a	2054 a	806 a	1323 a	1199 a	1441 a	947 a	1205 a
1.0 Boron Banded	1490 a	2014 a	838 a	1379 a	1207 a	1595 a	924 a	1123 a
1.0 Boron Broadcast	1395 a	1877 a	848 a	1320 a	1028 a	1264 a	845 a	1035 a
2.0 Boron Banded	1494 a	1975 a	747 a	1294 a	1215 a	1458 a	933 a	1143 a
2.0 Boron Broadcast	1474 a	1896 a	809 a	1363 a	1199 a	1412 a	904 a	1127 a
4.0 Boron Broadcast	1225 a	1664 a	678 a	1166 a	1150 a	1382 a	816 a	1055 a
0.75 Boron with Herbicide	1507 a	2001 a	799 a	1333 a	1081 a	1313 a	789 a	969 a
20 Copper Sulphate Banded	1539 a	2073 a	796 a	1304 a	1107 a	1353 a	861 a	1107 a
20 Zinc Sulphate Banded	1399 a	1873 a	773 a	1245 a	960 a	1173 a	881 a	1090 a
Limestone Means	1480	1948	799	1307	1150	1395	897	1118
Minimum L.S.R.(L.S.D.)(.05)	430	432	324	448	363	444	323	355
Maximum L.S.R.(.05)	494	495	372	514	416	509	371	407
Coefficient of Variance	17.1%	13.0%	23.8%	20.1%	18.5%	18.7%	21.1%	18.6%

	1966	1967
Cotton planted	Auburn M - May 19	Auburn M - May 5
Irrigated as needed	June 27, July 12 and 27	June 16, August 15 and September 5

** Four ton dolomitic limestone applied to all plots in 1963.
* All plots 50+50+50 banded at planting.

Duncan's Multiple Range Test: Yield followed by the same letters are not significantly different (.05).

Experiments in the greenhouse have indicated that high rates of limestone may result in trace element deficiencies in the soil. These results are from field studies designed to verify greenhouse results.

The area of the field with 4 tons of fine lime in addition to the 4 tons of dolomitic limestone produced lower yields with all treatments as compared to the area with only 4 tons of dolomitic limestone. Boron has increased yields but the increase has not been statistically significant. The soil pH in 1967 was 7.2 on the area which received the 4 tons of fine lime as compared to pH 6.1 on the areas which did not have the fine lime.

NITROGEN REQUIREMENTS OF CORN
1966-67 -- EXPERIMENTAL RESULTS

Portageville Field
Soil Type: Sandy Loam

Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Topsoil:	2.2	224+	440	300	2800	4.8	3.5	12.5
Subsoil:	2.0	185	260	320	3100	5.0	3.0	12.5

Soil Treatment		1966				1967			
		Yield in Bushels Per Acre With Per Acre Planting Rates of:							
Starter $N+P_2O_5+K_2O$	Sidedress $N+P_2O_5+K_2O$	13,760	18,085	22,800	27,920	11,733	16,685	20,898	24,858
0+25+25	0	39.8	22.6	12.2	20.8				
25+25+25	25+0+0	79.1	77.7	63.6	55.3				
25+25+25	75+0+0	107.1	109.4	95.3	87.4				
25+25+25	125+0+0	116.1	115.2	107.3	101.2				
25+25+25	175+0+0	113.7	116.8	97.3	94.4				
25+25+25	225+0+0	112.5	122.4	109.7	99.3				
25+25+25	275+0+0	110.3	122.1	120.7	110.4				
L.S.D. (.05) For plant population		15.6 bushels							
L.S.D. (.05) For nitrogen treatment		9.6 bushels							

Single Cross corn planted April 7-12 with starter and Sidedress May 13.
Irrigated June 20, 29, and July 7.
Harvested September 6

0+50+50	0					16.1	8.3	7.8	6.9
50+50+50	0					37.4	43.2	23.7	16.5
50+50+50	50					71.4	78.9	79.7	76.6
50+50+50	100					80.0	103.6	111.3	107.1
50+50+50	150					83.9	111.1	110.3	113.8
50+50+50	200					87.6	115.5	115.4	120.8
50+50+50	250					82.6	116.2	112.6	123.0
L.S.D. (.05) For plant population						7.7 bushels per acre			
L.S.D. (.05) For nitrogen treatment						6.8 bushels per acre			

Applied plowdown soil treatment and 2 tons limestone before breaking rye under.
Single Cross corn planted April 3.
Irrigated June 14
Harvested September 7
Rye seeded on plots in fall of 1966 to increase organic matter content

This experiment was designed to determine the optimum rates of planting and nitrogen for corn in Southeast Missouri. With the lower rates of nitrogen there was little value from higher rates of planting. When higher rates of nitrogen were applied a higher planting rate was necessary to utilize the treatments. Results indicate most optimum rate of planting as 17 to 20,000 plants with a total application of 200 pounds of nitrogen.

FERTILIZER REQUIREMENTS OF CORN AND SOYBEANS 1966-67 -- EXPERIMENTAL RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Topsoil:	2.2	224+	440	300	2800	4.8	3.5	12.5	Sandy Loam
Subsoil:	2.0	185	260	320	3100	5.0	3.0	12.5	Sandy Loam

Soil Treatment	Corn 1966 Bushels Per Acre	Soybeans 1967 Bushels Per Acre
None	13.6 d	50.5 ab
100+ 0+ 75	113.6 c	49.5 ab
100+ 25+ 75	122.2 abc	48.5 ab
100+ 50+ 75	121.9 abc	50.9 ab
100+ 75+ 75	139.3 a	48.8 a
100+100+ 75	114.4 bc	46.9 b
100+ 75+ 0	116.0 bc	45.6 b
100+ 75+ 25	120.0 bc	48.3 ab
100+ 75+ 50	116.6 bc	48.7 ab
150+ 75+ 75	114.2 bc	48.9 ab
100+ 75+100	121.8 abc	48.8 ab
100+ 25+ 25	123.6 abc	49.2 ab
100+ 50+ 50	118.3 bc	48.7 ab
100+ 0+ 0	120.8 bc	51.4 a
100+100+100	132.7 ab	48.4 ab
Minimum Least Significant Range(L.S.D.)(.05)	15.8	3.7
Maximum Least Significant Range(.05)	18.9	4.4
Coefficient of Variance	9.7%	5.2%
Planted:	Pioneer 3306-April 7	Hill-May 11
Irrigated:	June 20, 29-July 7, 15	September 11
Stalk count plants per acre:	15,000	-

Duncan's Multiple Range Test: Any two yields not followed by the same letter are significantly different from each other at odds of 19:1 (5%).

This experiment was designed to determine the need by corn for phosphorous and potassium on a soil testing high in these two elements.

In 1965 only nitrogen was required for maximum yields of corn whereas in 1966 there was a response to phosphate and potash.

In 1967 soybeans were planted on the same plots with no additional fertilizer. Yields were excellent but previous fertility treatments on the corn had little or no effect on the soybeans.

CROP ROTATION EXPERIMENT
1966-67 -- EXPERIMENTAL RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Sandy Loam Soil	1.4	224+	540	160	1700	4.8	2.5	8.1
Clay Soil	3.2	160	500	940	7000+	5.3	3.8	22.1

Crop Sequence			Bushels of Soybeans Per Acre							
			Sandy Loam Soil				Clay Soil			
			1966		1967		1966		1967	
First Year	Second Year	Third Year	Second Year	Third Year	Second Year	Third Year	Second Year	Third Year	Second Year	Third Year
Cotton	Soybeans	Corn	47.9 a		47.2 ab		32.9 a		38.2 a	
Cotton	Soybeans	Wheat-Sudan	47.3 a		49.4 a		35.1 a		36.8 a	
Cotton	Soybeans	Wheat-Soybeans	44.5 ab	16.0	45.4 b	19.5 b	33.8 a	13.7 b	35.7 a	27.5 b
Cotton	Soybeans	Soybeans	42.1 b	32.5	41.3 c	24.5 a	34.1 a	33.2 a	36.2 a	35.1 a
Minimum Least Significant Range(L.S.D.)(.05)			3.6	-	3.1	-	4.5	3.4	2.5	-
Maximum Least Significant Range(.05)			3.7	-	3.2	-	4.7	3.4	2.6	-
Coefficient of Variance			3.9%	-	3.9%	-	6.6%	4.1%	3.4%	-
Hill soybeans planted			May 27		May 11		May 31		May 23	
Hill soybeans planted after wheat			June 14		June 7		June 21		June 7	
Irrigated			July 1		September 11		June 27		-	

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

This experiment indicates the depression of approximately 10 bushels in yields of soybeans following soybeans on the loam soil as compared to the soybeans following cotton. The above data and previous data emphasizes the importance of rotating soybeans on this soil.

LIME AND FERTILIZER REQUIREMENT OF SOYBEANS
1966-67 -- EXPERIMENTAL RESULTS

Portageville Field Initial Soil Test	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Sandy Loam	1.7	224+	440	260	2500	4.8	3.0	11.0
Clay	1.9	224+	310	940	6000	5.6	2.0	21.5

Soil Treatment		Bushels of Soybeans Per Acre					
		Sandy Loam				Clay Soil	
Tons Limestone	Annual Fertilizer $N+P_2O_5+K_2O$	1966 Non-irrigated	1966 Irrigated	1967 Non-irrigated	1967 Irrigated	1966 Irrigated	1967 Irrigated
LIMESTONE X FERTILIZER MEANS							
None	None	34.2 abc	35.5 ab	28.0 e	35.9 a	28.5 b	36.6 ab
None	13+50+50	33.8 abc	35.8 ab	28.0 e	34.3 ab	28.3 b	34.1 c
1	None	34.0 abc	35.2 abc	29.2 de	36.4 a	28.6 b	37.9 a
1	13+50+50	35.3 abc	36.4 a	27.8 e	34.9 a	29.1 b	35.7 abc
2	None	34.1 abc	34.6 abc	31.0 cd	36.0 a	28.6 b	37.0 ab
2	13+50+50	33.3 bc	35.7 ab	27.6 e	34.3 ab	29.7 ab	36.0 abc
4	None	33.9 abc	33.5 bc	29.6 de	35.2 a	32.3 a	37.0 ab
4	13+50+50	33.7 abc	32.6 c	28.1 e	32.1 bc	29.0 b	34.9 bc
Minimum Least Significant Range(L.S.D.)(.05)		2.5		2.1		3.0	2.3
Maximum Least Significant Range(.05)		2.9		2.4		3.3	2.5
IRRIGATION MEANS		34.0 b	34.9 a	28.7 b	34.9 a		
Minimum Least Significant Range(L.S.D.)(.05)		0.02		0.02			
Maximum Least Significant Range(.05)		0.02		0.02			
LIMESTONE MEANS							
None		34.0 e	35.7 b	28.0 h	35.0 c	28.4 a	35.3 a
1		34.7 d	35.8 a	28.5 g	35.7 a	28.9 a	36.8 a
2		33.7 g	35.1 c	29.3 e	35.1 b	29.1 a	36.5 a
4		33.8 f	33.1 h	28.9 f	33.7 d	30.6 a	36.0 a
Minimum Least Significant Range(L.S.D.)(.05)		0.02		0.03		2.1	1.6
Maximum Least Significant Range(.05)		0.02		0.03		2.3	1.7
FERTILIZER MEANS							
	None	34.0 a	34.7 a	29.5 c	35.9 a	29.5 a	37.1 a
	13+50+50	34.0 a	35.1 a	27.9 d	33.9 b	29.0 a	35.2 b
Minimum Least Significant Range(L.S.D.)(.05)		1.2		1.0		1.5	1.1
Maximum Least Significant Range(.05)		1.3		1.1		1.5	1.1
Coefficient of Variance		4.1%		3.8%		5.5%	3.3%
Limestone applied 1963							
Hill Soybeans planted:		May 27	May 27	May 11	May 11	May 31	
Irrigated		-	July 28		Aug. 17	July 13 + Sept 10	Aug. 21

Fertilizer banded at planting
Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

Irrigation increased yields significantly in 1966 and 1967 on the sandy loam soil. Fertilizer has not increased yields of soybeans on these two soils which test high in phosphorous and potassium. Limestone has not responded on these soils in 1966 and 1967.

This experiment was designed to determine the need for limestone by soybeans on the two soil types at the Portageville Field. Irrigation was included in the study on the sandy loam soil whereas water was applied as needed on clay soil only.

LIME AND FERTILIZER REQUIREMENTS OF SOYBEANS
1967 -- SOIL TEST RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Sandy Loam	1.7	224+	440	260	2500	4.8	3.0	11.0
Clay	1.9	224+	310	940	6000	5.6	2.0	21.5

Soil Treatment: Tons Limestone	Annual Fertilizer $N+P_2O_5+K_2O$	O.M.	P_2O_5	K	Mg.	Ca	H	pH	C.E.C.
				Portageville Loam					
LIMESTONE X FERTILIZER MEANS (NON-IRRIGATED)									
None	None	2.2 a	201 fg	363 d	220 de	3333 fgh	2.7 a	5.4 h	12.5 bc
None	13+50+50	2.2 a	318 ab	403 abcd	213 e	3267 gh	2.5 ab	5.3 h	12.0 cd
1T	None	2.2 a	203 fg	350 de	260 bc	3633 cde	2.2 bc	5.6 g	12.7 bc
1T	13+50+50	2.3 a	297 b	430 abc	246 bcde	3700 cde	2.3 abc	5.6 fg	13.2 ab
2T	None	2.2 a	224 ef	374 d	260 bc	3767 bcd	2.2 bc	5.7 efg	13.2 ab
2T	13+50+50	2.2 a	309 b	436 ab	246 bcde	3666 cde	2.0 cd	5.7 efg	12.8 b
4T	None	2.3 a	259 cd	350 de	213 e	4166 a	1.3 ef	6.1 bc	12.8 b
4T	13+50+50	2.4 a	341 a	440 a	213 e	4267 a	1.7 de	5.9 d	13.7 a
LIMESTONE X FERTILIZER MEANS (IRRIGATED)									
None	None	1.8 b	160 h	310 ef	300 a	3267 gh	1.5 ef	5.7 ef	11.3 de
None	13+50+50	1.8 b	250 de	374 d	307 a	3233 h	1,7 de	5.8 e	11.5 de
1T	None	1.8 b	164 h	270 f	246 bcde	3467 efgh	1.0 f	6.1 b	11.0 e
1T	13+50+50	1.9 b	261 cd	367 d	280 ab	3500 efg	1.2 ef	6.0 cd	11.3 de
2T	None	1.8 b	178 gh	307 ef	246 bcde	3533 ef	1.2 ef	6.1 bcd	11.3 de
2T	13+50+50	1.9 b	288 bc	387 bcd	240 cde	3500 efg	1.2 ef	5.9 d	11.3 de
4T	None	1.9 b	199 fg	300 ef	240 cde	4000 b	0.3 g	6.5 a	11.7 de
4T	13+50+50	1.8 b	301 b	380 cd	254 bcd	3866 bc	0.5 g	6.5 a	11.7 de
Minimum L.S.R. (L.S.D.)(.05)		0.2	28	47	31	237	0.4	0.1	0.7
Maximum L.S.R. (.05)		0.2	33	54	36	273	0.5	0.2	0.8
IRRIGATION MEANS									
Non-irrigated		2.26 a	269 a	393 a	234 b	3725 a	2.1 a	5.7 b	12.9 a
Irrigated		1.83 b	225 b	337 b	265 a	3545 b	1.1 b	6.1 a	11.4 b
Minimum L.S.R. (L.S.D.)(.05)		.02	0.1	0.1	0.1	11	.01	.01	.02
Maximum L.S.R. (.05)		.02	0.1	0.1	0.1	11	.01	.01	.02
LIMESTONE MEANS									
None		2.00 d	232 c	363 c	260 a	3275 d	2.1 a	5.6 d	11.8 d
1Ton		2.04 c	231 d	354 d	258 b	3575 c	1.7 b	5.8 c	12.0 c
2Ton		2.05 b	250 b	376 a	248 c	3617 b	1.6 c	5.7 b	12.2 b
4Ton		2.10 a	275 a	367 b	230 d	4075 a	1.0 d	6.3 a	12.5 a
Minimum L.S.R. (L.S.D.)(.05)		.04	0.1	0.1	0.1	0.1	.01	.01	.01
Maximum L.S.R. (.05)		.04	0.1	0.1	0.1	0.1	.01	.01	.01
FERTILIZER MEANS									
	None	2.03 a	199 b	328 b	248 a	3646 a	1.5 a	5.9 a	12.1 a
	13+50+50	2.07 a	295 a	402 a	250 a	3625 a	1.6 a	5.8 b	12.2 a
Minimum L.S.R. (L.S.D.)(.05)		.74	10	16	11	84	.2	.06	0.3
Maximum L.S.R. (.05)		.74	10	16	11	84	.2	.06	0.3
Coefficient of Variance		5.9%	6.6%	7.4%	7.3%	3.8%	16.4%	1.4%	3.2%
				Portageville Clay					
LIMESTONE X FERTILIZER									
None	None	2.30 a	211 a	467 a	940 a	5733 b	5.3 a	5.5 d	24.2 a
None	13+50+50	2.43 a	261 a	473 a	900 a	5767 b	4.5 b	5.7 cd	23.2 bc
1	None	2.47 a	229 a	487 a	927 a	5833 ab	4.3 bc	5.8 bc	23.5 ab
1	13+50+50	2.33 a	274 a	467 a	927 a	5767 b	3.7 bcd	6.0 a	22.5 cd
2	None	2.43 a	238 a	437 a	913 a	5900 a	3.8 bcd	5.9 ab	22.8 bcd
2	13+50+50	2.43 a	265 a	450 a	940 a	5833 ab	3.5 cd	6.0 a	22.7 bcd
4	None	2.40 a	244 a	437 a	913 a	5900 a	3.0 d	6.1 a	22.0 d
4	13+50+50	2.27 a	231 a	453 a	913 a	5900 a	3.5 cd	6.0 a	22.5 cd
Minimum L.S.R. (L.S.D.)(.05)		.46	59	73	55	115	.82	.18	.84
Maximum L.S.R. (.05)		.50	64	80	61	126	.89	.20	.91
LIMESTONE MEANS									
None		2.37 a	236 a	470 a	920 a	5750 c	4.9 a	5.6 c	23.7 a
1T		2.40 a	252 a	477 a	927 a	5800 bc	4.0 b	5.9 b	23.0 b
2T		2.43 a	252 a	443 a	927 a	5867 ab	3.7 bc	6.0 ab	22.8 bc
4 T		2.33 a	238 a	445 a	913 a	5900 a	3.3 c	6.1 a	22.8 c
Minimum L.S.R. (L.S.D.)(.05)		.33	41	51	39	82	.58	.13	.59
Maximum L.S.R. (.05)		.35	44	55	42	87	.61	.14	.63
FERTILIZER MEANS									
	None	2.40 a	231 a	456 a	923 a	5842 a	4.1 a	5.8 b	23.1 a
	13+50+50	2.37 a	258 a	461 a	920 a	5817 a	3.8 a	5.9 a	22.7 a
Minimum L.S.R. (L.S.D.)(.05)		.23	29	36	28	58	.41	.09	.42
Maximum L.S.R. (.05)		.23	29	36	28	58	.41	.09	.42
Coefficient of Variance		10.3%	12.8%	8.4%	3.2%	10.5%	10.9%	1.7%	1.9%

Duncan's Multiple Range Test: Results followed by the same letters are not significantly different (.05).

