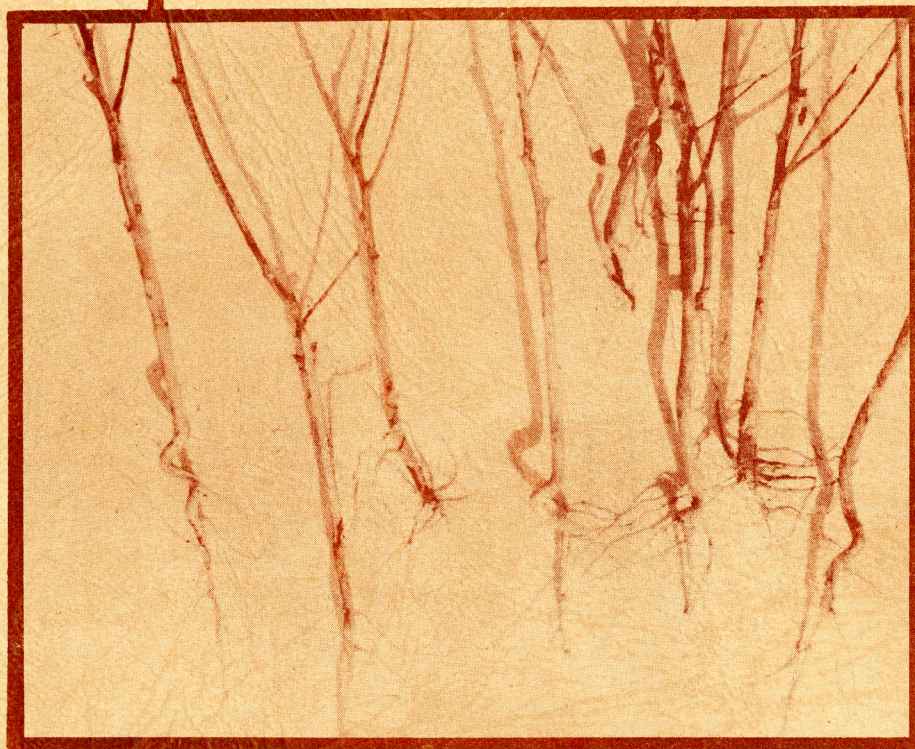


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Report 168
April, 1958



SOIL COMPACTION



AT LEFT - Cotton roots,
crooked and twisted by
inability to penetrate the
soil. These plants were
grown on a hard, compact
soil very low in organic
matter.

(SCS Photo)

Arizona Agricultural Experiment Station
UNIVERSITY of ARIZONA
T U C S O N

SOIL COMPACTION

W. H. Fuller¹

New emphasis is being placed on the depressing influence of soil compaction on maximum crop yields. Depending upon their origin, there are two broad classes of soil compaction, namely: (1) "genetic" - compaction formed during the natural development of the soil and (2) "induced" - compaction formed by mechanical pressure of farm implements and by the weight of water. Corrective methods are often the same for the two classes, although correction of compaction does not lend itself to generalizations since it appears in many different forms.

What is a compacted soil?

A soil may be rather uniformly compacted from the surface to lower depths or it may be compacted in layers. A compacted soil usually has an apparent density of about 50% or more higher than in its natural state. It is rather hazardous to assign a level of density to define soil compaction. For the purpose of discussion, it may be well for us to visualize a compacted soil as one whose apparent density is sufficiently high to adversely influence crop production. (1) The pore space in compacted soil is greatly reduced and water penetration is slow or almost wholly retarded. (2) The size of soil aggregates or structures are reduced, particularly in the coarse range in soils where compaction has been induced. (3) Air movement has also been shown to be lower in compacted soils than in soils of good tilth. (4) Roots

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penetrate compacted soils to a limited extent or not at all. (5) The feeding area of the roots thus may be drastically reduced as a result of soil compaction. Root room is as important to the plant as pasture-area is to the farm animal. (6) The micro-biological activity in a compact soil area is less than in well-aerated soil. In some Arizona soils microbiological activity has been so retarded that plant buried residues were found to be in a perfect state of preservation a year after plowing. The green chlorophyll was still in evidence in plant residues in some clods.

