THE RELATION OF SUBSOILING, DEEP LIME AND DEEP PHOSPHATE APPLICATION TO THE YIELDS OF CORN, PEANUTS, AND ALFALFA IN VIRGINIA

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Foreword

With this report the Virginia Agricultural Experiment Station begins a new series of publications, to be called "Research Reports." The designation will cover such things as research of a seasonal nature; progress in long-time research which has revealed some tentative conclusions, or some conclusive results from a segment of a larger research project; or general surveys and observations not based entirely on exacting research.

While the report given here is in process of printing, two others are being issued in mimeograph form: Research Report No. 2, "Small Grain Varietal Tests Conducted In Virginia - 1955;" and Research Report No. 3, "Virginia Corn Performance Tests Conducted in 1955." These two were not mimeographed in large enough quantity to supply all agricultural libraries throughout the country; but there are copies available on request.

THE RELATION OF SUBSOILING, DEEP LIME AND DEEP PHOSPHATE APPLICATION TO THE YIELDS OF CORN, PEANUTS, AND ALFALFA IN VIRGINIA[1]

R. K. Stivers, J. H. Lillard, G. D. Jones, and A. H. Allison[2]

Subsoiling has been practiced to a limited extent in some areas of the United States for many years. However, its use has been restricted because there is very little concrete evidence to indicate that subsoiling alone has paid its way, except on a few very special soil conditions. Its use in Virginia has been limited, but claims for its success have been made by a few users.

Application of lime in the subsoil has been tried in Virginia with little or no observable benefits (1). However, it has been reported (2) that the practice may have promise of raising yields on certain Virginia soils.

Deep application of limestone and fertilizer combined with the physical action of subsoiling appeared to offer a possible method for improving root growth and yields of corn and peanuts on certain soils in the Coastal Plain. Furthermore, the same treatments might influence root growth and yield of alfalfa on some soils of the Piedmont areas. One experiment was initiated in each of these two physiographic regions to measure the effects of subsoiling with and without deep applications of lime and/or phosphate fertilizer.

1/ This paper was presented before the Agronomy Section, Association of Southern Agricultural Workers Meeting at Louisville, Ky., February 7, 1955. It is a joint contribution of the Agronomy and Agricultural Engineering Departments, Virginia Agricultural Experiment Station, and the Soil and Water Management Section, Soil and Water Conservation Research Branch, ARS, U. S. Department of Agriculture.

2/ When this report was first written, Mr. Stivers was associate agronomist with the Virginia Agricultural Experiment Station (he is now with the agronomy department at Purdue University), and Mr. Allison was assistant agronomist (he is now with a fertilizer company). Mr. Lillard is agricultural engineer with the Experiment Station and project supervisor for ARS. Mr. Jones is assistant agronomist at the Piedmont Field Station.

Table 1. Analyses of original soil samples.

Sample Depth	pH	% O.M.	Truog P lbs/A.	Exch. Cat. me/100 gms. soil H^+	Ca^{++}	Mg^{++}	K^+	Na^+	Cation Exch. Cap. me/100g	% Base Sat.
Manteo silt loam, Spring 1951										
0-8 in.	5.1	2.7	14	7.4	1.7	0.26	.17	N.D.	9.5	22
8-16 in.	5.0	.77	12	7.7	1.2	0.26	.092	N.D.	9.3	17
Sassafras loamy fine sand, Spring 1951										
0-8 in.	5.7	.64	89	3.5	.70	.14	.15	.040	4.5	23
8-16 in.	5.7	.22	42	4.8	.72	.081	.093	.035	5.7	16

Deep Lime, Deep Phosphate, and Subsoiling on Manteo Silt Loam in the Northern Piedmont

A Manteo silt loam located in the northern Piedmont at Orange, Virginia, was used for the alfalfa test. The area had not been cultivated for many years, and was considered to be highly infertile and strongly acid. An analysis of the soil samples taken just prior to the initiation of the experiment is given in table 1. The pH was approximately 5, and the base saturation of 22% was low. Exchangeable potassium and Truog phosphorus were considered medium and low, respectively. Exchangeable calcium was very low.

The experimental design was a complete randomized block with four replications.