CHISELING AND IRRIGATION OF SOYBEANS
1967 EXPERIMENTAL RESULTS

Portageville Field

	Bushels of Soybeans Per Acre			
	Sandy Loam Soil		Clay Soil	
	Non-irrigated	Irrigated	Non-irrigated	Irrigated
Chisel Middles	44.9 a	46.1 a	36.8 a	29.3 a
Check	44.9 a	48.0 a	37.0 a	29.1 a
Irrigation Means	44.9	47.0	36.9	29.2
Minimum Least Significant Range(L. S. D.)(. 05)	2.9		1.6	
Maximum Least Significant Range(. 05)	2.9		1.6	
Coefficient of Variance	4.4%		3.0%	

	Sandy Loam Soil	Clay Soil
Hill Soybeans planted	May 23	May 23
Irrigated	August 23 and September 5	August 8

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (. 05).

The middles between rows were chiseled 12 inches deep July 19 in order to increase penetration of irrigation water.

Chiseling increased yield of soybeans on the loam irrigated plots but not significantly. There was no effect of chiseling on the clay soil.

Irrigation increased yields on both soil types in 1967.

FERTILIZER AND IRRIGATION REQUIREMENTS OF SOYBEANS
1966-67 -- EXPERIMENTAL RESULTS

Clarkton Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	H	pH	C.E.C.
Topsoil	1.0	190	160	220	1100	2.2	5.5	6.2

	Bushels Soybeans Per Acre			
	1966		1967	
Soil Treatment	*Non-irrigated	Irrigated	Non-irrigated	Irrigated
None	40.1 abcdefgh	40.9 abcdefgh	22.5 b	37.7 abc
(Seed not inoculated)	38.9 bcdefgh	41.5 abcdefgh	22.3 b	36.4 abc
0 + 0+30	39.0 bcdefgh	44.1 abcdef	23.5 b	36.7 abc
0 + 0+60	36.0 fgh	41.4 abcdefgh	21.8 b	37.0 abc
0 +30+60	42.7 abcdefg	47.7 a	25.2 ab	43.6 a
7-1/2+33+25-1/2+Traces	38.2 cdefgh	45.6 abcde	25.7 ab	39.4 abc
7-1/2+33+25-1/2	43.6 abcdef	46.8 ab	23.8 b	42.5 ab
6 +18+30+3 mn	41.6 abcdefgh	46.6 ab	22.8 b	41.9 abc
6 +22+22+3 zn	37.8 defgh	45.6 abcde	26.0 ab	36.5 abc
4 lbs. Boron	40.4 abcdefgh	44.9 abcde	28.8 a	35.4 bc
2 lbs. Boron	37.4 efgh	45.4 abcde	23.3 b	37.9 abc
100 lbs. Trace Element Mixture	38.3 cdefgh	45.9 abcd	25.4 ab	36.5 abc
50 lbs. Nitrogen sidedress July	35.2 gh	43.5 abcdef	24.3 ab	35.9 abc
100 lbs. Nitrogen sidedress July	36.1 fgh	46.3 abc	25.0 ab	35.6 bc
100 lbs. Sulphur	33.6 h	44.1 abcdef	23.7 b	34.5 c
Minimum Least Significant Range(L.S.D.)(.05)	6.9		4.2	6.8
Maximum Least Significant Range (.05)	8.3		5.0	8.0
<u>IRRIGATION MEANS</u>	38.6 b	44.7 a	24.3	37.8
Minimum Least Significant Range(L.S.D.)(.05)	1.8			
Maximum Least Significant Range (.05)	1.8			
Coefficient of Variance	9.9%		10.4%	10.8%
Hill soybeans planted:	May 5		May 5	
Irrigated	June 27 July 12, 27	June 27 July 12, 27 September 8	None	June 15 August 14 September 5

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different.

* These plots were irrigated same as irrigated plots except last irrigation September 8 on which no water was applied.
The one extra irrigation on September 8, 1966 increased yields of soybeans by 6 bushels. In 1967 irrigation increased yields on average of 13.5 bushels as compared to the non-irrigated plots. The above data indicates a response to phosphate on the irrigated plots in 1967 even though the soil test indicates an ample supply. Trace elements did not improve yields but in some instances reduced yields of soybeans.

NITROGEN AND IRRIGATION REQUIREMENTS OF SOYBEANS
1966 EXPERIMENTAL RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Sandy Loam Soil	2.0	208	300	320	4200	5.0	2.0	14.0
Clay Soil	2.6	288	453	1047	5567	5.5	4.2	23.0

Soil Treatment $N+P_2O_5+K_2O$	Bushels Soybeans Per Acre			
	Sandy Loam Soil		Clay Soil	
	*Irrigated	Non-irrigated	**Irrigated	Non-Irrigated
No Treatment	47.8 a	48.0 a	22.7 a	21.5 a
50+0+0	46.4 a	48.0 a	22.3 a	21.3 a
100+0+0	49.3 a	48.0 a	22.8 a	21.1 a
Average	47.8	48.0	22.6	21.3
Minimum Least Significant Range(L.S.D.)(.05)	4.0	5.2	2.4	1.1
Maximum Least Significant Range(.05)	4.1	5.3	2.5	1.2
Coefficient of Variance	3.7%	4.8%	4.7%	2.4%

* Irrigated loam soil July 15, July 28 and September 9.
** Irrigated clay soil July 13 and September 10.
Hill soybeans planted May 27 on loam and May 31 on clay soil.

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different at 5% level.

Yields of soybeans were not significantly increased by nitrogen and irrigation on the loam soil but a slight increase in yield was obtained by irrigation on the clay soil.

WHEAT AND SOYBEAN ROTATION
1966-67 -- EXPERIMENTAL RESULTS

Portageville-Clay Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	H	pH	C.E.C.
Topsoil:	1.7	150	500	1140	3800	14.0	4.2	29.0

	Bushels Per Acre			
	1966		1967	
Methods of Handling Wheat Straw	Wheat	Soybeans	Wheat	Soybeans
Straw burned - disc and plant soybeans	43.8 a	20.2 b	27.9 ab	32.2 b
Straw scattered - disc and plant soybeans	42.7 a	17.8 b	25.5 bc	31.9 b
Straw scattered - break, disc and plant soybeans	43.3 a	17.8 b	24.4 c	30.7 b
Straw scattered with 33 lbs. nitrogen break, disc and plant soybeans	43.4 a	21.3 b	24.7 c	32.3 b
Straw scattered - disc and plant soybeans 12+48+48 applied to soybeans	44.2 a	18.3 b	27.8 ab	30.9 b
Straw burned - disc and plant soybeans 12+48+48 applied to soybeans	45.4 a	20.4 b	29.4 a	32.0 b
Full season soybeans		37.2 a		40.9 a
Full season cotton	Seed Cotton 1818		Seed Cotton 1383	
Minimum Least Significant Range(L.S.D.)(.05)	8.7	6.9	5.4	5.8
Maximum Least Significant Range(.05)	9.7	7.8	6.0	6.6
Coefficient of Variance	7.5%	12.2%	7.0%	6.8%
Monon Wheat seeded	November 18, 1965		October 22, 1966	
Full season Hill soybeans planted	May 28, 1966		May 23, 1967	
Hill soybeans following wheat planted	July 9, 1966		June 17, 1967	

Duncan's Multiple Range Test: Yields followed by same letters are not significantly different.

Wheat planted in fall with 9+36+36 starter and topdress in March with 66# Nitrogen.
No fertilizer applied to full season soybeans but rotated with cotton plots.
Fertilizer applied to cotton plots 100+50+50.
All plots irrigated as needed.

This experiment was designed to determine the benefits of retaining the wheat straw or burning prior to planting soybeans after harvesting the wheat. Also included various methods of preparing the soil for planting soybeans.

Above data indicates that full season soybeans have produced highest yields but did not have benefit of the wheat crop. Burning the straw as indicated above has produced as high or higher yields as compared to plowing it under. This fact may be changed after the experiment has continued for several years.

FERTILIZER EXPERIMENTS WITH WHEAT
1966 EXPERIMENTAL RESULTS

SUMMARY OF INITIAL SOIL TESTS

Location:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Clarkton Field	1.0	240	135	30	0	4.4	3.5	3.8	Sand
Portageville Field	1.7	224+	590	300	2500	4.8	3.0	11.1	Fine Sandy Loam
Portageville Field	2.4	189	455	940	6500	5.5	4.0	24.7	Clay

Limestone has been applied to Clarkton and Portageville-Loam since initial soil tests were taken. Additional soil tests will be taken at completion of experiment.

Soil Treatments			Bushels of Wheat Per Acre			(1) Bushels of Soybeans Per Acre
Basic Plowdown	Starter $N+P_2O_5+K_2O$	Nitrogen Top Dress	Clarkton	Portageville Loam	Portageville Clay	Portageville Loam
INFLUENCE OF PLOWDOWN, STARTER, AND NITROGEN FERTILIZER ON WHEAT YIELDS						
No Treatment			10.9 g	26.9 e	9.2 d	38.1 ab
	9+36+36	None	14.0 f	27.4 de	12.6 d	40.1 ab
	None	33#N-March	30.4 e	37.6 abc	20.7 c	37.1 ab
	9+36+36	33#N-March	32.9 de	38.8 ab	24.6 bc	37.8 ab
	None	66#N-March	34.5 d	41.1 a	32.4 ab	35.6 ab
	9+36+36	66#N-March	38.6 c	37.7 abc	36.5 a	34.2 b
	9+36+36	100#N-March	42.1 abc	37.3 abcd	37.9 a	35.7 ab
	9+36+36	132#N-March	45.5 a	30.1 bcde	40.8 a	40.6 a
0+400+0	9+36+36	None	15.1 f	28.4 cde	11.0 d	34.9 ab
0+400+0	9+36+36	33#N-March	31.2 de	36.5 abcde	24.5 bc	34.2 b
0+400+0	9+36+36	66#N-March	39.6 bc	37.4 abcd	32.7 ab	36.3 ab
0+400+0	9+36+36	100#N-March	42.4 abc	36.9 abcd	34.8 a	35.3 ab
0+400+0	9+36+36	132#N-March	43.3 ab	36.5 abcde	37.3 a	34.3 b
Minimum Least Significant Range(L.S.D.)(.05)			3.6	8.8	7.8	5.3
Maximum Least Significant (.05)			4.2	10.3	9.1	6.2
Coefficient of Variance			6.6%	15.1%	16.9%	8.7%
INFLUENCE OF TIME OF NITROGEN APPLICATION ON YIELDS OF WHEAT						
	9+36+36	66#N-Seeding	22.9 b	34.8 b	38.6 a	39.8 a
	9+36+36	66#N-January	38.0 a	38.6 ab	38.7 a	39.2 ab
	9+36+36	66#N-March	39.5 a	41.7 a	45.1 a	37.6 b
	9+36+36	66#N-April	25.1 b	38.0 ab	43.4 a	38.9 ab
	9+36+36+Trace	66#N-March	38.3 a	42.5 a	45.6 a	38.6 ab
Minimum Least Significant Range(L.S.D.)(.05)			2.3	4.4	9.4	1.6
Maximum Least Significant Range(.05)			2.4	4.7	10.1	1.8
Coefficient of Variation			3.7%	5.4%	11.8%	2.3%
INFLUENCE OF STARTER FERTILIZERS ON WHEAT YIELDS						
	9+36+36	66#N-March	42.0 ab	40.8 a	46.0 a	38.9 a
		75+36+36-March	40.5 b	44.3 a	44.7 a	36.8 a
	9+ 0+36	66#N-March	40.5 b	42.8 a	45.4 a	35.3 a
	9+36+ 0	66#N-March	43.4 a	42.0 a	45.5 a	36.8 a
	6+24+24	69#N-March	43.3 ab	41.7 a	45.6 a	38.3 a
	12+48+12	63#N-March	41.6 ab	41.8 a	45.8 a	39.3 a
Minimum Least Significant Range(L.S.D.)(.05)			2.6	4.4	4.7	4.7
Maximum Least Significant Range(.05)			2.8	4.8	5.1	5.2
Coefficient of Variance			3.4%	5.7%	5.6%	6.9%
Monon wheat planted:			Oct 4, 1965	Oct 5, 1965	Oct 7, 1965	

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

These results indicate that nitrogen was essential at all locations. The application of a starter in addition to the nitrogen increased yields at all locations.

The March application of nitrogen produced higher yields of wheat as compared to applying all nitrogen at seeding or in April but increases at two locations were statistically significant.

(1) Hill soybeans were planted June 14 on the plots of the loam soil to determine carryover effect of the fertilizer applied to the wheat. No fertilizer was applied to the soybeans. Soybeans irrigated July 7.

FERTILIZER EXPERIMENTS WITH WHEAT AND SOYBEANS
1967 EXPERIMENTAL RESULTS

SUMMARY OF INITIAL SOIL TESTS

Location:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Clarkton Field	1.0	240	135	30	0	4.4	3.5	3.8	Sand
Portageville Field	1.7	224+	590	300	2500	4.8	3.0	11.1	Fine Sandy Loam
Portageville Field	2.4	189	455	940	6500	5.5	4.0	24.7	Clay

Limestone has been applied to Clarkton and Portageville-Loam since initial soil tests were taken. Additional soil tests will be taken at completion of experiment.

Soil Treatment			Bushels of Wheat Per Acre			Bushels of Soybeans Per Acre		
Basic Plowdown	Starter $N+P_2O_5+K_2O$	Nitrogen Top Dress	Clarkton	Portageville Loam	Portageville Clay	Clarkton	Portageville Loam	Portageville Clay
INFLUENCE OF PLOWDOWN, STARTER AND NITROGEN FERTILIZER								
No Treatment			10.8 c	17.6 e	4.8 f	28.3 b	21.4 a	34.8 a
	9+36+36	None	20.6 b	22.0 d	5.6 f	32.0 ab	22.6 a	33.3 a
	None	33#N-March	24.5 b	27.4 cd	13.3 e	31.2 ab	20.7 a	33.0 a
	9+36+36	33#N-March	32.1 a	31.0 abc	16.3 d	34.2 ab	21.8 a	33.1 a
	None	66#N-March	21.0 b	32.0 abc	22.3 c	28.7 b	22.0 a	33.1 a
	9+36+36	66#N-March	32.7 a	33.4 abc	26.6 b	32.8 ab	21.6 a	33.0 a
	9+36+36	100#N-March	32.2 a	31.9 abc	28.7 ab	34.2 ab	20.9 a	34.2 a
	9+36+36	132#N-March	33.8 a	35.3 ab	30.1 a	33.8 ab	23.5 a	35.2 a
0+400+0	9+36+36	None	23.8 b	23.2 d	6.6 f	34.2 ab	23.0 a	33.8 a
0+400+0	9+36+36	33#N-March	30.3 a	31.0 abc	15.9 d	35.9 a	22.9 a	34.1 a
0+400+0	9+36+36	66#N-March	33.6 a	36.6 a	26.7 b	36.2 a	22.6 a	35.4 a
0+400+0	9+36+36	100#N-March	33.1 a	33.5 abc	28.7 ab	36.9 a	22.5 a	34.9 a
0+400+0	9+36+36	132#N-March	32.7 a	29.5 bc	29.7 a	36.6 a	20.1 a	34.2 a
Minimum Least Significant Range(L. S. D.)(.05)			4.5	5.6	2.5	5.2	3.8	4.1
Maximum Least Significant Range (.05)			5.2	6.5	2.9	6.0	4.4	4.7
Cofficient of Variance			9.6%	11.3%	7.6%	9.1%	10.2%	7.1%
INFLUENCE OF TIME OF NITROGEN APPLICATION ON YIELDS								
	9+36+36	66#N-Seeding	29.8 c	36.8 ab	18.3 b	34.4 a	27.3 abc	41.2 a
	9+36+36	66#N-January	34.1 b	35.4 bc	18.7 b	32.7 a	25.7 c	41.0 a
	9+36+36	66#N-March	33.9 b	39.0 a	25.6 a	33.8 a	26.5 bc	43.2 a
	9+36+36	66#N-April	29.7 c	33.7 c	19.7 b	35.5 a	28.2 a	42.6 a
	9+36+36+Trace	66#N-March	37.0 a	37.8 ab	26.3 a	35.7 a	27.6 ab	43.8 a
Minimum Least Significant Range(L. S. D.)(.05)			2.6	2.5	2.4	3.0	1.6	3.9
Maximum Least Significant Range (.05)			2.8	2.6	2.6	3.2	1.7	4.2
Coefficient of Variance			4.2%	3.4%	5.9%	4.6%	3.1%	4.9%
INFLUENCE OF STARTER FERTILZIERS ON YIELDS								
	9+36+36	66#N-March	36.2 ab	39.2 ab	24.4 ab	36.1 a	27.8 a	39.1 a
		75+36+36-March	33.1 b	37.5 b	23.5 b	37.5 a	28.0 a	39.1 a
	0+ 0+36	66#N-March	36.8 ab	40.1 a	27.9 a	38.3 a	26.6 a	38.5 a
	9+36+ 0	66#N-March	33.1 b	40.5 a	27.5 a	38.2 a	27.2 a	39.1 a
	6+24+24	69#N-March	37.9 a	39.7 a	27.8 a	37.9 a	28.0 a	41.2 a
	12+48+12	63#N-March	36.9 ab	40.4 a	27.4 a	38.7 a	28.5 a	37.4 a
Minimum Least Significant Range(L. S. D.)(.05)			3.8	2.1	3.6	3.6	3.0	4.1
Maximum Least Significant Range (.05)			4.2	2.3	3.9	4.0	3.3	4.5
Coefficient of Variance			5.9%	2.9%	7.4%	5.3%	6.0%	5.8%
Monon wheat planted:			Sept 23 '66	Oct 29 '66	Oct 11 '66			
Wheat harvested:			June 6	June 7	June 7			
Hill soybeans planted following wheat:						June 8	Replanted June 27	June 8
Irrigated:						Aug 14 Sept 5	Sept 11	Aug 18 Sept 6

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

These data indicate that nitrogen was essential at all locations. A complete starter increased yields at all locations but was not statistically significant on the Portageville sandy loam soil.