What are some of the causes of soil compaction?

Soil compaction has become a prominent factor in achieving maximum crop production with the recent intensification of farming such as new fertilizer practices, new insecticides, new crop varieties, irrigation, drainage and other means of greater production. In the present stage of mechanization, the amount of traffic over farm land is exceedingly great. The weight of this traffic over cultivated land has increased with time. Many growers now have heavy-duty machinery available which they often use without mercy to the land. There are several distinct types and degrees of compacted layers in soils, depending upon the implements used:

- (1) Compaction caused by relatively light implements, used for seedbed preparation, such as the disc and harrow. These compact a soil at a shallow depth of about 3" to 4" depending upon the soil type and mechanical setting.
- (2) Compaction caused by heavy machinery such as a tractor, truck, or harvest equipment. The surface few inches are often drastically compacted by the heavy machinery, water penetration is materially affected, and

soil structures are broken into smaller aggregates or even pulverized into single grain particles.

(3) Compaction caused by plowing. This results in the familiar plow-sole.

The compact layer is deeper than that of the other two and will form at the base of the plow share.

(4) The vibration of machinery also accelerates compaction.

(5) Compaction caused by the weight and action of irrigation water. For example, an acre-foot of water weighs more than a thousand tons!

Perennial crops such as alfalfa develop hard spots as a result of compaction by water and reorientation of soil particles.

(6) Compaction caused by the hoofs of cattle and sheep on intensively grazed land. Much of this compaction is concentrated in the surface few inches.

What is the effect of soil compaction on crops?

Growing of any crop under irrigated conditions will cause a certain amount of soil compaction. The usual tillage practices, weight of irrigation water, dispersion of soil structure during wetting, etc., leaves the soil in a condition that requires plowing or tilling in order to get a suitable seedbed. The first signs of compaction may be noticed during preplant irrigation. Water intake rate may be slow and irregular if a soil is compacted. For example, a silty clay loam in the Yuma valley took water at an average rate of 0.46 inches per hour during the first hour when rough tilled but at only 0.09 inches per hour when excessively tilled.

The next critical period for establishing the extent of soil compaction is during the period of seedling emergence. Crusting of the surface soil is a form of compaction that often seriously reduces plant stand by preventing seedling emergence or possible

seed germination. Thinning of stand and skipping as a result of this form of compaction may be a large factor in crop production.

The presence of a plow sole or pressure pan as a result of tilling to a fixed depth year after year can cause considerable reduction in plant growth and yield. Figure 1 is a diagram of what has happened to plant growth on a silty clay loam in the Mesa area. When the pore space of the soil was reduced below 34% in a 3-inch tillage pan in the upper foot, guar failed to grow.

In Figure 2, note how cotton produced an average of only 178 pounds of lint per acre when the pore space was reduced in a 3-inch section to 38% in the plow sole in the upper foot. On the other hand, when the same soil had 47% pore space, a yield of 500 pounds per acre of long staple cotton was harvested. Likewise, in Figure 3 it is observed that reducing the pore space of a clay loam to 34% in the upper foot of soil did not prevent barley from growing, but it did reduce yields to an unprofitable level.

Soils under perennial vegetation such as alfalfa may become so compacted by continuous irrigation as to completely prevent growth. The so-called "hard spots" in alfalfa fields are caused by soil compaction. The compacted areas take water so slowly that the alfalfa that was well established the first year actually dies of drought. These spots enlarge each year until they may occupy a sizable area. Soil compaction as a result of applying irrigation water may reduce yields of annual row crops in a less dramatic manner.

Where land is sloping, compaction is conducive to accelerated erosion and water run-off. Various forms of soil compaction, therefore, may affect crop production per unit area in varying extents from slight to severe where no growth occurs. In general, soil compaction may affect crop growth and yield in the following ways:

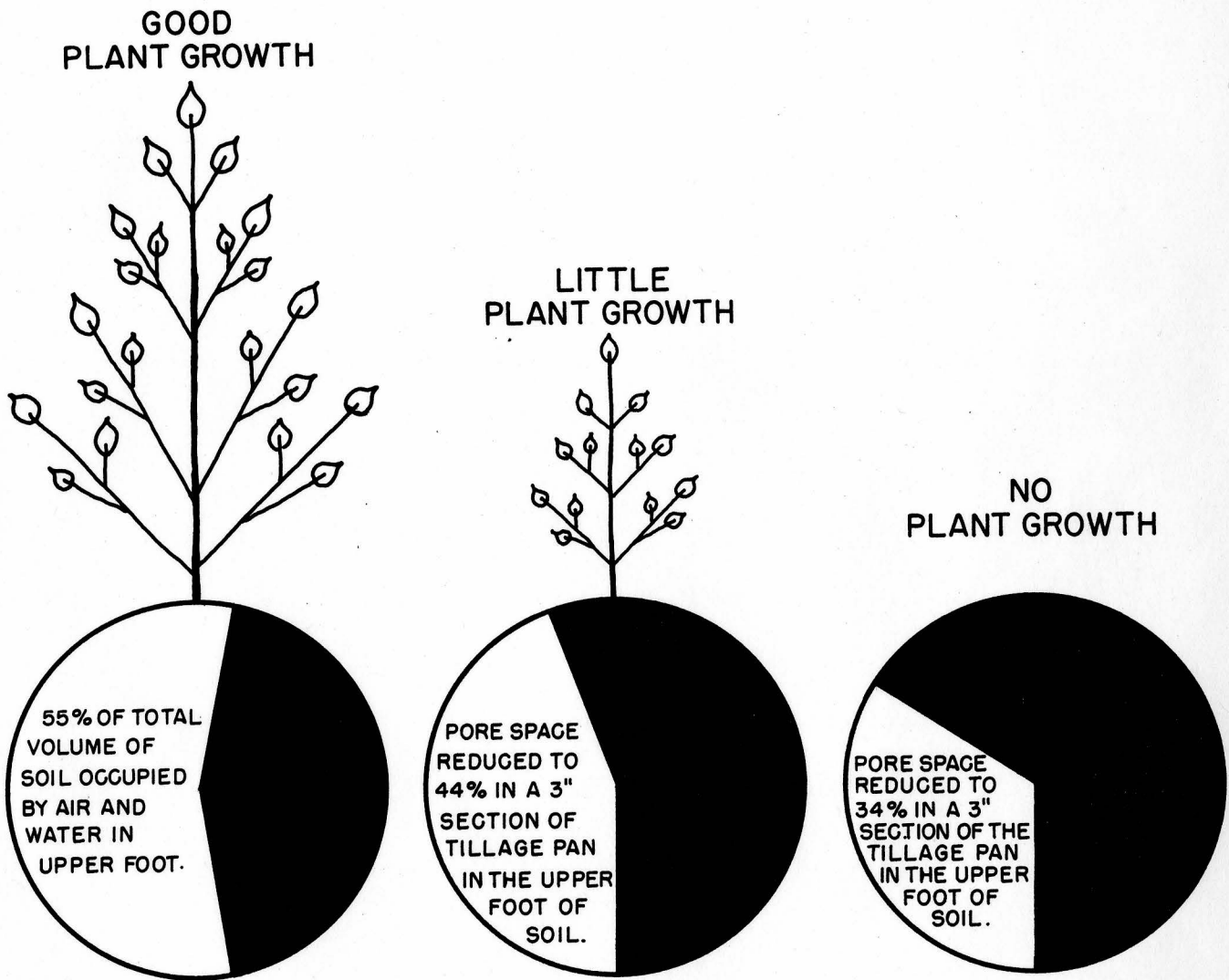


FIGURE 1. - SHOWING EFFECT ON THE GROWTH OF GUAR PLANTS OF EXCESSIVE TILLAGE WHICH COMPACTS THE SILTY CLAY LOAM SOIL IN WHICH THE PLANTS GROW.