Subsoil treatments were applied in April 1951 with an experimental machine. This subsoiler was trailer-mounted and consisted of a single chisel opener fitted with separate lime and superphosphate boots, hoppers, and feed mechanisms.

The treatments used are listed in table 2. Chisel openings were 1 and 2 feet apart. The ground limestone was banded in these openings at an average depth of 14 inches and rate of approximately 5 tons per acre. The superphosphate was applied in the same openings in bands about 4 inches directly above the limestone at a rate of approximately 500 lbs of P_2O_5 per acre.

The plow layer was treated with 3 tons of limestone, 20 lbs. of N, 400 lbs. of P_2O_5, and 300 lbs. of K_2O per acre in April 1951. Inoculated Kansas common alfalfa was seeded with oats as a nurse crop. An excellent stand was obtained on all plots. Later in the spring the oats were removed when in the hay stage.

The alfalfa was top-dressed with 100 lbs. of P_2O_5, 200 lbs. of K_2O, and 10 lbs. of borax per acre annually. In addition, ground limestone at the rate of one ton per acre was broadcast in 1952 and 1.5 tons per acre in 1953 to raise the soil pH to 6.5.

The alfalfa was cut four times in 1952, twice in 1953, and three times in 1954. Annual yields and 3-year averages for the 1952-1954 period are given in table 2. Chiseling

Table 2. Annual and average annual yields of alfalfa on Manteo silt loam, 1952-1954 inclusive.

Treatment	1952 Tons/A.	1953 Tons/A.	1954 Tons/A.	Avg. Tons/A.
1- No subsoil treatment	4.64	3.06	2.39	3.36
2- Chiseling 14 in. deep, 2 ft. spacing.	4.37	3.21	2.63	3.40
3- Chiseling + limestone 14 in. deep, 2 ft. spacing.	4.85	3.22	2.78	3.62
4- Chiseling + limestone 14 in. deep, + phosphate 10 in. deep, 2 ft. spacing.	4.70	3.31	2.84	3.62
5- Chiseling at 14 in. deep + phosphate 10 in. deep, 2 ft. spacing.	4.68	3.31	2.66	3.55
6- Chiseling + limestone at 14 in. deep + phosphate 10 in. deep, 1 ft. spacing.	4.77	3.35	2.88	3.67
Average	4.67	3.24	2.70	3.54
L.S.D. .05	N.S.	N.S.	N.S.	N.S.

alone resulted in the lowest average yields in 1952, but differences between this treatment and the others were not statistically significant. Annual yields for 1953 and 1954, and the average for the period 1952-1954, were lowest on the no subsoil treatment. However, the differences due to treatments were not significant.

Average yields declined from 4.67 tons per acre in 1952 to 2.70 in 1954. This decline was not due to a loss in stand, but rather to deficient rainfall (table 3). In 1953 and 1954 rainfall was approximately 10 inches below average for the growing season.

Root examinations in September 1952 revealed few roots down to and around the limestone bands. The volume of roots at that depth was considered too small to influence significantly the growth of the alfalfa. Observations of the growing crop during July and August 1952 indicated that seed formation was much greater over the fertilizer and limestone bands. Following the first harvest in 1954 the alfalfa was taller and darker green in color over the bands of limestone and phosphate but this effect was not great enough to affect the annual yield. The stand was excellent throughout the 3-year test period.

Table 3. Rainfall at the subsoiling experiment on Manteo silt loam, Orange, Virginia.

Year	April	May	June	July	Aug.	Sept.	Total
				Inches			
1952	5.63	5.70	4.09	1.72	4.76	3.30	25.20
1953	4.27	3.22	3.42	0.62	0.96	0.84	13.33
1954	3.39	2.95	2.06	3.18	1.36	0.66	13.60
Avg. '52 - '54	4.43	3.96	3.19	1.84	2.36	1.60	17.38
30 year Avg.	3.35	3.36	4.00	4.93	4.61	3.92	24.17

Deep Lime, Deep Phosphate, and Subsoiling on Sassafras Loamy Fine Sand in the Coastal Plain

A Sassafras loamy fine sand located in the Coastal Plain at Holland, Virginia, was used for a similar subsoiling test, with corn and peanuts as the crops. The area had been in cultivation for a long time. Soil test results, given in table 1, indicate that the soil was high in Truog phosphorus, low in organic matter and cation exchange capacity, and medium in potash. The percentage of base saturation and exchangeable calcium were both low. The soil pH was 5.7.