Topdressing wheat in March produced higher yields than oth mes of application tested.

FERTILIZER EXPERIMENTS WITH WHEAT
1966 EXPERIMENTAL RESULTS

LOCATION: Jerry Griffith farm near Qulin, Missouri

Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Topsoil:	1.6	22	60	180	1500	4.2	4.0	8.5	Silt Loam

Soil Treatment		Bushels of Wheat Per Acre			Bushels of Soybeans Per Acre	
Starter $N+P_2O_5+K_2O$	Topdress $N+P_2O_5+K_2O$	No Limestone	2 Tons Fine Limestone	Fertilizer Means	No Limestone	2 Tons Fine Limestone
No Treatment		16.8 fg	18.1 fg	17.4 ef	20.4 abc	22.8 a
9+36+36		23.8 f	32.0 e	27.9 d	19.9 abc	24.5 a
	33#N-March	11.4 g	10.4 g	10.9 g	15.3 c	16.4 b
9+36+36	33#N-March	38.5 bcde	44.6 abcd	41.5 abc	18.6 abc	23.0 a
	50#N-March	15.9 fg	11.2 g	13.6 efg	15.7 c	20.9 ab
9+36+36	50#N-March	35.8 de	42.9 abcd	39.4 c	19.6 abc	23.8 a
	66#N-March	19.2 fg	12.8 g	16.0 efg	16.6 abc	20.0 ab
9+36+36	66#N-March	44.9 abcd	48.1 ab	46.5 ab	20.9 ab	22.8 a
	100#N-March	13.4 g	10.2 g	11.8 fg	16.7 abc	15.8 b
9+36+36	100#N-March	46.2 abc	45.6 abc	45.9 ab	20.4 abc	24.2 a
75+36+36		44.4 abcd	47.8 ab	46.1 ab	21.5 a	24.3 a
	75+36+36-March	18.7 fg	18.4 fg	18.5 c	19.4 abc	23.8 a
9+36+36+Traces	66#N-March	44.8 abcd	50.3 a	47.6 a	19.4 abc	24.8 a
9+36+36	66#N-January	35.6 de	42.8 abcd	39.2 c	18.2 abc	22.3 a
9+36+36	66#N-April	37.4 cde	40.2 bcde	38.8 c	19.9 abc	22.2 a
9+36+36	132#N-March	36.9 cde	44.2 abcd	40.5 bc	16.1 abc	23.3 a
Minimum Least Significant Range(L.S.D.)(.05)		8.2		5.8	4.4	5.0
Maximum Least Significant Range (.05)		10.0		7.0	5.2	5.9
Coefficient of Variance		15.9%		15.9%	14.2	13.4

LIMESTONE MEANS	Wheat	Soybeans
No limestone	30.2 b	18.7
2 Tons Fine Limestone	32.5 a	22.2
Minimum Least Significant Range(L.S.D.)(.05)	2.0	-
Maximum Least Significant Range (.05)	2.0	-
Coefficient of Variance	15.9%	-

Monon wheat planted October 26, 1965. Harvested June 17, 1966.
Hill soybeans planted June 19 and harvested October 28, 1966.
Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

Results indicate a significant increase in yields with the application of phosphate on this soil which has a low phosphate test. The application of limestone improved yields where nitrogen, phosphate, and potash were added.

Nitrogen was essential for maximum yields with 66 pounds applied in March being the most effective.

FERTILIZER EXPERIMENTS WITH WHEAT
1966 EXPERIMENTAL RESULTS

LOCATION: Jerry Griffith farm near Qulin, Missouri

Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.	Soil Type
Topsoil:	1.6	22	60	180	1500	4.2	4.0	8.5	Silt Loam

Soil Treatment		Bushels of Wheat Per Acre			Bushels of Soybeans Per Acre		
Starter $N+P_2O_5+K_2O$	Pounds Nitrogen Topdress in March	No Limestone	2 Tons Fine Limestone	Fertilizer Means	No Limestone	2 Tons Fine Limestone	Fertilizer Means
PHOSPHATE X POTASH X LIMESTONE							
10+ 0+ 0	50	7.4 k	13.7 j	10.5 f	12.2 l	25.0 abcdef	18.6 e
10+ 0+30	50	13.0 j	20.6 ij	16.8 f	15.6 jkl	24.6 bcdef	20.1 de
10+ 0+60	50	12.1 j	16.9 ij	14.5 f	12.5 kl	18.5 hijk	15.5 f
10+ 0+90	50	11.2 jk	19.7 ij	15.5 f	14.2 kl	23.0 defgh	18.6 e
10+30+ 0	50	26.0 ghi	39.5 bcdef	32.8 de	17.4 ijk	25.5 abcde	21.5 bcde
10+30+30	50	23.4 hi	33.3 defg	28.3 e	17.1 ijk	23.5 cdefg	20.3 cde
10+30+60	50	30.1 fgh	37.1 cdef	33.6 de	17.0 ijk	26.0 abcd	21.5 bcde
10+30+90	50	32.3 efgh	42.4 abcde	37.4 cd	18.0 ijk	27.3 abcd	22.7 abcd
10+60+ 0	50	42.7 abcd	46.8 abc	44.7 ab	21.0 efghi	29.7 a	25.4 a
10+60+30	50	40.3 bcde	49.0 ab	44.6 ab	19.9 ghij	29.8 a	24.8 ab
10+60+60	50	36.6 cdef	46.6 abc	41.6 bc	18.0 ijk	27.9 abc	22.9 abcd
10+60+90	50	39.2 bcdef	48.0 ab	43.6 abc	18.9 ghijk	29.5 a	24.2 ab
10+90+ 0	50	36.8 cdef	46.0 abc	41.4 bc	18.1 ijk	26.4 abcd	22.2 abcd
10+90+30	50	46.5 abc	50.9 a	48.7 a	20.6 fghi	29.0 ab	24.8 ab
10+90+60	50	39.7 bcdef	45.7 abc	42.7 abc	19.8 ghij	27.4 abcd	23.6 abc
10+90+90	50	43.9 abc	46.4 abc	45.2 ab	18.0 ijk	27.5 abcd	22.8 abcd
Minimum Least Significant Range(L.S.D.)(.05)		8.7		6.2	4.1		2.9
Maximum Least Significant Range(.05)		10.7		7.5	5.0		3.5
PHOSPHATE MEANS							
0		10.9 c	17.7 d	14.3 c	13.6 e	22.8 c	18.1 c
30		28.0 c	38.1 b	33.0 b	17.4 d	25.6 b	21.5 b
60		39.7 b	47.6 a	43.6 a	19.5 d	29.2 a	24.3 a
90		41.7 b	47.3 a	44.5 a	19.1 d	27.6 ab	23.4 a
Minimum L.S.R.(L.S.D.)(.05)		4.4		3.1	2.1		1.5
Maximum L.S.R.(.05)		5.0		3.4	2.4		1.6
POTASH MEANS							
0		28.2 b	36.5 a	32.3 a	17.2 b	26.7 a	21.9 ab
30		30.8 b	38.4 a	34.6 a	18.3 b	26.7 a	22.5 a
60		29.6 b	36.6 a	33.1 a	16.8 b	24.9 a	20.9 b
90		31.6 b	39.2 a	35.4 a	17.3 b	26.8 a	22.1 ab
Minimum L.S.R.(L.S.D.)(.05)		4.4		3.1	2.1		1.5
Maximum L.S.R.(.05)		5.0		3.4	2.4		1.6
LIMESTONE MEANS							
No limestone		30.1 b			17.4 b		
2 Tons Fine Limestone		37.7 a			26.3 a		
Minimum L.S.R.(L.S.D.)(.05)		2.2			1.0		
Maximum L.S.R.(.05)		2.2			1.0		
Coefficient of Variance		15.7%			11.5%		

Monon wheat planted October 26, 1965 and harvested June 17, 1966.
Hill soybeans planted June 19 and harvested October 28, 1966.

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

The above data indicates that phosphate and limestone produced excellent yield increases of wheat but potash had little or no effect. This soil had a very low test in phosphorous and potassium.

SOIL FERTILITY EXPERIMENT WITH SUGAR BEETS
1966 -- EXPERIMENTAL RESULTS

Portageville Field Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Sandy Loam Soil	2.5	208	300	320	4200	5.0	2.0	14.0
Clay Soil	2.7	346	360	940	7000	5.9	2.0	24.0

*Soil Treatment			Sandy Loam Soil				Clay Soil			
Starter $N+P_2O_5+K_2O$	Nitrogen Sidedress		No Beets 100 Feet	Percent Sugar	Juice Purity Percent	Yield Tons/Acre	No Beets 100 Feet	Percent Sugar	Juice Purity Percent	Yield Tons/Acre
	July 8	August 9								
No Treatment			114 a	12.1 a	91.3	12.7 a	130 b	14.0 ab	92.0 a	5.4 e
50+ 50+ 50			120 a	12.6 a	90.1	13.4 a	170 a	14.0 ab	91.8 a	16.0 cd
100+ 50+ 50			114 a	12.4 a	88.8	12.0 a	160 a	14.4 a	91.4 a	15.5 d
100+ 0+ 50	50#N		138 a	11.6 a	87.8	12.7 a	170 a	14.2 a	91.2 a	19.4 ab
100+ 50+ 0	50#N		123 a	11.5 a	90.4	12.8 a	158 a	13.7 ab	90.7 a	17.4 bcd
100+ 50+ 50	50#N		129 a	12.1 a	89.7	12.4 a	166 a	14.0 ab	91.9 a	20.0 ab
100+ 50+ 50	50#N	50#N	123 a	11.2 a	89.6	11.2 a	170 a	13.5 ab	90.5 a	18.5 abc
100+ 50+ 50	100#N		140 a	11.4 a	89.4	12.2 a	185 a	14.4 a	91.6 a	19.9 ab
100+100+100			123 a	11.3 a	89.5	12.5 a	177 a	14.3 a	92.7 a	19.1 ab
100+100+100	50#N	50#N	117 a	11.9 a	88.3	12.9 a	159 a	13.1 b	91.9 a	18.3 abc
100+100+100	100#N	100#N	126 a	10.9 a	89.1	12.1 a	167 a	13.1 b	89.9 a	21.1 a
100+100+100+Boron	50#N	50#N	128 a	11.2 a	89.9	12.4 a	179 a	14.3 a	91.3 a	19.0 ab
100+100+100	50#N	100#N	130 a	11.8 a	90.1	12.6 a	169 a	13.5 ab	90.1 a	18.9 ab
All Treatment Means										
Minimum L.S.R.(L.S.D.)(.05)			33	1.5	2.5	2.0	25	0.9	2.7	2.6
Maximum L.S.R.(.05)			39	1.7	2.9	2.4	29	1.1	3.2	3.0
Coefficient of Variance			18.4%	8.8%	1.9%	11.3%	10.4%	4.7%	2.1%	10.1%

GWH 1 planted April 22 on loam: March 18 on clay soil.
Irrigated as needed: June 24, July 15, July 28 (loam only), September 10.

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

Sugar beets were late on the loam soil because of necessity to replant. Soil physical properties of the loam are such that emergence of the small plants has been very difficult.

The above data indicates that 100 to 150 pounds of nitrogen was required on the clay soil to produce maximum yields.

SOIL FERTILITY EXPERIMENTS WITH ALFALFA
1967 EXPERIMENTAL RESULTS

Portageville Field - Clay Soil Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Topsoil:	2.9	156	360	840	6000	5.7	2.0	21.0
Subsoil:	1.9	203	400	965	6400	6.4	1.0	21.5

Soil Treatment			Tons Yield of Hay Per Acre				
Limestone	Initial Fertilizer $N+P_2O_5+K_2O$	1967 Topdress $N+P_2O_5+K_2O$	1st Cutting June 12	2nd Cutting July 18	3rd Cutting August 10	4th Cutting Sept. 18	Total
LIMESTONE X FERTILIZER MEANS							
None	None	None	1.46 f	1.19 c	.68 d	.48 cd	3.81 e
None	0+400+ 0	0+50+ 0	1.88 de	1.33 ab	.79 bc	.52 bcd	4.52 bcd
None	0+400+200	0+50+100	1.92 cde	1.29 bc	.81 abc	.55 abc	4.57 bcd
None	0+ 0+200	0+ 0+100	1.68 ef	1.41 ab	.74 bcd	.55 abc	4.38 cd
3 Tons	None	None	1.77 ef	1.27 bc	.75 bcd	.47 cd	4.26 de
3 Tons	0+400+ 0	0+50+ 0	1.85 ef	1.27 bc	.72 cd	.46 d	4.30 de
3 Tons	0+400+200	0+50+100	2.02 bcde	1.38 ab	.83 ab	.53 bcd	4.76 bcd
3 Tons	0+ 0+200	0+ 0+100	1.92 cde	1.34 abc	.80 bc	.56 abc	4.62 bcd
6 Tons	None	None	2.31 abc	1.26 bc	.76 bcd	.55 abcd	4.88 bcd
6 Tons	0+400+ 0	0+50+ 0	2.34 ab	1.36 ab	.81 abc	.54 bcd	5.05 bc
6 Tons	0+400+200	0+50+100	2.30 abcd	1.35 ab	.82 abc	.63 a	5.10 ab
6 Tons	0+ 0+200	0+ 0+100	2.68 a	1.50 a	.91 a	.59 ab	5.68 a
Minimum Least Significant Range(L.S.D.)(.05)			.38	.14	.09	.04	.50
Maximum Least Significant Range(.05)			.38	.17	.11	.04	.58
LIMESTONE MEANS							
None			1.73 b	1.30 a	.76 b	.53 b	4.32 b
3 Tons			1.89 b	1.31 a	.77 b	.50 b	4.47 b
6 Tons			2.41 a	1.36 a	.83 a	.58 a	5.18 a
Minimum Least Significant Range(L.S.D.)(.05)			.19	.07	.05	.04	.25
Maximum Least Significant Range(.05)			.20	.08	.05	.04	.26
FERTILIZER MEANS							
	None		1.84 b	1.24 c	.73 b	.50 b	4.31 b
	0+400+ 0	0+50+ 0	2.02 ab	1.32 bc	.77 ab	.51 b	4.62 ab
	0+400+200	0+50+100	2.08 a	1.34 ab	.82 a	.57 a	4.81 a
	0+ 0+200	0+ 0+100	2.09 a	1.41 a	.82 a	.57 a	4.89 a
Minimum Least Significant Range(L.S.D.)(.05)			.22	.08	.05	.05	.29
Maximum Least Significant Range(.05)			.24	.09	.06	.05	.31
Coefficient of Variance			11.0%	6.3%	7.0%	8.7%	6.4%

Limestone and initial fertilizer applied September 1960.
Buffalo alfalfa was reseeded September 1966 after losing previous stand to high water.
Topdress application of fertilizer was applied only in 1967.

Duncan's Multiple Range Test: Yields followed by the same letters are not significantly different (.05).

The above data indicates maximum yields where six tons of limestone were applied in 1960 with 100 pounds of potash topdressed in 1967..

The stand of alfalfa has been very difficult to maintain on this soil because of high water and winter killing.

