Typical extension of large cotton roots into subsoil slot, right, compared with normal tillage root growth, left.

PRECISION TILLAGE FOR COTTON

Beneficial on Coarse-Textured Soils, but Not on Clay

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Benefits of "precision tillage" or deep tillage directly under the drill row for cotton were generally substantiated in the fourth year of San Joaquin Valley trials. Substantial increases in cotton growth, yield and earliness were obtained on coarse-textured soils at the U. S. Cotton Research Station, Shafter, and in Madera County tests. However, precision tillage trials on fine-textured soils in Tulare County did not show these benefits.

TILLAGE TRIALS, aimed at correcting soil compaction from farm machinery, were begun in 1960 in the San Joaquin Valley. This first year, vertical mulching before planting showed an increase in cotton plant height of 22% and a yield increase of 15% as compared with normally tilled plots. Slots for the mulch were 20 inches deep and filled with chopped cotton stalks. Plant response increased when the slot was directly under the plant row.

Tests in 1961 indicated that this increase in plant growth and yield was explained primarily by the subsoil slot rather than the mulch material. In these tests, the subsoil slot was accurately placed under the intended drill row. On August 23, the plant heights in the vertical mulch plots and the subsoil plots were 40 inches and 36 inches, as compared with 28 inches on the untreated check. Yields increased 37.7% on the vertical mulched plots and 34.7% on the precision tillage plots as compared with the check. Investigations showed extension of large roots to the bottoms of the subsoiled slots and many small roots. On the normal tillage plots, there were no large roots below 18 inches.

To insure accurate placement of the subsoil slot with respect to the plant row, a tool was assembled using two 30-inch subsoil shanks, followed by three bed listers or bedding shovels. With this tool, more precision in placing the deep tillage zone in close proximity to the intended drill row was expected, hence the term "precision tillage." An 80 hp wheel tractor with maximum ballast was found to be capable of pulling two 1-inch subsoil shanks 20 to 24 inches deep plus the three listers in moist soil and 18 to 22 inches deep in dry soil.

Beds with subsoil slot directly below intended drill row are seen in ph to right showing the two 30-inch subsoil shank

Cotton growth in precision tillage test plots. Normal tillage check rows are in center of photo, to right of plot sign.

INTERACTION OF SOIL COMPACTION AND PRECISION TILLAGE ON COTTON YIELD

Compaction level	Date of precision tillage	Penetrometer psi	Yield lbs/acre	First pick %
No compaction	.....	304	2570	80
	Before pre-irrigation	80	3060	86
	After pre-irrigation	92	3020	84
	Before planting	44	3160	84
Added compaction	.....	532	1260	65
	Before pre-irrigation	88	3190	86
	After pre-irrigation	76	3160	86
	Before planting	64	3110	86

below to left. Detail of tool used in precision tillage trials is seen in photo
ollowed by three bed listers or bedding shovels.

In 1962 a field was prepared for a precision tillage test at Shafter by plowing under a barley cover crop, subsoiling 20 inches deep in two directions on 40-inch centers, and listing for pre-irrigation. Half of the field, in alternate strips, was artificially compacted using a sheeps-foot roller which increased the soil bulk density from 1.55 grams per cc. to 1.72 grams per cc. Precision tillage operations were then made on each soil condition at three dates: two days prior to pre-irrigation; two weeks after pre-irrigation; and one day prior to planting. In each case the depth of tillage was between 22 and 24 inches. A non-compacted check plot represented land preparation typical of tillage procedures followed by many farmers. A compacted check plot represented an extreme condition that may or may not ever exist under normal conditions.

Precision tillage increased growth, yield and earliness of cotton regardless of the tillage date or the compaction level. The average yield for all precision tillage treatments ranged between 3,060 and 3,190 pounds of seed cotton per acre which represented a 21% increase over the noncompacted check. The yield of the compacted check was only 49% of the noncompacted check.

Penetrometer readings in early September, three days after the last irrigation showed that the compaction and tillage effects persisted throughout the season. When the plot yields were compared to the penetrometer readings, a nearly

straight-line relationship was obtained, with yields inversely proportional to penetrability, as shown in the graph. This correlation indicates the possibilities of using a penetrometer as a diagnostic tool.

Other locations

The response to precision tillage at other locations in the San Joaquin Valley was variable. Yield increases of 15% to 21% were obtained on coarse-textured soils in Kern and Madera counties. On fine-textured soils in Tulare County, essentially no response was obtained. Although a decrease of 5.9% was observed at one location, the data were not statistically significant. All of these soils were at field-capacity moisture content at the time of the precision tillage application, due to above-normal rainfall in February.