The experimental design was a complete randomized block with four replications. Two areas were used so that corn and peanuts could be grown simultaneously in a two-year rotation of corn followed by rye-grass winter cover the first year, and peanuts followed by crimson clover the second year. Corn stalks were disked in, and rye grass and crimson clover were turned under for the succeeding crops. Peanut vines were not returned to the plots after harvest.

The subsoil treatments were applied to both areas in April 1951; these are listed in table 4. Chisel openings were spaced 1.5 feet apart so that corn and peanut rows would be directly over alternate openings. Ground limestone at the rate of 4 tons per acre was banded in the chisel openings at an average depth of 14 inches. Superphosphate treatments were banded about 4 inches directly over the limestone at the rate of 430 lbs. of P_2O_5 per acre.

The average rate of fertilization of the plow layer for corn was 1000 lbs. per acre of 5-10-10 or 2-12-12 prior to planting. An additional 50 to 75 lbs. per acre of nitrogen was applied as sidedressing. For peanuts, 500 lbs. per acre of 0-10-20 fertilizer was applied on top of the row and worked into the soil after the peanuts were up. In 1952 only, 400 lbs. per acre of gypsum were applied to peanuts at the time of blooming in addition to the basic fertilization listed.

Both areas received additional applications of ground limestone in 1951 at the rate of 1200 lbs. per acre, and again in 1953 at the rate of 1500 lbs. per acre.

Aldrin applications at the rate of 2 pounds per acre were made annually on the peanuts for insect control. The peanut vines were dusted three times each year with 20

Table 4. Relation between the stand/yield ratio of corn and subsoil treatment, Holland, 1951-1953 inclusive.

Subsoil Treatment	1951			1952			1953			Average		
	Yield bu/A.	Plants/A. 1000's.	Yield stand ratio	Yield bu/A.	Plants/A. 1000's.	Yield stand ratio	Yield bu/A.	Plants/A. 1000's.	Yield stand ratio	Yield bu/A.	Plants/A. 1000's.	Yield stand ratio
1- No subsoil treatment	99.3	10.2	.00974	92.9	19.8	.00469	55.9	13.3	.00420	82.7	14.4	.00573
2- Chiseling 14 in. deep, 1½ ft. spacing.	106.5	11.6	.00918	108.9	20.2	.00539	65.6	13.6	.00482	93.7	15.1	.00619
3- Chiseling + limestone 14 in. deep, 1½ ft. spacing.	111.0	11.6	.00957	102.8	19.8	.00519	56.5	13.8	.00409	90.1	15.1	.00598
4- Chiseling + limestone 14 in. deep + phosphate 10 in. deep, 1½ ft. spacing.	127.4	12.5	.01019	92.9	20.0	.00465	54.9	14.0	.00392	91.7	15.5	.00592
5- Chiseling 14 in. deep + phosphate 10 in. deep, 1½ ft. spacing.	109.5	12.3	.00890	105.7	20.0	.00529	55.2	13.6	.00406	90.1	15.3	.00589
Average	110.7	11.7	.00946	100.6	20.0	.00503	57.6	13.6	.00424	89.7	15.1	.00594
L.S.D. .05	N.S.	N.S.		N.S.	N.S.		N.S.	N.S.		N.S.		
C.V.	18.7%			23.5%			23.6%			14.5%		

pounds per acre of sulfur to control leafspot. The first application of sulfur contained 1% DDT for leafhopper control.

Corn hybrids used were U. S. 262 in 1951, V.P.I. 802 in 1952, and U. S. 578 in 1953. Jumbo peanuts were used in 1951, J-11-L (a selection from Jumbo Runner) in 1952, and R. J. 15 in 1953. The 1951 peanut stand was damaged by the application of fertilizer while the leaves were damp. An excellent stand was obtained in 1952 and a fair stand in 1953.

Annual and 3-year average yields of corn for the period 1951-1953 are given in table 4. The corn stand and yield were lowest on the no subsoil treatment in 1951. The stand density, which was 1400 plants per acre less, appeared to be the major cause of the depressed average yield. In 1952 the chiseling plus limestone plus phosphate treatment yielded no better than the no subsoil treatment. The stands on all treatments were extremely high and they varied little from plot to plot. In 1953 the yield of the no subsoil treatment was approximately the same as those of three other treatments.