ALFALFA-FERTILIZER AND LIMESTONE
1967 SOIL TEST RESULTS

Portageville Field - Clay Soil

Initial Soil Test:	OM	P_2O_5	K	Mg.	Ca	pH	H	C.E.C.
Topsoil:	2.9	156	360	840	6000	4.7	2.0	21.0
Subsoil:	1.9	203	400	965	6400	6.4	1.0	21.5

Limestone	Soil Treatment: Initial Fertilizer $N+P_2O_5+K_2O$	Soil Treatment: 1967 Topdress $N+P_2O_5+K_2O$	O.M.	P_2O_5	K	Mg.	Ca	H	pH	C.E.C.
LIMESTONE X FERTILIZER MEANS										
None	None	None	2.80 a	369 ab	427 ab	947 ab	5700 e	2.67 bc	6.07 cd	21.50 bc
None	0+400+ 0	0+50+ 0	2.80 a	399 ab	447 a	1000 a	5733 de	3.67 a	5.87 e	22.83 a
None	0+400+200	0+50+100	2.70 a	382 ab	420 ab	940 ab	5700 e	3.17 ab	5.93 de	21.83 abc
None	0+ 0+200	0+ 0+100	2.60 a	337 b	427 ab	980 a	5700 e	3.17 ab	5.93 de	22.00 ab
3 Tons	None	None	2.60 a	354 ab	413 ab	973 ab	5800 cd	2.17 bcd	6.23 abc	21.17 bc
3 Tons	0+400+ 0	0+50+ 0	2.70 a	397 ab	393 ab	960 ab	5833 bc	2.17 bcd	6.17 bc	21.33 bc
3 Tons	0+400+200	0+50+100	2.87 a	401 ab	440 ab	940 ab	5833 bc	2.50 bcd	6.20 bc	21.67 bc
3 Tons	0+ 0+200	0+ 0+100	2.67 a	367 ab	417 ab	940 ab	5833 bc	2.50 bcd	6.17 bc	21.50 bc
6 Tons	None	None	2.80 a	409 a	420 ab	960 ab	5933 a	1.50 d	6.43 a	20.83 c
6 Tons	0+400+ 0	0+50+ 0	2.80 a	416 a	413 ab	920 ab	5967 a	2.00 cd	6.33 ab	21.33 bc
6 Tons	0+400+200	0+50+100	2.87 a	416 a	400 ab	920 ab	5900 ab	1.83 cd	6.33 ab	20.83 c
6 Tons	0+ 0+200	0+ 0+100	2.73 a	401 ab	387 b	893 b	5900 ab	2.00 cd	6.30 ab	21.00 bc
Minimum Least Significant Range(L.S.D.)(.05)			.27	58	51	75	89	.91	.18	.99
Maximum Least Significant Range(.05)			.31	67	59	86	103	1.05	.21	1.14
LIMESTONE MEANS										
None			2.73 a	372 b	430 a	967 a	5708 c	3.17 a	5.95 c	22.04 a
3 Tons			2.71 a	380 b	416 a	953 ab	5825 b	2.33 b	6.19 b	21.42 b
6 Tons			2.80 a	411 a	405 a	923 b	5925 a	1.83 c	6.35 a	21.00 b
Minimum Least Significant Range(L.S.D.)(.05)			.14	29	26	37	44	.45	.09	.50
Maximum Least Significant Range(.05)			.14	30	27	40	47	.48	.10	.52
FERTILIZER MEANS										
	None		2.73 a	377 a	420 a	960 a	5811 a	2.11 a	6.24 a	21.17 b
	0+400+ 0	0+50+ 0	2.77 a	404 a	418 a	960 a	5844 a	2.61 a	6.12 b	21.83 a
	0+400+200	0+50+100	2.81 a	400 a	420 a	933 a	5811 a	2.50 a	6.16 ab	21.44 ab
	0+ 0+200	0+ 0+100	2.67 a	368 a	410 a	938 a	5811 a	2.56 a	6.13 b	21.50 ab
Minimum Least Significant Range(L.S.D.)(.05)			.16	33	30	43	51	.52	.10	.57
Maximum Least Significant Range(.05)			.17	36	32	47	55	.57	.11	.62
Coefficient of Variance			5.8%	8.7%	7.2%	4.6%	0.9%	21.7%	1.7%	2.7%

Duncan's Multiple Range Test: Results followed by the same letters are not significantly different (.05).

1967 EXPERIMENTAL RESULTS

The soil physical conditions of the sandy loam soil on the Portageville Field has prevented penetration of irrigation water and plant roots during past seasons. In 1967 Zonolite (expanded mica) was mixed through the soil to a depth of 15 inches prior to planting of sugar beets.

During the growing season the sugar beets on the treated soil produced a larger top growth and required less pressure to insert a soil probe into the soil as compared to the non-treated area. As a result the data below indicates considerable difference in yields.

Soil Treatment	Tons Beets Per Acre	Percent Sugar	Percent Purity
Check	16.0	16.1	93.4
10 Ton Zonolite per acre	23.1	15.2	92.8

The sugar beets on the left side are in the check plot as compared to the beets on the right in the zonolite plot. Even though the subsoil was chiseled it compacted to the extent that the roots could not freely penetrate the soil as indicated by the growth of the beets on the left. The roots on the right grew through the zonolite area but upon reaching the area below the zonolite turned to the side.

The results of this experiment indicate that it is very important that some method be devised to prevent compaction of this soil following periods of high rates of rainfall.

LIMESTONE EXPERIMENT
1967 SOIL TEST RESULTS

Portageville Clay *Calcium Carbonate Limestone Size of Limestone Particles (Mesh per inch)	O.M.	P_2O_5	K	Mg.	Ca	H	pH	C.E.C.
- 10+ 20	1.2 ab	408 a	357 a	587 a	3933 ab	2.2 b	6.0 a	15.0 a
- 20+ 40	1.4 a	382 a	333 a	567 a	4433 a	2.0 b	6.1 a	15.8 a
- 40+ 60	1.0 b	393 a	350 a	593 a	4533 a	2.0 b	6.1 a	16.2 a
- 60+100	1.2 ab	418 a	353 a	573 a	4633 a	1.7 b	6.2 a	16.0 a
-100	1.3 ab	365 a	333 a	693 a	3833 ab	2.8 ab	5.6 ab	15.8 a
Hydrated	1.1 ab	416 a	323 a	593 a	3800 ab	2.5 b	5.8 a	14.8 a
None	1.2 ab	384 a	350 a	700 a	3200 b	4.2 a	5.0 b	15.5 a
Minimum Least Significant Range(L.S.D.)(.05)	0.3	80	90	173	936	1.4	0.7	2.3
Maximum Least Significant Range(.05)	0.4	89	100	192	1039	1.6	0.8	2.6
Coefficient of Variance	15.0%	11.4%	14.5%	15.8%	13.0%	32.2%	7.2%	8.4%

*Limestone applied at rate of 3 tons per acre and plowed down 1963.

Duncan's Multiple Range Test: Results followed by the same letters are not significantly different (.05).

This experiment was designed to determine the effect of various size of limestone particles on soil test results over a period of years.

The above data indicates that after five years the size of particle has had no significant effect on hydrogen ion concentration or pH of the soil.

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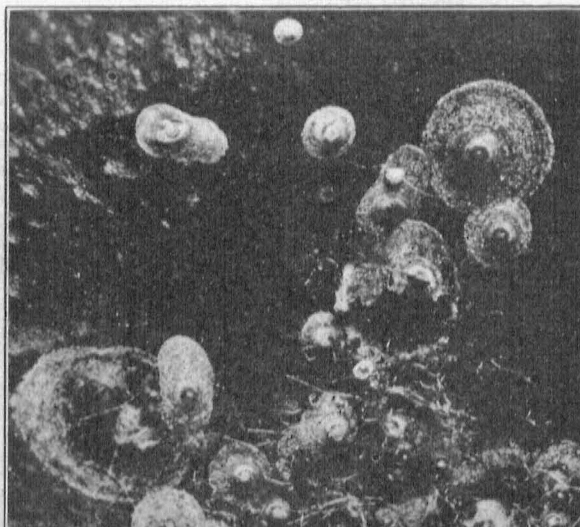

San Jose Scale Showing Female and Male Armors

SAN JOSE SCALE IN MISSOURI

COLUMBIA, MISSOURI.

January 1912

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(2) In the service of the U. S. Department of Agriculture.

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THE SAN JOSE SCALE IN MISSOURI.

By Leonard Haseman.

The San Jose scale was introduced into Missouri some eighteen years ago and has already become so firmly established in the State that hopes of its complete extermination have long since vanished. It has reached a stage where we can only expect to control it by preventing it from spreading further, and by cleaning up the orchards already infested. The control of this pest cannot be accomplished by any one man or any dozen men, but requires the concerted efforts of each and every fruit grower in the State, whether he be a commercial grower or a farmer with a small home orchard. It is the duty of every one engaged in fruit growing to acquaint himself with this pest and the methods of controlling it and then see that he does not shirk his duty when it comes time to act.

It is the aim of this report to place before the fruit growers of the State, as nearly as possible, the actual status of this pest in Missouri, the appearance of the pest, the nature of the injury it does, and the best methods for its control. This should enable anyone to recognize the scale and to know exactly what steps to take when he finds it in his orchard.

The control of the scale is really quite simple. To be sure, it is a very resistant insect, but, with the improved methods of spraying and with the best scale washes which we have today, it is an extremely easy matter to control it. In the control of this pest, first be sure that your trees are infested, then provide yourself with the proper wash and apparatus and spray thoroughly. You can hardly "spray" an infested tree too thoroughly. The scale washes kill by contact largely, so each individual insect must be hit.

The deplorable conditions of the orchards in the infested districts, the constant stream of inquiries from new and widely separated regions, where the scale is appearing, and the seeming lack of information as to the nature of the pest and its control, have called forth this report at this time. This department is especially anxious to see this scourge of the orchard taken in hand before it spreads further, and is ever ready to do all in its power to assist in the control of this and all other insect pests.

HISTORY AND INTRODUCTION INTO MISSOURI.

The San Jose scale was first introduced into this country at San Jose, California, in the early 70's and by 1873 had become so well established in that vicinity that it began to attract the attention of the fruit growers, though very little effort was made to control it until about 1880. During this time it multiplied and spread widely throughout California.

Prof. J. H. Comstock, then chief of the Division of Entomology of the U. S. Department of Agriculture, investigated the new pest and described it in his Annual Report for 1880 as the most pernicious scale insect known to work upon deciduous fruit trees. Despite the fact that active measures were taken by the horticultural societies and communities for the control of the scale, it continued to spread rapidly so that by 1890 it had reached Washington on the north and Mexico on the south, and about this time was carried to the Atlantic States on nursery stock from California.

Unfortunately, the way in which the scale was introduced into the East was most favorable for its immediate widespread dispersal over the entire country. It was introduced almost simultaneously into a couple of the large and well-known nurseries of New Jersey, which were doing business throughout the eastern, southern, central and middle western states. It was present in these nurseries several years before it was discovered, so that during this time thousands of infested trees were sold and numerous infestations established in the various States. In 1893 the attention of the entomologist of the United States Department of Agriculture was called to the presence of the scale in eastern orchards, and upon investigation the source of the infestation was traced to the New Jersey nurseries. Measures were at once taken to prevent further spread from these nurseries and to stamp it out where it was found, but the pest was already widely distributed, as infested orchards were soon located in Pennsylvania, Maryland, Virginia, New Jersey, Georgia, Florida, New York, Delaware, and Ohio.

It was during this general widespread distribution of the scale that the first infestations were brought into Missouri. Between 1891 and 1894 some twenty or thirty private orchards became infested and in each case investigated, the source was traced to the New Jersey nurseries. While the New Jersey nurseries were responsible for the original and unfortunately widespread distribution of the scale in Missouri, it is evident that some introductions are to be traced to other sources. One in particular was traced to a Pennsylvania nursery from which stock had been purchased in 1896, and in 1898 two of the Missouri nurseries received considerable infested stock from an Illinois nursery, but it was discovered in time to prevent its widespread distribution. The original infested orchards, according to Professor Stedman's report of 1898, were confined to St. Louis, Cape Girardeau, Webster, Cole, Randolph, Carroll and Jackson Counties, though some thirty suspected orchards had not been inspected at that time.

With the original infestations confined to a comparatively few private orchards and with the nurseries of the State apparently free from the scale, its control and the prevention of its further spread would have been a simple matter, had the State but taken immediate action in this direction. Many of the States whose horticultural interests were very small as compared with Missouri, rose to the occasion and gave their fruit growers the best protection that could be conceived, while Missouri, whose horticultural interests ranked third, left her fruit growers to the mercy of the scale, and nurserymen of other States turned to Missouri as a dumping ground for their scale-infested nursery stock.

PROVISIONS FOR THE CONTROL OF THE PEST IN MISSOURI.

It was not until 1899* that the legislature took steps toward the control of the pest in this State. In connection with the statutes of 1899 the act establishing the State Fruit Experiment Station at Mountain Grove, placed the control of insect pests and plant diseases dangerous to fruit growing in the hands of the Director and Inspector of that Station. This act was extremely complicated. It gave the Director and In-

Fig. 2.—San Jose scale. Apple moderately infested showing all stages of the pest. Natural size. (Original)

spector power to inspect but they must report their findings to the County Court which authorized the cleaning up of infested or infected premises. It would have been absolutely impossible to have carried out the portion of this act covering

*Article III, Chapter 67, Revised Statutes of 1899.

inspection work with any degree of success, even if the necessary funds had been provided, but as they were not it became a dead letter.

In 1901* the legislature passed an act which was meant to prevent the further introduction into Missouri of dangerous insect pests and plant diseases, aiming primarily at the San Jose scale, as was also the aim of the statutes cited above. This act requires that all stock shipped into the state must bear the name of the consignor and consignee, the contents of the package and a certificate of inspection showing that the enclosed stock has been duly inspected and found free from dangerous insect pests and diseases.

Here again no funds were provided for enforcing this act and no particular officer was given the power to enforce it, so that it in turn became a dead letter. These two acts, both of which proved to be of absolutely no value whatsoever in controlling the pest, meant to provide for controlling it where it was found in orchards or on other premises and to prevent further introduction into the State, but the matter of nursery inspection, which is often the most important factor connected with the control of the scale, was apparently overlooked. What Missouri has been in need of since 1895 is a simple and comprehensive bill providing the necessary funds and men, first, for preventing further introduction of this and other insect pests and plant diseases into Missouri; second, for the annual inspection of all premises where plants are grown for sale so as to prevent further distribution of pests within the State, and third, for the control of the pest in the orchards already infested. Until such provisions are provided the scale can never be controlled successfully in Missouri. Practically all of the other States, whether their orchard interests are worth mentioning or not, have provided such measures and it behooves Missouri, for the sake of her reputation as a progressive State, if for naught else, to provide her citizens with the same protection. This act should be as simple and straightforward as possible, avoiding all un-

*Session Acts of 1901, page 134.

necessary complications of county courts and sub-officials. The work should have a purely educational purpose with just as little of the strictly quarantine or police work as is absolutely necessary.

PRESENT DISTRIBUTION IN MISSOURI.

In almost every locality into which the scale was originally introduced, it has not only succeeded in maintaining itself, but also in extending its bounds, so that to-day it is astonishing to what extent the scale has spread over the State. While by far the greater percentage of the scale is still to be found in St. Louis, Cape Girardeau, Scott and Mississippi Counties, it is by no means confined to these and every few days new infestations are reported from localities and counties which but a few years ago were apparently perfectly free. It is not at all improbable that when all the orchards of the State have been thoroughly inspected, few will be the counties that are found entirely free from infestation. It would seem that the past four or five years have been exceptionally favorable for the multiplication and spread of the scale, not only in Missouri, but also in a number of other States, but this great addition of territory known to be infested is due rather to the general awakening of the fruit growers to the seriousness of the scale question, which has resulted in the careful examination and discovery of the scale for the first time in numerous localities, where it had been present for a number of years.

The first introduction of the scale into Missouri, as stated above, was made by the almost simultaneous planting of infested trees in a number of private orchards. None of these infested orchards, so far as known, were near any of the nurseries, so the possibility of its immediate and secondary dissemination over the State by home nurseries was greatly reduced. Until 1898 the nurseries of the State, so far as examined, had remained apparently free of the scale with the exception of an occasional lining out of trees from nurseries outside of Missouri, but these were always discovered and destroyed before the scale had had a chance to establish itself upon the home grown stock. The scale, being a non-respecter of persons or property, the fortunate condition of the apparent exemption of the Missouri nurseries from its attacks was not to be continued indefinitely. While making the annual inspection of the larger nurseries of the State in the summer

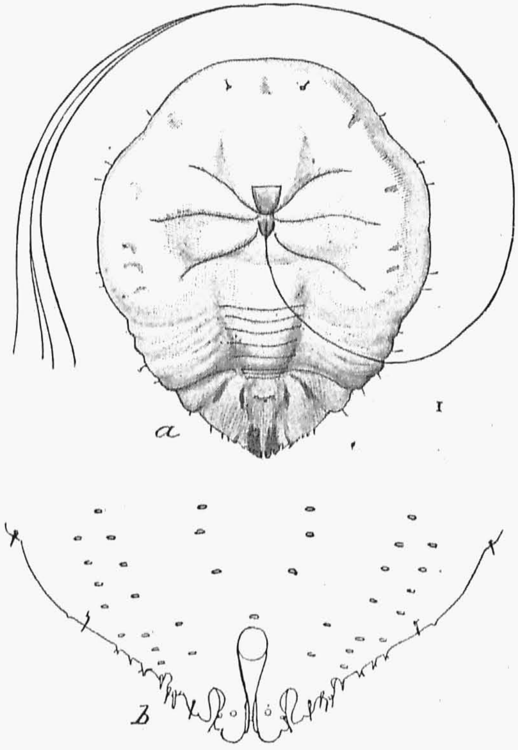

Fig. 3.—San Jose scale. Adult female removed from scale before development of eggs. (a) ventral view showing very long sucking setae. (b) anal plate showing characteristic ornamentation. Greatly enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture)

of 1906 the writer found three nurseries which, while apparently uninfested at the time, seemed almost certain of becoming infested soon, as the scale was in great abundance in neighboring orchards and no action was being taken to control its ravages in these grounds. According to my expectations, in the early summer of 1907 the proprietors of one of these nurseries discovered the scale in their own orchards adjoining their nursery blocks and also some of the nursery stock itself. They decided to burn the infested trees and to place no stock upon the market until the nursery was cleared of the scale. The trees of a couple of blocks of another one of these nurseries were found to have a considerable sprinkling of scales when inspected in 1907. These trees were burned and the others fumigated before they were sold. The third nursery was yet apparently free.

In 1908 Mr. E. P. Taylor, then Entomologist of the Missouri Fruit Experiment Station, while investigating the scale conditions of the orchards of the State, located scale in three or four small local nurseries which were furnishing stock to the farmers in their immediate vicinity, and the same summer the writer located a slight infestation in one of the larger nurseries, which was stamped out at once. In those nurseries found infested, measures have been taken to stamp out the pest and to properly treat the stock before being sold, so that there is little danger of the scale spreading farther from these particular nurseries.

The Department of Entomology of the Missouri Agricultural Experiment Station has been making annual inspections of most of the larger nurseries in this state and has, it is hoped, succeeded in assisting the nurserymen to keep their stock clean. There are a number of small local nurserymen and fruit tree agents buying and selling stock, who have never had their stock inspected. If they live near infested orchards, their nurseries are sure to be sources of continued distribution of the scale.

A great many of the present infestations, especially in new localities, are to be traced to agents, to infested nurseries in this State which are not inspected and, perhaps, to some of the larger nurseries which are careless about where they purchase stock. In most cases the nurserymen are perhaps unaware of the fact that they are offering for sale infested stock, but some cases that have come under the writer's observation cause him to doubt the absolute innocence on the part of some of the nurserymen. With the scale as with most other pests, preventive measures are both more effective and economical than are remedial measures, so what we need, to remedy this matter, is an act authorizing and providing for the annual inspection of all premises on which nursery stock is grown, either for sale or for home use. So long as we do not have adequate means for keeping our own nurseries clean, we cannot hope to make much headway against the scale, no matter how watchful we may be to prevent infested stock from being shipped into the state or how much enery may be exerted toward the control of it in the orchards.