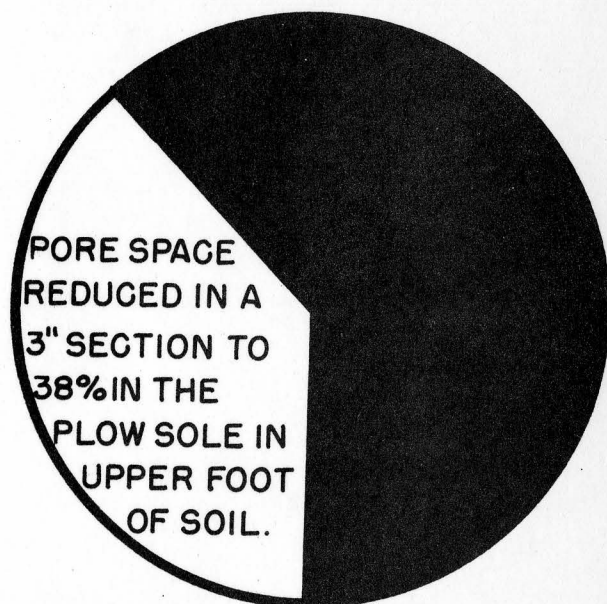
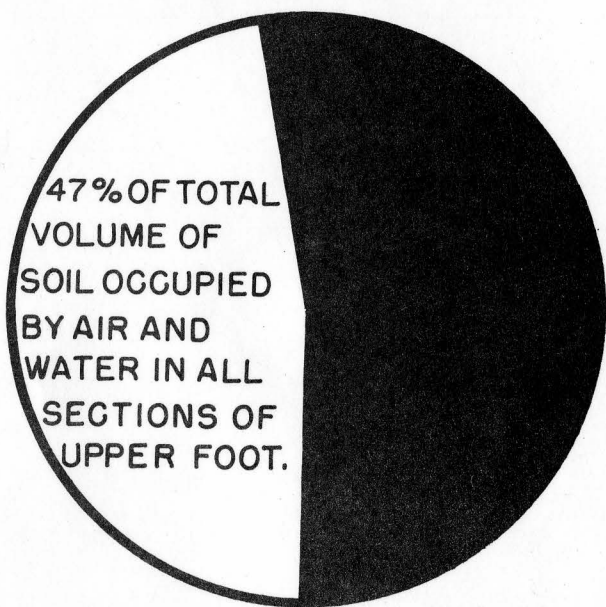
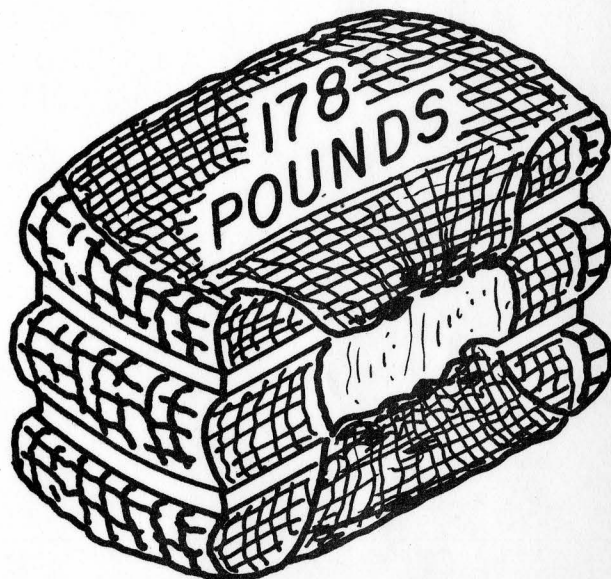
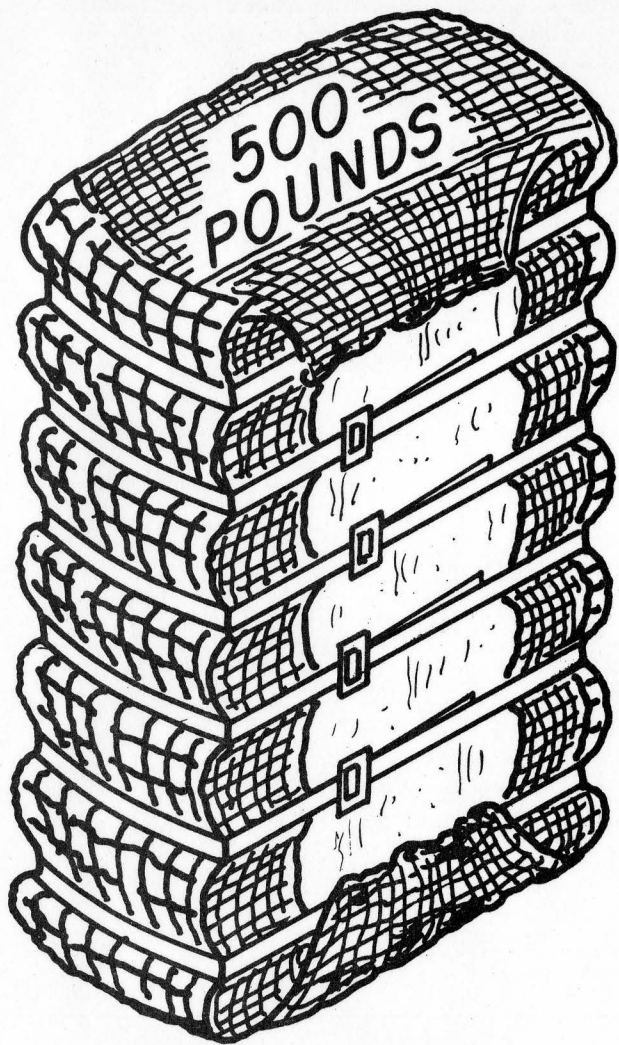
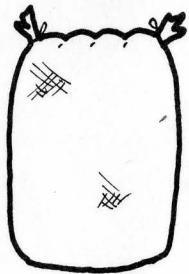


