SOIL PROFILE MODIFICATION TO ENHANCE ALFALFA PRODUCTION

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Introduction

Deep tillage is a primary tillage operation that manipulates soil to a greater depth than normal plowing. It is accomplished with a heavy-duty moldboard, disk, slip or chisel plow. The latter is commonly referred to as a subsoiler or ripper. To these implements one may add the wheel trencher and backhoe, used sometimes as deep tillage implements.

Deep tillage is a common practice on the intensively cultivated soils of the Imperial Valley and Southwest in general. There are two categories of deep tillage operations with respect to depth of tillage and frequency of operations.

Moderately deep to relatively shallow tillage of 8 to 18 inches is designed primarily to break up manmade compacted layers, such as plow pans and traffic pans. This tillage is part of regular cultivation programs on many farms.

Very deep tillage to depths of 1.5 to 5 feet or more is designed to break up natural hardpans, compacted layers, and stratification within the soil profile and mix layers of different textures to improve water transmission and enhance deeper rooting in the soil. Bringing clay subsoil layers to the surface of sandy soils reduces wind erosion and decreases the droughtiness of sandy soils.

Stratification is common in many alluvial soils of the Southwest, especially Imperial Valley soils. The abrupt textural boundaries adversely affect water movement and act like pans even though the contiguous layers may not be dense. Stratification also is manifested in layers with seemingly uniform texture, such as in sandy or loamy sand soils. Studies at the Imperial Valley Conservation Research Center showed that stratified loamy fine sands and fine sands can impede root development of field crops even though water transmission is favorable. Truck crops grow well on these soils after moderately deep tillage. The tilled, well-fertilized, 8 to 16 inch surface soil provides the relatively small soil volume needed for these shallow-rooted crops. The stratified fine sandy layers below 8 to 16 inches restrict development of the relatively deep root systems of most perennial and annual field crops. In these soils deep tillage invariably reduced soil strength and generally reduced bulk density, which enhanced root and subsequently, shoot development. Impeded root development in a Hanford coarse sandy loam was attributed (by University of California research workers) to the reduced tendency of these soils to crack and fracture in addition to pore-size rigidity and high density.

Deep plowing is a fairly expensive farm operation. At present moldboard plowing to a depth of 4 feet costs $60-80 per acre. The cost is further increased by cost for land leveling which is required after deep moldboard plowing. Costs of subsoiling and slip plowing range from $20-35 per acre, depending on kind of soil and depth and center-spacing of plowing. Since deep plowing is an expensive farm operation, there is a need for study of the economic justification of these operations. On some soils costs of deep plowing may be justified for high values vegetable and fruit crops, but not for other less valued crops.

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Experimental Procedure

Experiment #1: The effect of the following tillage treatments on growth of alfalfa was studied in a Rositas fine sandy loam:

(a) Conventional disking to 8 inch soil depth.
(b) Deep slip plowing in one direction to 3 feet depth on 7 feet centers.
(c) Deep slip plowing in two directions at right angles (to each other) to 3 feet depth on 7 feet centers for each direction.
(d) Deep moldboard plowing to 3 feet depth.

Plots 50 x 100 feet were replicated 4 times in a randomized block design.

Experiment #2: The effects of the following deep profile modification for salt removal and growth of various crops were conducted in plots 20 by 20 feet in a Holtville silty clay soil (silty clay, 0-18 inches overlying silt loam 18-40 inches +):

(a) Disking to 6 inch depth
(b) Mixing with a backhoe to 2 feet depth
(c) Mixing with a backhoe to 4 feet depth

The soil was leached by ponding, planted to Sudangrass, which was followed by alfalfa. The plots were replicated 3 times in a randomized block design.

Results and Discussion

Experiment #1:

The following table shows the total yield for the first year:

Tillage Treatment	Alfalfa Yield ton/acre
Disking, 8" depth	4.6
Slip plowing, 3' depth one direction	7.2
Slip plowing, 3' depth two directions	11.2
Moldboard plowing, 3' depth	9.4
LSD (0.05)	0.9

The beneficial effect of deep tillage is quite pronounced, with the yields in the order: slip plowing two ways > moldboard plowing > slip plowing one way > disking (no deep plowing). Test of soil profiles after the last cut showed clearly that rooting of alfalfa in the disked treatment and in areas between the slits of the slip plow treatments were restricted to the upper 12-18 inches of soil. Roots in the slits of the slip plow treatments reached depths of 36-48 inches. Contrary to expectation deep moldboard plots showed strips of good growth of alfalfa about 2.5 feet wide alternating with strips of poor growth of alfalfa 1.5 feet wide. The plow turned the soil about 135° and the plow slice was visible every 4 feet with 1/2-2/3 of the furrow slice being disturbed whereas the other 1/3-1/2 containing intact stratified layers below 18-24 inches soil depth. The order of yield was related to the degree of breaking up the stratified layers.

Bulk densities in the disturbed layers below disked layers were generally lower than bulk densities in the undisturbed layers at the same soil depth. The disturbed layers as compared to undisturbed layers invariably reduced soil strength as measured by resistance to penetration by steel rods.

Experiment #2:

The following table contains the total yield for the first year:

Tillage Treatment	Alfalfa Yield ton/acre
Disking (6" depth) $(PM)_0$	7.4
Mixing with a backhoe (2' depth) $(PM)_1$	8.7
Mixing with a backhoe (4' depth) $(PM)_2$	9.3
LSD (0.05)	0.5

The increase in yield with deep profile mixing was significant. The general results of the experiment may be summarized as follows:

(1) No appreciable difference was observed in infiltration rate during ponding, or in bulk density of the respective soil layers during cropping.

(2) The most notable differences in soil properties is the disruption of stratification $((PM)_2 > (PM)_1)$; decrease in soil strength as manifested in resistance to penetration by penetrometers and root development $((PM)_2 > (PM)_1 > (PM)_0)$.

(3) In general there was an increase in root and shoot development and in final crop yields in the order $(PM)_2 > (PM)_1 > (PM)_0$.

In addition to alfalfa other crops were grown and they all showed increase in yield in the order of $(PM)_2 > (PM)_1 > (PM)_0$. In general the increase in crop yields were more pronounced in summer crops (i.e. sudangrass and sesbania) than in alfalfa or winter crops (wheat and horse beans). Summer and winter tap-rooted crops (sesbania and horse beans) were more influenced by deep tillage than fibrous-rooted crops (sudangrass and wheat).