LIFE HISTORY AND APPEARANCE.

The San Jose scale is one of the Coccidae or true scale insects. These insects comprise one family of that sub-division of the Hemipterous insects, the Homoptera, in which the

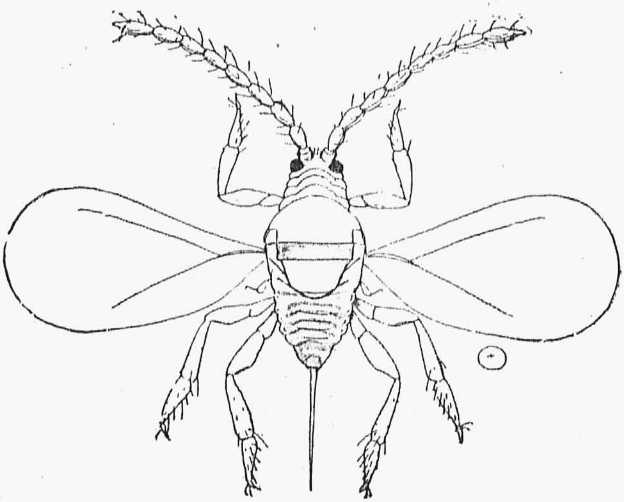

Fig. 4.—San Jose scale. Adult male. Greatly enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture)

winged forms usually have four membranous wings and the beak or sucking mouth parts are attached near the posterior edge of the head, which distinguishes them from the "true bugs" or Heteroptera, in which the wings are leathery at the base and the sucking beak attached at the tip of the head. Most of the scale insects are very small and often one must use a magnifying glass in order to see them.

Among the scale insects are to be found some of the most interesting as well as most important insect pests from an economical point of view. In this family we find the greatest diversions from the true type of Hemipterous insects. The difference in general appearance between closely related species of Coccidae, or between the sexes of the same species, is often as great as between species of insects of entirely different orders. The females do not develop wings on maturing. (Fig. 3) They remain concealed beneath the powdery or frothy secretion or scaly armor which helps to protect them. In some groups, however, these secretions are not produced, but in such cases the body wall is more or less thickened or hardened, which serves as a sort of protection. The only case of complete metamorphosis among the hemipterous insects is found in the development of the male Coccidae. On maturing they emerge as winged insects, possessing one pair of delicate wings, the posterior pair being replaced by halters, as in the flies. (Fig. 4) The adult males usually have the mouth parts replaced with a third eye.

The San Jose scale is included in the group of scale bugs commonly called the armored scales, in which the protecting secretion takes on a close fitting shield-shaped appearance. Among the common armored scales may be mentioned the oyster-shell scale, scurfy scale, rose scale, pine scale, and many others, all of which have a short, active larval existence, af which they settle down, begin feeding and secreting their protecting armor.

In the latitude of Missouri, the winter is passed in the half-grown larval state, securely protected beneath the small shield. (Fig. 5) As soon as spring opens and the sap begins to rise, they begin drawing sap again, increasing in size rapidly until about the first of June, when the males emerge

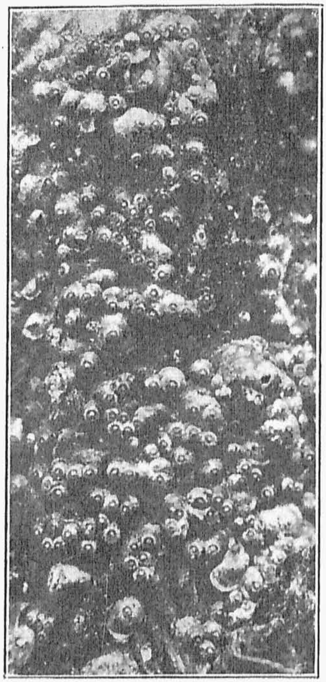

Fig. 5.—San Jose scale—in winter condition on peach twig. slightly enlarged. (Original.)

from beneath their shields and seek out the mature females. In a short time the females begin giving birth to living young, which escape from beneath the mother-armor and after moving about for a time, settle down, insert their long, needle-like, modified mouth-parts, begin drawing sap and secreting a shield over their bodies. (Fig. 6.) In a little over a month these young are mature and begin rearing young. This is continued throughout the summer, a number of broods being produced. The females continue rearing young for several weeks, so that the broods are not well defined. Any time during the summer all stages of the insect can be found side by side upon an infested tree. Late in the fall when winter begins to set in, the adults and nearly full grown insects as well as the very young, all seem to die, leaving only the half grown ones to pass the winter and begin the infestation the following spring.

From microscopical measurements the writer finds a remarkable uniformity in the size of the "winter over" insects. The diameter of the armor varies from .35 mm. to .5 mm., with an average of about .42 mm. It, therefore, seems evident that the insects which live through the winter must all be born about the same time, or at least during a certain restricted period in late fall. This fact may help to simplify the methods of controlling the scale. Further experiments and observations along this line will be made.

The development of the armors protecting the "winter over" insects is advanced to what is called the "black stage" before they hibernate. Younger insects, whose armor has not yet reached the black stage, and older insects, whose armor has taken on the characteristic dirty gray color, all seem to succumb to the winter. This blackening of the armor is of great advantage to the scale, especially during the winters of extremely low temperature, as the black covers absorb much more heat from the sun and thereby keep the insects, as well as the limb or tree on which they are attached, much warmer than would lighter colored armors. The effect of whitening accompanying the use of lime-sulphur wash in the late fall should in itself therefore greatly increase the mortality of the scale during severe winter.

DEVELOPMENT OF INSECT.

After birth the young insects usually remain motionless for a short time underneath the parent armor, after which they escape and travel about from one to forty-eight hours before settling down. During this active period, they are almost microscopic creatures, pale yellow in color, with six legs, two filamentous hairs at the posterior end of the body, two antennae, and a long, slender, thread-like proboscis similar to other insects of this order. (Fig. 7.) Soon after settling down the appendages are lost and the insects take on a bag-shape, with the beak inserted in the bark.

After the insertion of the proboscis the body is drawn full of sap and a white fluffy secretion begins to appear upon the back of the insect (Figs. 6, 8, 9). This fluffy, fiber-like secretion is quite delicate and usually completely covers the body of the insect within twenty-four hours from the time the beak is inserted, giving the insect the appearance of an oval mass of loosely grown, cottony fibers. This stage in the development of the scale or armor is called the white, fluffy stage and is of short duration, soon being replaced by the second stage, or the tufted stage. A denser layer of waxy threads begin to project from beneath the loose threads along the edge of the body. This is the beginning of the true scale or armor and increases in size as the insect grows. The tuft of loose white filaments becomes centrally located and gradually disappears, apparently weathering away, leaving a crater-like depression at the apex of the scale. (Fig. 8, 9). The true scale soon begins to take on a darker color, passing through shades of gray and finally becoming nearly black when it has reached what is called the "black stage" in its development. As stated above, it is in this stage that the insect hibernates in the latitude of Central Missouri. As the insect increases in size the armor is enlarged to accommodate it by the production of new filaments along its margin. These

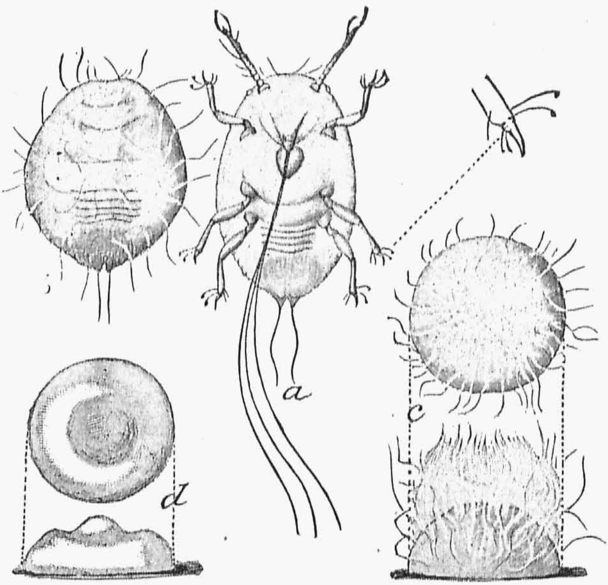

Fig. 6.—San Jose scale. Young larva developing scale; (a) ventral view of larva showing long sucking beak; (b) dorsal view of same somewhat contracted, with first waxy filament appearing; (c) dorsal and lateral view of same further developed; (d) later stage of same showing matting of waxy secretions to form young scale. (From Bureau of Entomology, U. S. Dept. of Agriculture)

filaments, which at once enter into the formation of the scale, no longer take on the black color, so that the mature scale has a dirty gray appearance, with a lighter yellowish central portion and a lighter outer portion.

The time required for the insect to mature seems to vary considerably, especially when the temperature varies. The time required by the females to mature seems to range from forty to fifty days, while the males mature sooner. During the development of the female insect two molts are thrown off, the first after about twenty days, which shows through the scale, producing the light yellowish central portion, and the second after about thirty days, which shows through the scale as a light marginal band. A third molt is cast by the males, for on maturing they escape from their pupal case and back out from underneath their armor and appear as winged insects.

During the earlier stages there is no marked difference between the male and female scale, but as they increase in size and approach maturity, the male scale assumes an oval shape, while the female scale, when not crowded, remains circular. (Figs. 1, 8, 9). The female scale becomes much larger than the male scale and is characterized by the distinct light central area, including the prominent nipple followed by a band of darker and bordered by a second light area.

By lifting up the edge of one of the large female scales with the point of a pin, the mature yellow female is seen to fit snugly into the cavity between the slightly arched true scale and the delicate white, film-like ventral scale. The mature female scale when viewed under the microscope, is found to be a small yellow, plump-bodied creature, containing a number of mature eggs or young embryos. (Fig. 10.) The long thread-like setae forming the sucking mouth-parts are attached to the ventral surface some distance back from the broadly rounded anterior edge, while at the posterior end is the somewhat triangular-shaped, much scalloped anal plate. The mature male is a small, gnat-like creature, expanding about four millimeters, with two delicate wings, a single long anal style and a pair of long antennae.

REPRODUCTION.

The San Jose scale is not so prolific as some of the plant lice and numerous other insects, but under favorable conditions the percentage of mortality is very low, so that at the close of the season the number of offspring from a single female is really very large. Soon after impregnation the female begins giving birth to living young. The breeding period varies considerably with different females and is considerably influenced by variations in temperature, but has been found to extend over a period of about six weeks on an average. The average number of young produced each day is from eight to ten, though it is not uncommon to find a larger number produced in one day. It has been found that

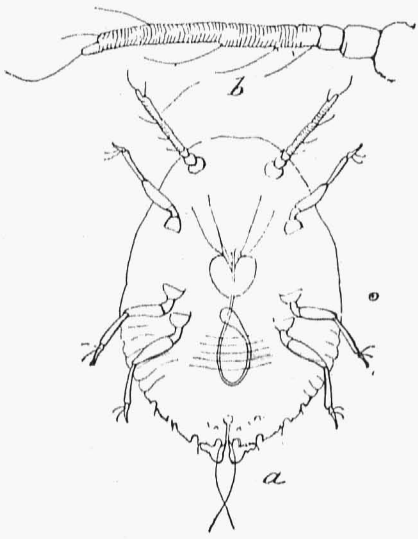

Fig. 7.—San Jose scale—young active larva before settling down: (a) ventral view of larva showing long needle-like setae, greatly enlarged; (b) antenna still more enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture.)

there are more females than males, so that for every three to four hundred young produced by each female at least two hundred are females. With the four generations that are produced each year in the latitude of Missouri and with two hundred females and about an equal number of males as the progeny of each female, it will be found that the product of each winter-over female is to be numbered by the billions at the close of the season provided each female insect lives and produces young. This accounts for the rapidity with which this pest overruns and destroys an orchard.

PERIOD OF LARVAL ACTIVITY.

For a short time after birth the young larvæ remain inactive beneath the armor of the parent, after which most of them come out from under the armor and seek out a favorable place to settle down. By far the greater percentage of the young larvae become fixed within less than twenty-four hours, though they have been found to survive without food and crawl about for forty-eight hours. It is not uncommon to find a number of the young larvae settling down around the margin of the parent armor, which would go to show that they had probably established themselves as soon as they emerged from the armor. (Fig. 11). The most of the larvae, however, travel about upon the limbs, twigs, leaves and fruit in search of favorable shelter and a place to insert their beak. The first scales found upon recently infested trees are usually present at the base of buds in the fork of twigs, healed-over scars, or other favorably protected places, which makes it quite difficult at first for the casual observer to detect them.

The young larva is an active little creature and when placed upon a smooth surface, such as paper, is able to crawl a considerable distance in a few hours, but when placed upon a rough or an uneven surface, such as the ground or rough bark of trees, progress is made with much difficulty.

The migrating habits of the young active larvæ were studied with a view of determining how far they could travel. (Fig. 12.) Specimens placed upon smooth paper moved off in a fairly straight line travelling at the rate of 54 inches an hour, and being 40½ inches from the starting point. Should they travel at this rate for the 48 hours of their active larval life, they would cover 216 feet and migrate 162 feet. But fortunately the ground over which they must travel in getting from tree to tree is not smooth like the surface of paper. Specimens placed upon paper over which sand was strewn made little progress. They seemed to wander about aimlessly, crawling up over sand grains and often retracing their steps. They traveled at the rate of 11¼ inches per hour and advanced but 4⅞ inches. At this rate they would travel only

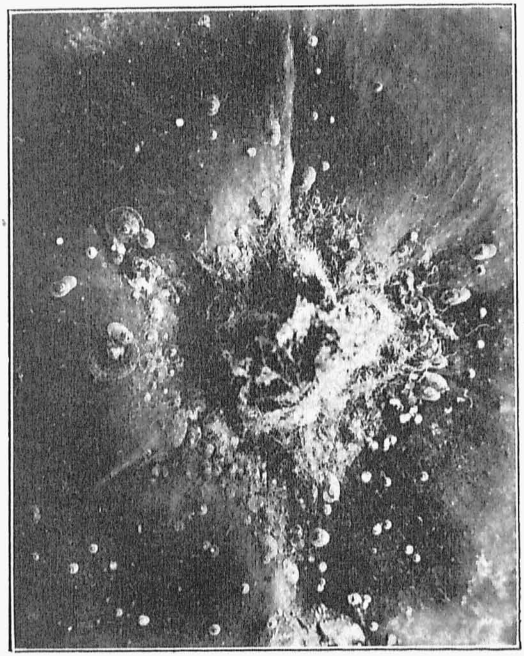

Fig. 8.—San Jose scale—tip of infested apple with all stages of the pest; slightly enlarged. (Original.)

45 feet and advance 19½ feet during their life time. These are more nearly the conditions prevailing in the orchard where the insects are found crawling about. In the orchard the distance actually traveled by the larvæ on foot is measured in inches or feet. If the larvæ had no other way of getting from one tree to another than by descending to the ground

and crawling along until a tree was reached, it would be a long time before an orchard would be completely overrun.

METHODS OF SPREAD.

Under the subject of the spread of the scale, we shall consider the means of spreading from one country or locality to another and from one orchard to another in the same locality, or from tree to tree in the same orchard.

The introduction of the scale into a country or locality from a widely separated one is made principally upon nursery stock, scions, cuttings, etc. The infested trees, cuttings, scions, etc., are planted out in orchards or placed in nurseries where they continue to grow and produce an abundant crop of scales, which are soon transferred to other trees in the orchard and nursery and thus a center of infestation for the whole community is established.

Under extremely favorable conditions it can be seen very readily that new infestations could be established through the agency of infested fruit. It is not at all uncommon to find pears and apples on the market that are literally alive with the scales. The insect breeds readily on fruit and can be shipped long distances in this way. Then when the fruit is consumed the parings and damaged fruit might be thrown out in the backyard near trees and shrubs and in case there were any mature impregnated females upon them, the newly born larvæ might succeed in establishing themselves upon the trees or shrubs, though the chances are against them and no authenticated case is on record where an infestation was ever established in this way. Flies and other insects visiting infested crated or barreled fruit on the market might also carry the young scales to fruit trees or shrubs. The possibility of infestations being established in this way is much greater in towns and cities than in the country.

The scale is spread from one orchard to another within the same neighborhood, or from tree to tree in the same orchard, largely through the agency of birds, insects, man and other animals, wind and running water. There are a great many birds that are regular inhabitants of the orchard during their breeding season, others are regular visitors, coming to feed upon the fruit, while still others are seen from time to time in the orchards, feeding upon caterpillars and other insects. Throughout the summer and fall the trees of badly infested orchards are continually more or less completely overrun with the small, young, active larva of the scale, so whenever a bird or insect alights upon a limb, a number of these larva are sure to crawl upon its feet and in case this bird or insects flies to a neighboring orchard or tree, some of the

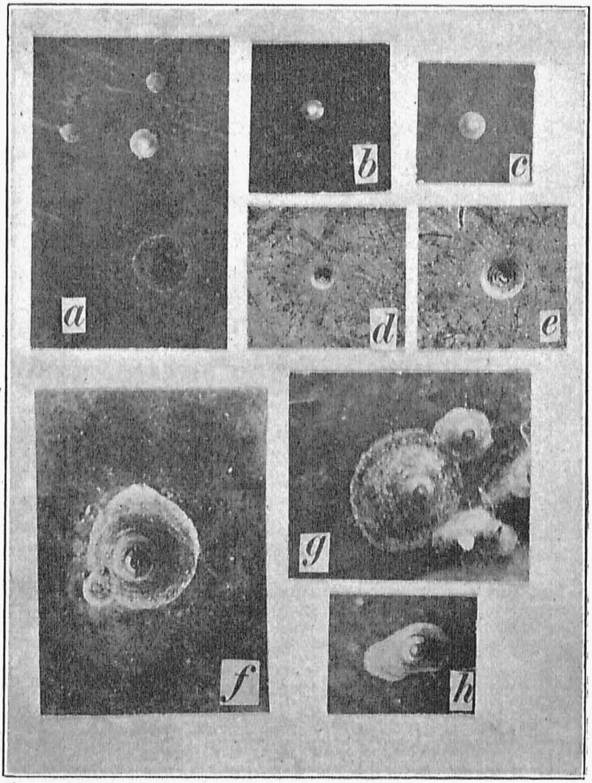

Fig. 9.—San Jose scale—(a) to (g) showing development of the female scale from the time the active nymph settles down and begins feeding until the insect is mature; (h) small elongated scale of the mature male insect before emerging as the winged insect. (Original)

larvæ are taken along and thus a new infestation is established.