RESPONSE OF PRECISION TILLAGE ON VARIOUS SOILS

Soil type	Percent soil moisture	Increase in yield with precision tillage
Chino clay loam	22	+ 2.6 NS
Traver loam	27	- 5.9 NS
Chino silty clay loam	20	- 5.1 NS
Ripperdan fine sandy loam	7	+14.9 * *
Atwater loamy sand	11	+17.7 *
Fresno fine sandy loam	12	+11.2 *
Hesperia fine sandy loam	9	+21.2 * *

* Sianificant at the 1% level
** Significant at the 5% level

The effectiveness of a standard nematocide application (9 gallons of DD, 10 to 12 inches deep) was increased when precision tillage was applied. A further increase in nematode control was obtained when the nematocide was injected at the bottom of the subsoil slot. The yields from these plots reflected both the effects of increased nematode control and precision tillage, as shown in the table:

INTERACTION OF PRECISION TILLAGE AND NEMATOCIDE APPLICATIONS

Treatment	Yield lbs/acre	Nematode index*
A Check	1910	98
B Normal fumigation	2530	51
C Precision tillage	2240	94
D Treat. B + Treat. C	2790	36
E Treat. B + deep fumigation	3010	18
LSD 5%	330	18

* Arbitrary scale 0 = perfect control, 100 = no control (based on extent of root galling by root knot nematode, Meloidogyne incognita).

In two field trials, where potash deficiency symptoms were noted in previous years, the addition of potassium fertilizer was effective only when precision tillage was used. This response is of a different nature than the response with nematocide since the potassium deficiency appears not to be a limiting factor in plant growth until precision tillage increased root extension and plant growth, as shown in the table.

INTERACTION OF PRECISION TILLAGE AND POTASSIUM FERTILIZER ON MADERA COUNTY SOILS.

Treatment	Seed Cotton Yield lbs/acre	
	Test 1	Test 2
A Check	2210	1750
B Precision tillage	2540	2060
C B + deep K	2860	2400
D B + sidedress K	2980	2260
E Sidedress K	2190	1730
LSD 5%	160	410

Mechanical impedance to root development is a factor in nearly all agricultural soils. Studies of soil physical properties in other states have shown that coarse textured soils with their greater pore space rigidity more effectively resist root penetration. Limited root development in coarse-textured soils as compared to fine-textured soils can be more harmful to growth and production due to the lower water-holding capacity and nutrient availability of these soils.

Field studies in 1963 have confirmed the greater benefits to be derived from precision tillage for cotton on coarse textured soils in the San Joaquin Valley.

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MINIMUM TILLAGE FOR COTTON

THE CONCEPT OF PLACING permanent tracks in the field to support traction equipment and machinery has often been discussed as a possible method of reducing soil compaction, decreasing the number of field operations, and allowing tillage to be applied only to the specific zones requiring soil modification. Based on the precision tillage concept, and a modification of the permanent track principle, a minimized tillage or permanent bed system for cotton following cotton was developed. A long-term replicated test was initiated in January 1961 to compare this minimized tillage system with normal tillage practices.

The minimized tillage system included stalk disposal with a special root and stalk shredder, precision tillage, nematocide application and planting for a total of four tractor operations. Further refinements included using wide front axle tractors to restrict traffic to alternate furrows, leaving untraveled furrows for irrigation. The beds in these plots are to remain in the same location for at least three years.

The normal tillage system consisted of stalk disposal using the same special machine, double-disk harrowing, plowing at right angles to the beds, disk harrowing, listing for irrigation, nematocide application and planting. The total traffic for the normal system was eight trips. Using 80% of the rated horsepower of each tractor as an approximate guide, 130 horsepower-hours per acre were used on the normal tillage and 52 hp-hrs/acre on the minimized tillage system. This represents a decrease of 60% in the total energy requirements.

Control of trash was found to be the greatest operational problem in the permanent bed plots. This problem was minimized by adjusting the listers on the precision tillage equipment for maximum-height beds and adjusting the planter so the planter wings removed about one-third of the bed, thus planting below the trash. No experience was obtained on early post-emergence weed control since the field, fortunately, was relatively weed free. Prior to the first irrigation a dirting-cultivation was applied with no serious trash interference problems. Trash caused no problems after the first irrigation.

The cotton stands obtained were the same for both treatments. All measurements of soil moisture, bulk density, plant height, and yield were almost identical for the two treatments.

The permanent bed test will be continued for at least two additional years to allow observation of long-term effects. The permanent bed treatment will be considered a success and a possibility for a minimum tillage practice for cotton if the yields continue to be equal or greater than normal tillage. During this period, precision tillage plots will be applied on as many soil types and moisture conditions as possible to complete the overall evaluation of this minimized tillage system for cotton, incorporating the precision tillage concept.