Annual yields varied from 57.6 bu/acre in 1953 to 110.7 in 1951. The low average yields in 1953 may have been caused by the July drouth (table 5). The 1953 stands varied from 13,300 to 14,000 plants per acre. There were no statistically significant differences in yields because of treatment in any year. The coefficients of variability ranged from 18.7% to 23.6%, indicating that plots treated alike varied a great deal.

The three-year average annual yields of corn varied from 82.7 to 93.7 bushels per acre (table 4). The lowest average yield was on the no subsoil treatment. This yield was 7.4 bushels per acre less than the next highest yield. There were no statistically significant differences in yields associated with treatment. However, the 3-year average yield/stand ratio was slightly lower for the no subsoil treatment than for all others. Observations of the growing corn crop failed to show any consistent differences associated with treatment in any year.

Yields of peanuts and peanut vines are given in tables 6 and 7. The 1951 and 1952 yields of both peanuts and peanut vines were higher than in 1953. It appears that deficient

rainfall in July 1953 was largely responsible for the reduction in yields that year. There were no definite trends or significant differences in yields of either peanuts or peanut vines associated with treatment in any year or in the 3-year average.

Table 5. Rainfall at the subsoiling experiment on Sassafrass loamy fine sand, Holland, Virginia.

Year	April	May	June	July	Aug.	Sept.	Total
				Inches			
1951	2.91	2.71	4.54	2.95	7.85	3.04	24.00
1952	2.44	2.43	2.93	5.88	4.98	1.78	20.44
1953	3.26	4.64	3.54	1.32	10.61	4.76	28.13
Avg. '51 - '53	2.87	3.26	3.67	3.38	7.81	3.19	24.19
25 yr. avg.	3.41	3.14	3.43	4.83	4.54	4.12	23.47

Investigation of the roots of corn and peanut plants in 1952 revealed only a few more roots around the subsoil bands of limestone and phosphate than elsewhere. The quantity of roots in this area was too small to account for any real differences in yields.

Table 6. Annual and average annual yields of peanuts from the subsoiling experiment on Sassafras loamy fine sand, Holland, Virginia.

Treatment	1951 lbs/A.	1952 lbs/A.	1953 lbs/A.	Avg. lbs/A.
		Dry Weight		
No subsoil treatment	1710	1942	1116	1589
Chiseling 14 in. deep, 1½ ft. spacing	1474	2033	1262	1590
Chiseling + limestone at 14 in. deep, 1½ ft. spacing.	1721	2033	1082	1612
Chiseling + limestone at 14 in. deep, phosphate at 10 in. 1½ ft. spacing.	1705	2214	1054	1658
Chiseling at 14 in. deep + phosphate at 10 in. deep, 1½ ft. spacing.	1852	2105	1091	1683
Average	1692	2065	1121	1621
F. .05	N.S.	N.S.	N.S.	N.S.
C.V.	21.1%	12.8%	14.4%	19.2%

Table 7. Annual and average annual yields of peanut vines, from the subsoiling experiment on Sassafras loamy fine sand, Holland, Virginia.

Treatment	1951 lbs/A.	1952 lbs/A.	1953 lbs/A.	Avg. lbs/A.
		Dry Weight		
No subsoil treatment	2393	3321	1897	2537
Chiseling 14 in. deep, 1½ ft. spacing.	2627	3647	1997	2757
Chiseling + limestone at 14 in. deep, 1½ ft. spacing.	2581	3412	1724	2572
Chiseling + limestone at 14 in. deep, phosphate at 10 in. deep, 1½ ft. spacing.	2390	3430	1797	2539
Chiseling at 14 in. deep + phosphate at 10 in. deep, 1½ ft. spacing.	2417	3884	1906	2736
Average	2481	3539	1864	2628
F. .05	N.S.	N.S.	N.S.	N.S.
C.V.	9.8%	7.5%	14.4%	11.7%

CONCLUSIONS

This 3-year investigation revealed no real differences in yields of alfalfa, corn, or peanuts which were associated with chiseling alone or in combination with subsoil applications of limestone and/or superphosphate.

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