Among the birds that are responsible for much of the local spread of the scale may be mentioned the English sparrow, catbird, robin, oriole, woodpecker, sapsucker, brown thrush, and cuckoo. Among the insects, the flies, beetles, aphis-lions, grasshoppers, and butterflies are often found carrying the young larvæ of the scale. Man himself in many cases is responsible for the local spread of the scale. The mischievous chap or foot-sore tramp who slips through the

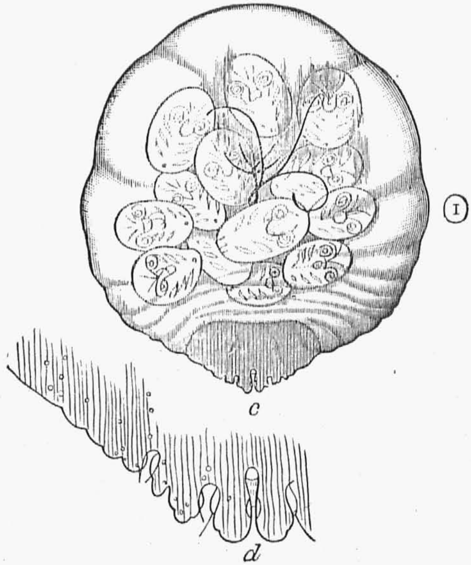

Fig. 10.—San Jose scale: (c) mature female removed from scale with young insects showing through the body wall of the parent; greatly enlarged; (d) anal plate still more enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture)

fence and fills his pockets with ripe apples from an infested tree, is sure to carry along with him a number of the young scale larvæ, and doing the same thing at the next orchard a mile or two farther along the road, some of the larvæ may escape and get upon the trees and start a new infestation. The gathering of fruit, especially in the case of summer and early fall varieties, is sure to spread the scale from tree to tree.

The local spread of scale by wind and rain is very noticeable. The small larvæ are so light that they can be carried a considerable distance by the wind, just the same as dust or pollen grains from flowers and trees, which are often carried for miles before a heavy gale. The direction of most rapid

Fig. 11.—San Jose scale—showing cluster of young scales which settled down beneath the parent armor and later crowded it off; on peach, slightly enlarged. (Original)

spread of the scale over an orchard is controlled by the prevailing summer winds. This fact was brought out very forcibly in one of the orchards in which the experimental work, reported later, was carried on. It was a block of eight year old peach trees, consisting of fifteen rows each way. The scale had been introduced from neighboring orchards upon the trees along the west side about three years before the writer visited the place and the prevailing west and southwest winds carried it eastward like a flame over a dry prairie.

The entire west half of the orchard had been killed, while the degree of infestation decreased rapidly toward the east, the first row or two on the east side being only slightly infested.

The writer's attention has been called to a number of cases where the scale had evidently been carried considerable distances by running water and new infestations thus established. By a heavy, dashing summer rain the young larvæ are washed from infested trees by the thousands and carried away by the water, which may flow through a neighboring orchard where some of the larvæ find lodgment.

Of the numerous possible methods of local spread of the scale, the wind is responsible for by far the greater percentage of the spread from tree to tree in the same orchard or from one orchard to a closely adjoining one. Birds and insects are evidently responsible for the larger percentage of spread between widely separated orchards in the same locality, but their relative importance, as compared with that of the wind, rapidly decreases with the spread at shorter range.

The spread of the scale by the wind, insects, and rain, is accomplished entirely during the season of multiplication, by the actual transportation of the young active larvæ. By the time the larvæ are two days old they have either settled down or have starved to death, so that the only time during which the insect can be transplanted from one tree to another, and an infestation established, is during the first two days of its active larval life. Once they have inserted their beaks and begun to secrete their armor, the females never leave the spot

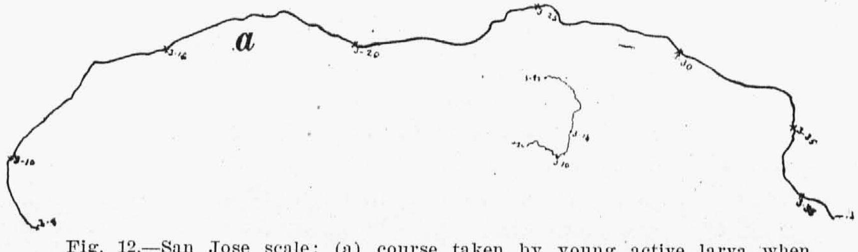

Fig. 12.—San Jose scale: (a) course taken by young active larva when placed upon surface of smooth paper; (b) course taken by young active larva when placed upon paper over which sand had been strewn. Figures represent hours and minutes required to cover this distance, (x¼). (Original.)

and the males only after maturing. It is impossible for birds or insects to collect the half-grown or mature scales upon their feet and then transfer them to other trees, for once the proboscis is withdrawn from the bark the insect is without power to insert it again and it soon dies.

The spreading of the scale to distant localities or countries, unlike the local spread, is accomplished almost entirely during the dormant season. The partially developed males and females are borne upon the trees and when these are transplanted and growth begins in the spring, they continue feeding and mature just the same as if their food plant had never been disturbed.

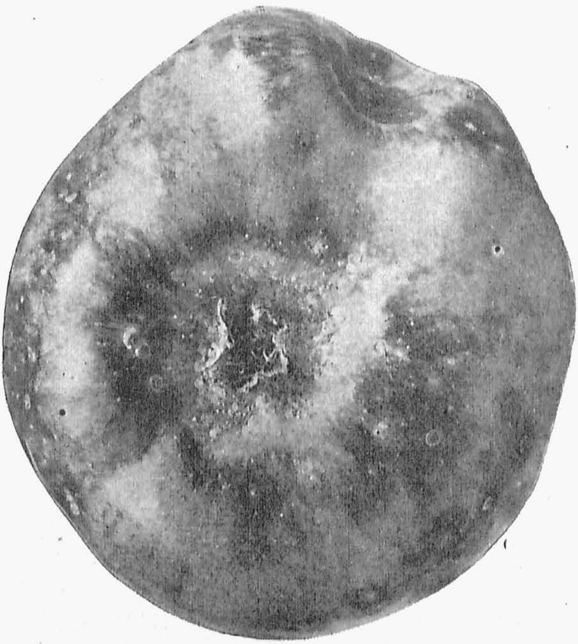

Fig. 13.—San Jose scale—scale on Ben Davis apple showing blotches caused by the feeding of the insect upon the fruit; natural size. (Original)

FOOD PLANTS.

The San Jose scale, as is too often the case with imported pests, is not only so nearly free from natural enemies and so perfectly adjusted to climatic conditions that it has become one of our most prolific breeders, but the ease with which it adapts itself to new food plants has made it one of our most omniverous of scale insects.

It is known to us principally as a pest upon fruit trees and it is here that the bulk of injury is done, though it has been found to feed upon upwards of a hundred other trees, shrubs, vines and other plants*. From the writer's observations he finds that it shows a preference for apple, peach, pear, and some varieties of cherries, and plums of the Damson, Japanese and Chickasaw varieties. Among shrubs and bushes in Missouri it is found most abundantly upon the currant and firebush. In a few cases it has also been found upon oak and soft maple trees though such cases are rare except where the trees are in or adjoining badly infested orchards. So far as the writer's observations go, the scale seems to show little preference for any one variety of apple or pear over that of another. There is a marked difference, however, in the readiness with which old and young trees become infested. In many instances apples under ten years will be completely encrusted, while nearby trees from twenty to forty years old will be only slightly infested. This apparent preference of the scale for young trees is so marked in many instances that the fruit grower is inclined to maintain that it will not attack old trees. The bark on old trees is much heavier than on young trees and there is much more surface to cover, so that multiplication is accomplished under greater difficulties and a longer time is required for the scale to completely cover an old tree, but they will eventually do so.

This same fact appears in the case of young and old peach trees but to a much less degree. On the peach tree the scale is largely confined to the wood under four or five years

*Fernald Coccidae of the World, p. 275.

of age. New wood remains comparatively free from scale the first season, except upon very badly infested trees, where the young scales advance upon the new wood. Wherever they settle down the growth of the wood is checked, causing a depression and a marked distortion of the twig. The dry corky surface layer of peach bark, after three or four years, becomes so thick that the scale is apparently unable to insert its delicate proboscis. For this reason the living scales are confined largely to the smaller limbs and terminal branches of

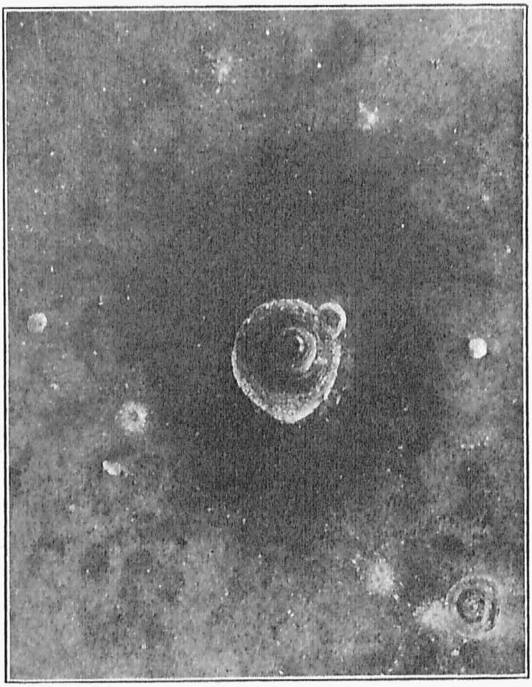

Fig. 14.—San Jose scale—mature female insect upon Ben Davis apple, greatly enlarged, showing the distinct blotch caused by the insect. (Original)

the peach, which causes the characteristic dying away of these and the subsequent sending out of new growth from down nearer the trunk of the tree. It is this same corky surface layer of bark which probably helps to protect most of the sour cherries and some varieties of plums from the attack of the scale.

INJURY DONE.

The scale injures a tree in two ways. First, by drawing large quantities of sap from it, and second, by the incidental introduction of poison along with the drawing of sap. It is difficult to estimate which of the two is responsible for the greater amount of injury. Evidently there must be a great amount of sap annually withdrawn from the tree which is completely encrusted with the scale, but it hardly seems likely that this can be sufficient to account for the wholesale destruction of orchards.

Soon after one of the young insects settles down, inserts its beak and begins secreting the armor, the surrounding bark and wood begins to take on a "blood-shot" appearance. This is especially noticeable on apple, peach and pear trees and upon fruit. (Figs. 13, 14.) In many cases this discoloration extends almost completely through small apple twigs. It is unnatural for the wood and bark of these trees to be colored up in this way and it must evidently offer considerable interference to the normal flow of the sap, besides greatly reducing or completely destroying the vitality of the affected cells. It is not unlikely that this incidental introduction of poisonous secretions, along with the drawing of sap, is responsible for more of the injury than the actual drain of sap.

The most of the scale injury is done between early summer and late fall, when the insects are actively feeding and introducing poison. Some maintain, however, that during warm periods in the winter the scale draws considerable sap and that the winter injury is therefore quite considerable, and as proof of this they show that in the winter the scales upon a limb soon die if it is cut off and allowed to dry. This dying of the hibernating insects upon dried wood by no means proves that they have been starved. We must take into account the fact that the wood, on drying and shrivelling, must do considerable mechanical injury to the small, helpless insects by crushing them against their protecting armor, and that but few of our insects, especially the soft bodied ones, are able to pass the winter except in places where there is a greater or less amount of moisture. Without the proper amount of moisture surrounding a hibernating insect, its body will dry out, the same as a potato or apple under like conditions.

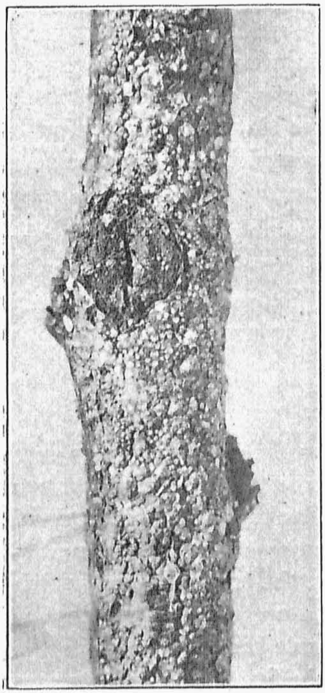

Fig. 15.—San Jose scale—peach twig badly infested with San Jose scale showing the insect as it would appear to the unaided eye; natural size. (Original)

As proof that the scale can live without food during the winter, the writer would cite an observation made in connection with the experimental work, discussed later, where one row of peach trees was treated with the lime sulphur soda wash, which killed the terminal branches, but failed to destroy all the scales on them. Early in the spring these trees were examined and the terminal branches found to be dead and devoid of the normal plant sap, though the bark and wood was yet moist and some living scales were present upon them.

The ideal conditions for the scale was found in the minute apartment between its dense dorsal armor and the delicate whitish scale covering the moist bark of the limb or twig which it infests.

The injury supposed to be done by the scale during the winter is often used to emphasize the great importance of fall spraying. The writer heartily joins in encouraging fall rather than spring spraying, not to obviate any winter injury done by the pest, but for the simple reason that most farmers have more time for such work in the fall, more favorable weather can be found, the scale can be reached before it has provided its extra winter protection, and the work can be repeated in the spring in case the fall work is not entirely effective.

Unfortunately the injury done by the scale is not confined to the tree. During the active breeding season the young active scales crawl all over the foliage and fruit where many settle down. Wherever the scale attacks fruit a distinct blotch develops. These blotches are always conspicuous upon green and pale colored apples, and even upon Ben Davis and other similarly colored varieties these blotches are more or less conspicuous. (Fig. 14.) Many countries will not receive infested fruit and fruit men are, therefore, beginning to refuse to accept such fruit.

The annual loss due to the presence of the scale upon fruit is increasing each year and it is an item which must be taken into account when considering scale injury.

LIFE OF INFESTED ORCHARD.

For the first year or two after the scale has been introduced into an orchard of bearing trees, it is quite difficult for the casual observer to detect it. For this reason it is usually present in an orchard a year or more before the owner discovers it, or, as very often happens, the trees may begin dying before his attention is called to the presence of the pest. A bearing tree of moderate size as a rule becomes completely encrusted, if not actually killed, within five years from the time the first scales are introduced and, according to the observations of many fruit growers, trees may be killed in three years. In spite of the fact that the scale selects protected places to settle down, a close observer will readily detect them as soon as a tree becomes infested. At first they will be found around the buds, in healed-over scars, at the forks of the twigs, and similarly protected spots. The casual observer may not notice these but as soon as they begin to encrust the limbs any fruit grower should detect them and as soon as they are discovered there is no excuse for permitting them to continue their ravages unmolested until the orchard is destroyed. The characteristic gray, scaly appearance of the bark of badly infested trees, due to the millions of minute armors, at once reveals the presence of the insect. (Fig. 15.) The sickly appearance of a badly infested orchard which develops a weak, unhealthy foliage that begins to drop early in the fall, and in the case of peach trees, the presence of a great deal of dead wood in their tops and much young growth near the ground and the presence of red blotches on the bark and fruit all help to reveal the presence of the dreaded pest.

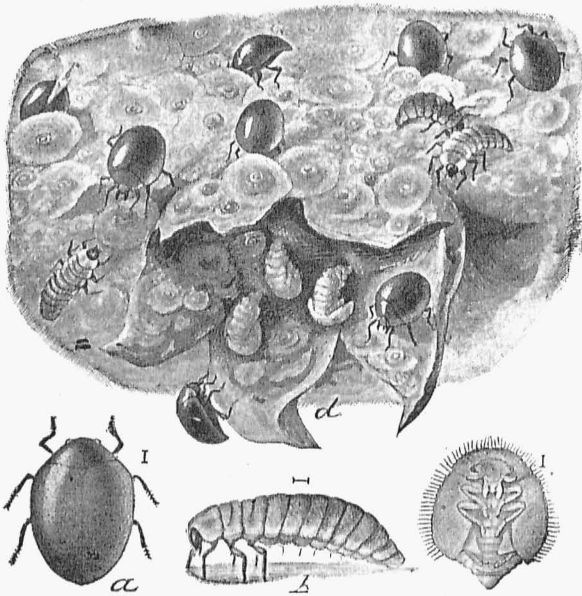

Fig. 16.—San Jose scale—blossom end of pear showing San Jose scale, with larvae and adult lady-beetles feeding on them; (a) adult beetle; (b) larva; (c) pupa, all enlarged. (From Bureau of Entomology, U. S. Dept. of Agriculture.)

THE SCALE IN THE NURSERY.

It is in the nurseries that the greatest precaution must be taken against the scale, if we are to successfully combat it. From a single infested nursery, through ignorance or carelessness, hundreds of new localities can easily be stocked with the scale in a single year. In former years, when the importance of the scale was not yet known, the possibility of such wholesale spread was quite great, but the increased watchfulness on the part of nurserymen, fruit growers, and state and government officials, since the real danger of the pest is known, is anticipating much of this inexcusable spread of the pest.

Each and every nurseryman owes it to himself, to his profession and to his patrons, to grow only absolutely clean stock. He cannot be too careful in his selection of seedlings, scions, buds and other stock, and in case the scale is accidentally introduced into his nursery, he should spare no time or pains in immediately clearing it out. Such stock as is found visibly infested during the growing season should be removed and destroyed and all other stock likely to be infested should be properly treated—fumigated or dipped—before offering it for sale. A careful nurseryman is not likely to get the scale generally distributed over his entire nursery and when it happens to break out in one part of the nursery it can easily be stamped out at once by prompt action.

A nurseryman should also be careful in the selection of his grounds. He should try to get a locality where the scale is not yet present, if possible, and should select grounds as far from orchards as possible. He should also strive to grow strong healthy stock which can be placed upon the market as young as possible. From an entomological as well as horticultural point of view, old, overgrown stock should not be allowed to remain in the nursery, nor should it be placed upon the market.