FIGURE 2. - NOTE HOW YIELD OF LONG STAPLE COTTON, GROWN IN A CLAY LOAM SOIL, IS AFFECTED ADVERSELY BY TILLAGE OPERATIONS WHICH COMPACT THE SOIL.



1400
POUNDS

900
POUNDS

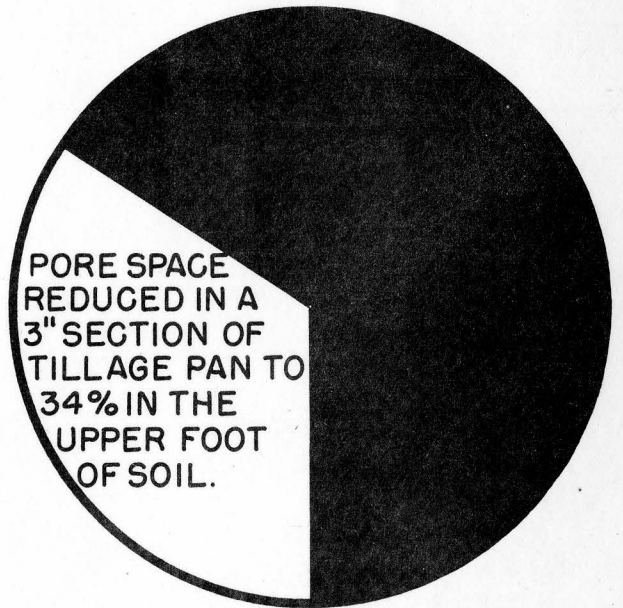
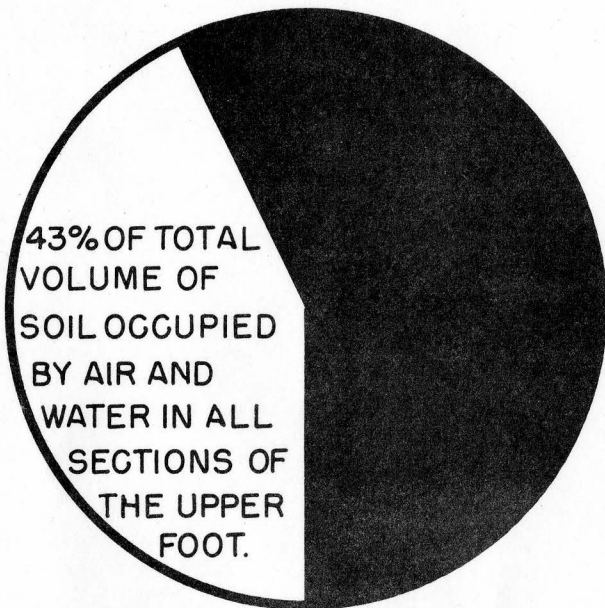
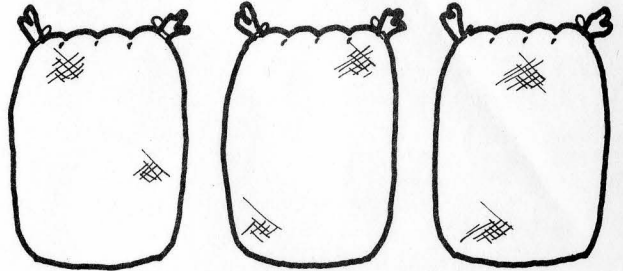
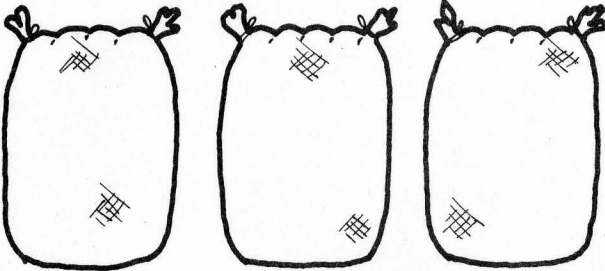
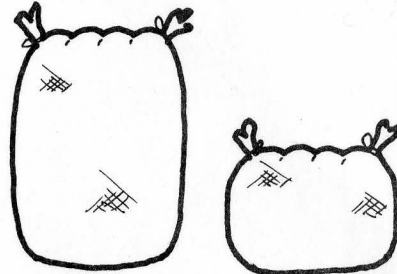
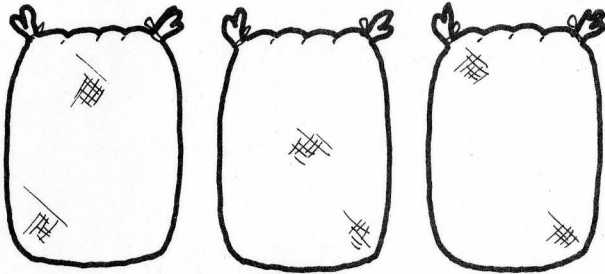