THE SCALE IN THE YOUNG ORCHARD.

It should be the duty of each fruit grower to take every possible precaution in the selection of stock. Order trees only from such nurseries as have been properly inspected and certified by a duly authorized official. Then, on receipt of the stock, subject each tree to a careful examination and in case the scale is found, report the same to the State Nursery

Inspector, and see to it that none of the trees are planted until properly treated.

Where the pest is found in young orchards, every possible effort should be put forth immediately to exterminate it. In case it is discovered while yet restricted to a few trees, and the orchard is in an uninfested district, the safest plan is to destroy the infested trees and replace them with others. But if neighboring orchards are infested, one should simply provide himself with the necessary outfit and materials for waging a systematic warfare against the pest. For small trees the box fumigator has been used considerably but the average fruit grower will have best results with fall or spring spraying. A badly infested orchard should be severely pruned back so as to remove as much of the dead and infested wood as possible and leave the tree open so that it can be much more thoroughly covered with the wash. By all means do not leave the young orchard at the mercy of the scale in hopes that it will outlive the injury or that something will appear to destroy the pest, for every moment lost is that much gained by the pest. Keep the young orchard clean and healthy and there will be less trouble with the mature bearing orchard.

THE SCALE IN THE OLD ORCHARD.

The control of the scale in the young orchard is a simple matter indeed as compared with its control in an orchard of large bearing trees. As stated elsewhere, the scale multiplies with greater difficulty upon an old, rough-barked tree, which is the only point in favor of the owner of an infested orchard of old trees. On trees from twenty to forty feet tall the scale can be properly controlled only by means of a power sprayer, provided with an elevated tower for reaching the topmost branches. In order to fully appreciate the enormity of such work in an old orchard, one should read the report of some experiments conducted by the New York Station* in old orchards where in some cases it required as much as twenty gallons of the wash to cover a single tree.

*New York Experiment Station, Bul. 296.

In an orchard of old trees, more so than in a young orchard, the severest pruning possible, from a horticultural point of view, should be resorted to. If the trees have been neglected, they should be thoroughly worked over and cut back so as to give the tree a low, open head. This is coming more and more into practice among progressive fruit growers, as it not only greatly obviates many of the unpleasant factors of the oft disagreeable though absolutely essential practice of spraying, but also greatly reduces the expense of later pruning and gathering of the fruit. Pruning should be followed up by the same thorough application of washes as advised for the young orchard, sparing neither material nor time in covering every spot.

THE SCALE ON CITY PREMISES.

One of the most important factors the landscape gardener has to deal with in many localities is the selection of ornamental shrubs and hardy plants, which are not attacked by the scale, for landscaping parks, estates and city premises. Since many of the standard ornamental shrubs and hardy plants are attacked by the scale, it is advisable to carefully consult a list* of them and so far as practical select only those that are not attacked. This is especially advisable if the landscaping is to be done in a region where the scale is already abundant.

When the scale is discovered on city premises or in parks, while yet confined to a few trees and shrubs, these should be destroyed at once and replaced by immune stock. But where the pest is so generally distributed that its extermination by the destruction of infested stock does not seem practical, the best plan is to spray thoroughly with one of the scale washes.

NATURAL ENEMIES.

The San Jose scale has comparatively few natural enemies, and throughout the greater part of its range in this

*Conn. Experiment Station Report 1902, p. 132.

country, they help but little in controlling it. These may be divided into two groups, parasites and predacious enemies and include both plant and animal forms. Attempts have been made to introduce from Japan and China some of its natural enemies which are more or less effective in controlling it.

The most important of the parasitic forms are fungi and various tiny hymenopterous insects. In the warm, humid climate of Florida there is a species of fungus* (*Sphaerostilbe Coccophila*) that has been found to be quite effective in controlling the scale. The warm, rainy summer months offer the best possible conditions for the development of the fungus. Attempts to distribute the fungus to more northern localities have so far proven a failure. In 1907 the writer attempted to introduce this fungus upon the common cactus scale in the greenhouse here, but the attempt was unsuccessful. Various observers have found scattered samples of fungus-infested scales, but throughout the greater part of our country the destruction of the scale by fungus diseases is slight. In some cases the tiny parasitic wasps are quite effective in controlling some of our native species of scales but are found to be much less effective against the San Jose scale.

The most important predaceous forms are the lady beetles (*Coccinelledae*), syrphus flies, lace-winged insects, true bugs, mites and birds. Some species of lady-beetles are quite fond of the scale. The larvæ as well as the adults prey upon it, and, where sufficiently abundant, help a great deal in controlling it. (Fig. 14.) The larvæ or maggots of the syrphus flies prey upon the larvæ of the scale to some extent, as do also the aphis lions, the larvæ of the lace-winged flies. A number of different species of true bugs, mites and birds have also been found to feed to some extent upon the scale.

SPECIAL WEATHER CONDITIONS DESTROY SCALE.

Rain, sleet, and sudden freezing and thawing are far more effective in checking the scale than are the parasitic and predaceous enemies. Heavy dashing rains in the summer

*Florida Agr. Exp. Sta. Bult. 41.

wash millions of the newly hatched young from infested trees, where they perish. In the winter sleets remove the protecting armors from millions leaving them exposed to the cold. The sudden changes in temperature during the dormant season are often very effective in destroying the San Jose scale. In some cases it would seem that the scale had been almost completely exterminated over closely restricted areas in Missouri by unusual weather conditions during the dormant season.

REMEDIES.

We shall here consider only such remedies as have been found to be both effective and practical. These may be divided into two groups: first, fumigating with a poisonous gas, and, second, spraying or dipping with some insecticide.

The destruction of the scale by thorough fumigation is more certain than either dipping or spraying, since a gas is more penetrating than a liquid, but unfortunately the scope of its applicability is much limited. Where infested stock can be enclosed in a tight box, or rooms in which the deadly gas is generated, it can be completely freed of the scale. The practice of fumigating finds its greatest usefulness in the nursery, where infested stock can, with little extra labor and at slight expense, be carefully fumigated, which, if properly done, will not injure the stock and yet destroys every scale present. Fumigation is also used with success in young orchards where the trees can be covered with a tent or box made of heavy cloth, well saturated with oil, which makes it practically air tight. Orchards of large bearing trees have been successfully fumigated, but the expense of treating rapidly increases with the size of the trees, and it should not be undertaken by the average fruit grower in the orchard. He will get better results from fall or spring spraying and run less risk of injuring his trees.

To prove effective, infested trees should be treated with gas while they are dormant, for at this period much larger quantities of the gas can be used without injuring the trees.

Hydrocyanic acid gas should be used since it is one of the most deadly gases and can be produced very simply. It is made by combining water, sulphuric acid and potassium cyanide.

If trees are kept as dry as practicable during fumigation there is quite a margin between the point where the gas is quickly fatal to the scale and where it becomes injurious to the trees. For this reason there are a great number of different formulae recommended. The following formula, which is sufficient for 100 cubic feet of space, has been used by the Bureau of Entomology of the United States Department of Agriculture:

Commercial sulphuric acid..............1 oz.
Refined potassium cyanide (98 per cent)..1 oz.
Water ....3 fluid oz.

To fumigate nursery stock the trees should be carefully packed in the fumigating room so as to permit of the free circulation of the gas among them. Then after the room has been made as nearly air tight as possible, mix water and sulphuric acid in a glazed, earthenware vessel and when all is ready drop the potassium cyanide into the vessel and leave the room at once. One cannot be too careful with this gas, as a single breath of it is sufficient to prove fatal.

After the gas has acted for forty-five minutes, open the room and thoroughly ventilate it before entering it to remove the stock. As soon as the trees are removed from the room their roots should be moistened to prevent further drying out. Much of the injury supposed to be done by the gas is caused by the stock drying out too much before and after fumigation.

To fumigate orchard trees they are covered with a tent or enclosed in a canvas box in which the gas is generated. Growing trees in the orchard can be fumigated with good success but the difficulty and expense of the gas treatment, except for nursery stock and very young orchard trees, makes it prohibitive in case of deciduous fruits.

Spraying as a means of controlling the scale may be considered under two headings—summer spraying and winter spraying. Summer spraying may be passed over without much consideration. With our present knowledge of the pest and contact insecticides summer spraying is not at all practical except where trees are so badly infested that it seems likely they will be destroyed before fall spraying can be done. In such cases a couple of applications of one of the contact insecticides, commonly used for plant lice and other soft-bodied insects, will will go a long way toward checking the undue multiplication of the scale. Such an application will destroy many of the young, active scales before they settle down but has little effect upon the protected insects.

The most effective and economical method we have at present for the control of the San Jose scale in the orchard is to spray with one of the best scale-destroying washes in the fall or early spring. There are a number of washes which are entirely effective when properly applied. These may be grouped in two main divisions—oil and lime-sulphur washes.

In some respects the oil washes have advantages over the lime-sulphur, while in other respects the latter has marked advantages. The oil washes are applied more easily, spread more evenly and creep down into cracks and crevices, where it is difficult to force the lime-sulphur wash. It takes less of an oil wash to cover the same surface and the average fruit grower is likely to spray more thoroughly with the oil washes, especially if he does not "retouch" trees sprayed with lime sulphur. An oil wash, if used at proper strength, is more quickly fatal, which often enables it to destroy the scale before dashing rains come and wash it off. Among the disadvantages attending the use of oil washes may be mentioned the price of material, in case prepared commercial brands are used, and the greater danger of injuring the trees by successive applications.

The lime-sulphur wash is the old standard scale wash. It has been in use since the early introduction of the scale into California and when properly prepared and carefully applied is extremely effective in controlling the scale. Points in favor of the lime-sulphur wash are the cheapness with which it can be prepared, its secondary value as a fungicide, its uninjurious effects upon trees, and the thoroughness with which it can be applied if one goes to the trouble of "touching up" patches that are missed by the first application. The principal factors which make this wash out of favor with many fruit growers are the trouble accompanying its preparation by external heat and its caustic properties, which make it disagreeable to use. But with a little experience and care, one can prepare and apply it without suffering the least inconvenience.

PREPARATION OF WASHES.

Among the oil washes are a number of proprietary preparations such as Scalecide, Target Brand Scale Destroyer, Killoscale, and Soluble Oil 95 per cent. These were thoroughly tested by the writer at different strengths in the fall of 1907 and spring of 1908 and found to be entirely effective when applied at sufficient strength. They come prepared ready to dilute with the proper amount of water, in which they are readily soluble. This makes them in great favor where only a small amount of mixture is needed and where one does not care to go to the trouble of preparing home-made washes, but the cost prevents their more general use in large commercial orchards.

Kerosene emulsion at a strength of 16 to 20 per cent was also carefully tested in the same experiments and gave equally good results. It is prepared as follows:

Soap (laundry or homemade)...4 pounds.
Kerosene (coal oil)............8 or 10 gallons.
Water (soft) ....5 gallons.

A suds is made by boiling the water and soap. The boiling suds is then poured into the spray barrel containing the oil and the mixture vigorously agitated by pumping it back into itself for several minutes, when a milk-like solution is formed, which will not separate out into layers of oil and water for several hours. To this add enough water to make fifty gallons of wash. This is prepared with very little trouble, at about half the cost of the prepared miscible oils, and is just as satisfactory as a scale destroyer.

As a cheap substitute for the commercial brands of miscible oils, Mr. C. L. Penny* has prepared a number of formulae for mixing homemade oil emulsions similar to the commercial brands. The cost of materials for preparing these washes varies from ten to fifteen cents per gallon, depending upon the particular kind of oils used.

To prepare the best lime-sulphur wash possible, the proper amounts of lime and sulphur should be mixed and boiled with external heat until a deep orange color appears. The time required for producing this color varies from 30 to 60 minutes, depending upon the vigor with which the boiling is continued. When the so-called black lime is used in place of the white a much darker wash is produced. The wash must be boiled sufficiently to thoroughly combine the lime and sulphur and thereby produce the compounds which destroy the scale.

The simplest outfit for preparing lime-sulphur wash is a couple of 25 or 50 gallon iron kettles mounted over an open fire. A slightly more convenient outfit is a large feed-cooker, which will save much heat and time in preparing the wash. But where a sufficient amount of the wash is needed to warrant it, a small boiler should be provided and the wash cooked with live steam.

To obviate the difficulty of boiling with external heat, caustic soda may be added, which will prolong the boiling for a considerable time. Some very good results have been gotten from the use of the self boiled wash, but it is more expensive than the boiled wash and far inferior as a scale wash. It should never be used where boiling with external heat is possible.

There are quite a number of different formulae for preparing the lime-sulphur wash, but the essential thing is to use enough lime and sulphur to thoroughly combine with each other and produce a sufficiently concentrated wash to destroy the scale. The formula 15-15-50 seems to give just as good

*Pa. Station Bulletin No. 86.

results as where the lime and sulphur are increased to 30 pounds for 50 gallons of wash. By adding extra lime, all the sulphur readily combines and the wash on drying shows up much better on the trees, which helps greatly in "touching up" skipped patches. The effect of whitening in itself helps to increase the mortality of the scale during severe winter and also keeps the buds back considerably which are further points in favor of the extra lime. The writer prefers the following formula:

Lime	25 lbs.
Sulphur	15 lbs.
Water	50 gal.

Either flowers of sulphur or sulphur flour may be used. Only fresh white stone-lime should be used. Badly air-slaked lime is apt to give poorer results, as is also the case with the so-called black lime. Make a thick paste of the sulphur; slake the lime in the cooking receptacle and when vigorous boiling has begun, add the sulphur paste. Keep the mixture boiling for from 30 to 60 minutes, adding a small quantity of hot water from time to time in case it gets too thick. After the boiling is completed, strain the mixture into the spray barrel or tank, add enough water to make 50 gallons and apply at once. If the wash is allowed to cool, it will give very much poorer results.

This wash is quite caustic and one should carefully protect his hands and face from it. Cheap leather gloves well saturated with oil is an excellent protection for the hands. It is quite injurious to a harness if allowed to remain upon it and will corrode the spray pump if not carefully rinsed out after the work is completed.

As a substitute for the home-made lime sulphur, there are various commercial brands of concentrated lime sulphur. These washes are prepared by boiling large quantities of lime and sulphur in a small quantity of water thereby producing a concentrated solution which must be diluted before applying. The various commercial brands vary as to the amount of lime and sulphur they contain. The comparative value of any particular brand can be tested by the use of a hydrometer. These brands should test from 30 to 35 on the Beaume' scale. These commercial brands of lime sulphur are much cheaper than the commercial brands of miscible oils but even they are more expensive than a commercial fruit grower can well afford to use. If a great quantity of spray is to be used, it will pay a fruit grower to prepare his own concentrated lime sulphur. The following formula produces a concentrated solution with a density of from 30 to 33 on the Beaume' scale, which is almost identical with the commercial brands and which costs only about half as much.

Lime	60 pounds
Sulphur	120 pounds
Water	50 gallons

Slake the lime in a small quantity of water, make a paste of the sulphur and add it to the slaking lime in the barrel. Boil with live steam for about one hour. After the boiling is completed the wash can be diluted and used at once or stored in tight barrels for future use. The concentrated lime sulphur wash should be diluted with from eight to ten parts of water when used as a scale wash.

EXPERIMENTS FOR CONTROL OF SCALE.

In the fall of 1907 and spring of 1908 the writer undertook a series of experiments for the control of the scale. These were planned primarily for the purpose of testing a number of commercial brands of scale-destroyers and for comparing their efficiency and cost of applying with that of standard home-made washes. The washes were used at different strengths, to ascertain what strength is needed for the destruction of the scale and at what strength they can be used without injury to the tree. Incidentally, the experiments were planned with a view of comparing the results of fall and spring spraying and they also served as demonstration work in scale control.

PLANS OF EXPERIMENTS.

The experiments included blocks of apple, peach, plum and cherry trees in the orchards of Mr. Henry Taake, and blocks of apple, peach, plum and pear trees in the orchards of Mr. C. H. Trampe, both of St. Louis County. The blocks of peaches in the Taake orchards included 15 rows of eight-year-old trees. Each of the rows except the check was sprayed in the fall with a different wash, or a different strength of wash, and in the spring the work was repeated. The block of apples included ten rows of trees, most of which were of bearing age. These were sprayed in the fall and repeated in the spring with some of the same washes used on the peaches. The Damson plums were all sprayed with the same wash in the fall and repeated in the spring, while the other plums and cherries were given a single application in the spring.

In the Trampe orchards only three different washes were used, with a view of testing these particular washes on a larger scale than was possible in the Taake orchards, where so many different washes were used. In all, about 8 acres of young and old bearing trees were sprayed. The results of the fall work were so gratifying that it seemed unnecessary to repeat the work in the spring, except in case of the block of bearing pears, but on returning for final inspection in June the writer found that the owner had sprayed the entire orchard a second time.

Early in the spring before the second application of the washes was made, each row of trees was carefully gone over and from accurate counts of numerous samples, an estimate was made of the living and dead scales. In the latter part of June this was repeated to determine the final effectiveness of each wash and now after a lapse of three years the following extract from a letter recently received from Mr. Taake is of interest since it shows how permanent were the results of the spraying, even though neighboring orchards were overrun with the scale.

"I have sprayed but once since you were here and then did not spray the plum trees of which you make mention. These plum trees have remained clean since your spraying. The apple trees seem to be again getting the San Jose scale on the smaller trees. Peach trees are all cut out and gone. Your spraying cleaned them of the scale but the trees seemed not to do well at all since, and on not getting any peaches, always freeze, out they went."

COOPERATIVE EXPERIMENTS.

The writer also had access to a number of large orchards sprayed by their owners under his direction, as well as a number of orchards sprayed on contract by Mr. C. F. Mason, of Jefferson Barracks. This offered an opportunity of comparing the results of the test experiments with those of many others and the final conclusions are therefore drawn from a very large acreage of sprayed orchards rather than from a few test rows.

WASHES USED.

The following is a list of the washes, with the various strengths at which they were used in the experiments:

1.	Scalecide	1 gallon of oil to 10 gallons of water
2.	Scalecide	1 gallon of oil to 15 gallons of water
3.	Scalecide	1 gallon of oil to 20 gallons of water
4.	Target Brand Scale Destroyer	1 gallon of oil to 10 gallons of water
5.	Target Brand Scale Destroyer	1 gallon of oil to 15 gallons of water
6.	Killoscale	1 gallon of oil to 10 gallons of water
7.	Killoscale	1 gallon of oil to 15 gallons of water
8.	Soluble Oil (95%)	1 gallon of oil to 10 gallons of water
9.	Soluble Oil (95%)	1 gallon of oil to 15 gallons of water

10. Kerosene emulsion 20% of oil
11. Kerosene emulsion 16 2-3% of oil
12. Lime 25 lbs.; sulphur 16 2-3 lbs.; salt 15 lbs,; water 50 gallons boiled one hour
13. Lime 25 lbs., sulphur 22 lbs., water 50 gallons; boiled 1 hour
14. Lime 15 lbs., sulphur 15 lbs., water 50 gallons; boiled 1 hour
15. Lime 25 lbs.; sulphur 15 lbs., water 50 gallons; boiled 1 hour
16. Lime 17½ lbs.; sulphur 19 lbs.; caustic soda 10 lbs., water 50 gallons; self boiled

Hereafter in this report the washes will be referred to by number.

FALL SPRAYING AND RESULTS.

In the discussion of the spraying work the writer will take up the two orchards separately and in case of the Taake orchards, the work on the blocks of peach, apple, plum and cherry will be considered separately.

Taake Orchard.

The degree of infestation in this orchard varied from slight to very bad. Over half of the peach trees had been killed and those used for the experiment varied from moderate to very bad. Some of the apple trees were dead and all the others, with the exception of a few of the larger ones, were badly infested. The Damsons were very badly encrusted, while the other plums and cherries were in most cases only slightly infested.

In order to save space and to facilitate comparisons, the data on the spraying work and results will be given in tabular form.

PEACHES.

No. of Row	Date of Application	No. of Wash	Date of Inspection	Live Scales in 250 counts	Per cent Destroyed	REMARKS
1	Nov.24-30	12	Mch.14	40	80.4	A very poor grade of badly air-slaked black lime was used, to which poor results are attributed.
2	"	14	"	50	80	"
3	"	13	"	50	80	"
4	"	16	"	25	90	Even after doubling the amount of caustic soda it was found necessary to apply external heat.
5	"		"	230	8	Used as check, sprayed in spring with Target Brand Scale Destroyer 1-10.
6	"	8	"	0	100	Very windy during application.
7	"	2	"	0	100	Light rain 15 hours after application.
8	"	1	"	0	100	"
9	"	10	"	1	99.6	Applied late in evening.
10	"	5	"	0	100	Same as in case of 7.
11	"	4	"	0	100	"
12	"	7	"	4	98.4	Oil not perfectly soluble, scum left.
13	"	6	"	0	100	Same as 12.
14	"	9	"	0	100	Very windy during application.
15	"	3	"	7	97.2	"

APPLES.

No. of Row	Date of Application	No. of Wash	Date of Inspection	Live Scales in 250 counts	Per cent Destroyed	REMARKS
1	Nov.24-30	12	Mch.14	50	80	Same poor grade of lime used as on peaches.
2	"	13	"	50	80	"
3	....	...	"	225	10	Check, sprayed in spring spring with Scalecide 1-10.
4	"	2	"	1	99.6	Wind very strong during application.
5	"	7	"	50	80	Oil dissolved poorly; cool, brisk wind.
6	"	6	"	0	100	"
7	"	9	"	1	99.6	Brisk wind.
8	"	8	"	0	100	"
9	"	7	"	50	80	Same as 5.
10	"	6	"	4	98.4	Counts made from samples taken from top of large trees.

DAMSONS.

The Damsons were all sprayed with wash (6) on the afternoon of Nov. 26 and the following morning, and was followed in a few hours with quite a shower of rain. An inspection of these trees on March 14 showed that the wash had given equally as good results as on the apples and peaches.

Trampe Orchard.

In this orchard the degree of infestation varied from very bad, where whose trees were encrusted, to very slight, where it was difficult to find scales. The most of the trees were of bearing age, though many were small. The lime-sulphur wash was used upon bearing pears, the kerosene emulsion upon apples and peaches, and the Scalecide upon apples, peaches and plums. The report of the application and the results of the three washes are given in one table:

No. of Wash	Date of Appli-cation	Date of Inspec-tion	Live scales in 500 counts	Per cent De-stroyed	REMARKS
2	Dec. 2-7	Mch. 13	2	99.6	Cool, clear weather.
11	"	"	2	99.6	Cool, clear weather.
13	"	"	125	75	Same lime as used in the Taake Orchard.
....	......	"	480	5	From pear tree used as check. Dug up in spring.

While one cannot draw definite conclusions from a careful count of a few hundred scales, he can in a way estimate the value of the different washes. The final results of the different washes can be best ascertained after the scales escaping the treatment have had an opportunity of multiplying. But here again, for comparison, it is necessary to know the relative degree of infestation before the washes were applied. To prevent any irregularity in this respect, these experiments were planned so as to have as nearly uniform degree of infestation for all the washes as possible. The writer also selected orchards that were as badly infested as was thought worth while attempting to save, since he appreciates the fact that while most of the wide awake fruit growers discover the scale in their orchards before it has made much headway, the average fruit grower does not detect it until the trees have become encrusted and are beginning to die. So it is therefore not sufficient that the washes prove effective in controlling slight infestations, but they must be equally effective for severe cases.

The results of the fall work show very decidedly in favor of the oil washes. The lime used for the lime-sulphur washes, as stated elsewhere, was of a very poor grade of dark lime. The washes failed to color up properly, and would not adhere to the trees as they should have done, so the results were as good as was expected. The so-called black lime should not be used for preparing this wash when it is possible to get the white lime.

For the two months following the fall applications of the washes there was comparatively little precipitation to interfere with the work of the washes. The dates and amounts of precipitation for the two months following the spraying are as follows:

Nov. 27—Light shower.
Dec. 8—Slight sprinkle.
" 13—Light rain and snow.
" 14—Three inches of snow.
" 17—Light rain and snow.
" 22—Showers.
" 23—Three inches of snow.
" 27—Light rain.
Jan. 3—Light rain.
" 10—Light rain.
" 11—Light rain followed by snow.
" 12—Snow.

SPRING SPRAYING AND RESULTS.

In the Taake orchard the same washes in each case, with but few exceptions, were repeated in the spring. The Trampe orchard was sprayed by the owner with wash (2) in the spring.

Taake Orchard.

PEACHES.

No. of Row	Date of Application	No. of Wash	Date of final inspection	Amount of re-infestation	REMARKS
1	Mch.16-19	15	June16	An occasional scale	Very strong wind.
2	"	15	"	"	Very strong wind.
3	"	15	"	"	Very strong wind.
4	....	...	"	Very slight	Fall application severely injured trees.
5	Mch.16-19	4	"	None perceptible	Not sprayed in fall.
6	"	8	"	"	Favorable weather.
7	"	2	"	"	Favorable weather.
8	"	1	"	"	Favorable weather.
9	"	10	"	"	Strong wind.
10	"	5	"	"	Favorable weather.
11	"	5	"	"	Favorable weather.
12	"	7	"	"	Favorable weather.
13	....	...	"	"	Left unsprayed in spring.
14	Mch.16-19	9	"	"	Favorable weather.
15	"	3	"	An occasional scale	Favorable weather.

The kerosene emulsion and lime-sulphur washes were applied when the wind became very strong which, together with a small amount of precipitation greatly interfered with the spraying. It appeared as though the excess of caustic soda in the wash with which row four was sprayed in the fall had completely destroyed the trees, so that they were left unsprayed in the spring. From the inspection in June, however, it was found that only the terminal branches had been killed and the trees were putting out a strong growth, while only a few live scales were found.

APPLES.

No. of Row	Date of Application	No. of Wash	Date of final inspection	Amount of re-infestation	REMARKS
1	Mch.16-19	12	June16	Very slight	Very strong wind.
2	"	13	"	"	Very strong wind.
3	"	1	"	None perceptible	Not sprayed in fall.
4	"	2	"	"	Favorable weather.
5	"	7	"	"	Favorable weather.
6	"	6	"	"	Favorable weather.
7	"	9	"	"	Favorable weather.
8	"	8	"	"	Favorable weather.
9	"	9	"	"	Favorable weather.
10	"	6	"	"	Favorable weather.

The applications of the lime-sulphur washes were much interfered with by very strong wind and a slight drizzle of rain in the afternoon of March 17. A much better grade of lime was used for preparing the spring washes and the increase of effectiveness is quite marked. The Killoscale dissolved much better in the spring than it did in the fall, probably due to the warmer weather.

PLUMS AND CHERRIES.

	Date of Application	No. of Wash	Date of final inspection	Amount of reinfestation	REMARKS
Damson plums	Mch.17	9	June16	None perceptible	Sprayed in fall also.
Wildgoose plums	"	9	"	"	Sprayed only in spring.
Newman plums	"	9	"	"	Sprayed only in spring.
Cherries	"	9	"	"	Sprayed only in spring.
Cherries	"	7	"	"	Sprayed only in spring.

Trampe Orchard.

No. of washes, fall treatment	Date of final inspection	Amount of re-infestation	REMARKS
2	June 16	An occasional live scale	Re-sprayed by owner the latter part of March with wash (2)
11	"	None perceptible	"
13	"	Very slight	"

Weather conditions were very favorable during the spring application and for the month following. Slight precipitation and high wind slightly interfered with the spraying for a couple of days, but for the month following warm weather prevailed with very slight precipitation. This gave the washes an excellent opportunity for reaching the scale before they were washed off.

COST OF WASHES.

The following table gives the cost of the different washes used in experiments, when prepared ready to apply.

No. of Wash	Cost per gallon	No. of Wash	Cost per gallon
1	$0·05	9	$0.033
2	.033	10	.025
3	.025	11	.020
4	.05	12	.0151
5	.033	13	.0143
6	.085	14	.0094
7	.059	15	.0104
8	.05	16	.022

This is figuring the miscible oils at the price per gallon in barrel lots; kerosene at 10 cents per gallon, in barrel lots; lime at 35 cents per bushel; sulphur at 2 3-4 cents per pound, and caustic soda at 5 cents per pound. In the preparation of the boiled washes no estimate has been made of the cost of boiling. If it were necessary to buy the fuel and pay an extra man to prepare the washes, it would increase the cost of the boiled washes about three mills per gallon; but in most cases where there is plenty of refuse material going to waste that can be used for fuel, and some member of the family can look after the boiling of the wash without greatly interfering with other work he may be doing, so the average fruit grower needs hardly consider the boiling of the washes as an additional expense.

The lime sulphur washes, as is seen from the figures, can be prepared much more cheaply than any of the oil washes tested, but in spite of this the writer is rather in favor of the oil washes when it comes to the control of the single pest, the scale. The average fruit grower will have better success with one of the oil washes, especially if he is yet an amateur in the spraying business. The kerosene emulsion at 16 2-3 per cent is prepared more easily than is the lime-sulphur wash and at only slight increase in cost. As a scale destroyer, the emulsion has proved as effective as any of the washes tested, and from every appearance the two applications have not done the slightest injury to the trees treated. With a little care any one can prepare this wash and it should be more generally used for the control of the scale.

The writer's experience with the prepared miscible oils convinces him that they are excellent remedies for the scale when used at a strength of one gallon of the oil to twelve or fifteen gallons of water. Where two applications are made a greater strength of wash is unnecessary and is more liable to cause injury to the trees. At a greater dilution perfect results can hardly be expected unless fall spraying is done shortly after the leaves fall and this repeated in the spring just as the buds are opening. Were it not for the price of these oils, there would be a far greater demand for them. The average fruit grower will not pay from three to four cents a gallon for spraying material when with little trouble he can prepare a similar wash for a little over half the cost, or with slight additional trouble of preparing and applying he is able to make a wash for about one-third of the cost.

From the results of the above experiments it would seem that there is practically no difference in the effectiveness of the four miscible oils used. The essential thing is to have a sufficient percentage of oil to destroy the scale and this seems to be present in each case when the oils are diluted 1 to 12 or 15. Killoscale contains a quantity of sulphur and perhaps other ingredients which add to the cost and makes it slightly caustic, but which does not seem to add to its value as a scale destroyer. Two thorough applications of either of the four oils tested at a proportion of 1 to 15 will give as perfect results in controlling the scale as can be expected.

TIME TO SPRAY.

From the results of the experimental work the writer is convinced that late fall is the time to spray to secure best results. This is especially the case if the oil washes are used. Some have found that injury is done by applying the washes before the trees have had an opportunity of hardening up for the winter, but for the latitude of Missouri spraying should be done before the last of November, if possible. It should be done as soon after the leaves are shed as is safe, for in this way the scales are reached before they have thoroughly protected themselves for the winter. Early November is the best time to spray in this latitude.

If it is impossible to spray in the fall before winter sets in it should then be postponed until late spring just before the buds open. At that time the lime-sulphur wash should be used, if possible, for when carefully applied it is not only effective in destroying the scale, numerous other insects and their eggs, but also has marked fungicidal properties and takes the place of a protective wash. When the scale is abundant, an application of the oil washes should be made in early November, and this supplemented with an application of the lime sulphur in the spring.

APPARATUS.

Thoroughness of application is of greater importance in the control of the scale than proper selection and preparation of the wash, and since thoroughness depends primarily upon the efficiency of the apparatus, it is all important that the selection of a spraying outfit be made with the greatest care. There are a number of things to be considered in the selection of a spraying outfit, foremost among which may be mentioned efficiency, durability, and ease of operating. With a first class sprayer one can cover a tree twice as thoroughly in one-half the time and with one-half the material needed for doing the same work with a cheap outfit. A cheap outfit may stand the wear for a short time but is sure to prove an expensive investment.

For the control of the San Jose scale, high pressure, which can be produced by a barrel sprayer, a large hand-power sprayer, a power sprayer, or a compressed air outfit, is all important. A small bucket sprayer will serve the purpose where there are only a few plants or shrubs, but where the shrubs are tall, or where fruit trees are to be treated, one should not undertake the work without a barrel sprayer or larger outfit. A barrel sprayer will serve the purpose where there are only a few hundred trees to be treated, but when one has ten or twenty acres of orchards, he should secure a good sprayer. The saving of time and labor and the greater uniformity of the work will soon pay for the extra cost of the power outfit, while the extra cost of operating it is very slight.

A barrel-sprayer outfit should be equipped with a couple of 25 foot leads of hose, a couple of 10 foot extension rods, and a couple of double Vermorel, Mistry, or other good nozzles. The hose should be four or six ply, preferably the latter, as it is much more durable and will carry the pressure much better than the four ply. A cheap and convenient extension rod can be made of one-half inch gas pipe, or a copper lined bamboo rod can be gotten along with the spray pump. The extension rods should be provided with a stop-cock at their lower end.

A power sprayer should be equipped with leads of hose, extension rods, and nozzles as above, together with a large tank provided with an agitator, and where large trees are to be treated, a tower should also be provided.

Each fruit grower should first decide upon the size and type of sprayer that will best suit his needs, taking into consideration not only the orchards but also vineyard, truck and field crops, ornamentals and shade trees. These are all attacked by insect pests and fungus diseases and should be treated with fungicides and insecticides. Then secure the catalogs of reliable manufacturers of spraying outfits and order the outfit that best suits your needs.

SUMMARY.

The scale was first introduced into Missouri between 1891 and 1894.

At present infestations have been located in one-third of the counties of the State, though the bulk of the scale is confined to some six counties.

The nurseries of the state so far as examined had remained apparently free of the scale until 1906, but since then slight infestations have been found in three or four small local nurseries and in three of the larger ones, but in each case it has been stamped out.

Fruit growers should buy trees only from properly certificated nurseries.

Nurserymen are responsible for most of the spread of the scale to new localities widely separated from infested regions, while the local spread of the pest is due principally to wind, birds, insects and rain.

Each fruit grower should examine his orchards for the scale and if it is discovered, he should check it at once, for if permitted to continue its ravages unmolested, it will destroy the orchard in from three to five years.

The most effective and economical method of controlling the scale in the orchard is by carefully applying one of the

best scale washes during the dormant season, preferably in the fall, soon after the leaves are shed or in the spring just before the buds open.

Badly infested orchards should be sprayed both in the fall and in the spring. Where only one application can be made, the best results will be gotten from the fall work.

Thoroughness of application is the most important factor in spraying, for a poor wash properly applied will give better results than an effective one poorly applied.

The lime sulphur wash is by far the cheapest on the market, and when properly prepared and applied is just as effective for the control of the scale as any of the other washes, besides being an excellent remedy for plant lice and having fungicidal properties.

The fruit grower who is yet an amateur in the spraying business is likely to secure best results from the use of an oil wash.

A 16 2-3 per cent emulsion is thoroughly effective.

Of the four miscible oils tested it is impossible to detect any difference in their effect upon the scale. A fall and spring application of either of them at a strength of 1 to 15 is thoroughly effective. They should not be used at a greater strength except when only one application can be given, when one gallon of oil to ten or twelve gallons of water will prove effective. They should never be used at a greater dilution than one to fifteen.

Summer spraying for the control of the scale with any of the washes so far tested is impracticable.

A thorough fall and spring application of either the boiled lime-sulphur, 16 2-3 emulsion of kerosene, or one of the miscible oils at a strength of 1-15 will control the pest in any orchard.

Severe pruning should precede spraying.

An efficient spraying outfit is all-important, for it is only with such that the most thorough work can be done.

It is only through the most thorough work and combined action of all the fruit growers in the infested localities that we can hope to effect a complete control of the pest. So let each and every one unite with that determination which makes failure impossible, and the desired results are assured.

ACKNOWLEDGMENTS.

The writer takes this opportunity of thanking Messrs. Henry Taake and C. H. Trampe for giving him access to their orchards for experimental work and for valuable assistance with the spraying work. He is indebted to Mr. E. P. Taylor, formerly of the Missouri Fruit Experiment Station, and Professor J. M. Stedman, formerly of this Station, for valuable data on the distribution of the scale in the state, and to Mr. C. F. Mason, of Jefferson Barracks, for data on the results of his spraying.