FIGURE 3. - EFFECT ON THE YIELD OF BARLEY OF EXCESSIVE TILLAGE OPERATIONS WHICH COMPACT THE SOIL.

- (1) Reduces root feeding area by the smaller pore space and the mechanical obstruction of pressure pans.
- (2) Reduces seed germination.
- (3) Prevents maximum emergence of seedlings.
- (4) Reduces the amount of water available to plants.
- (5) Reduces aeration - Roots require soil air to grow.

What are some corrective or preventive measures for soil compaction?

Tillage practices

- (1) Eliminate as much traffic with heavy implements as possible.
- (2) When tilling the soil, work it at the proper moisture content. Very wet soil compacts much more readily than dry soil. Breaking the soil when dry is the most important way of eliminating compact soil.
- (3) Break up the soil below the compacted layers, where practical, when preparing a seedbed. In Arizona two types of plows are used for breaking the soil,
(a) a heavy disc plow and (b) heavy moldboard plow with hydraulic lifts.
Plow below the compacted layers where practical.
- (4) Deep plowing has helped remove compacted layers as well as eliminate horizontal zonations caused by different texture materials.
- (5) Knifing has been used to break up and lift compacted layers. It has less damaging influence on soil structure than plowing.
- (6) Chiseling is a process involving one or more teeth set at various depths, to break up compacted layers. It also helps increase water penetration and aeration.

Compacted soils should be broken when the soil is relatively dry to take advantage of the greatest possible shattering effect. These implements lose their effectiveness in wet soil. Use light tillage implements for seedbed preparation and cultivate as infrequently as possible. Also allow the soil to dry thoroughly as possible and air out before the preplant irrigation.

The effectiveness of the method used to reduce or correct soil compaction will vary with the circumstances. Caution should be taken to select the correction procedure most suitable to the circumstance.

Organic Matter

Return as much of the crop residues as possible. Burn only when disease is a factor in production. Organic residues should be worked into the soil as deeply as practical. Plowing under organic matter with a moldboard plow is considered as one of the most desirable methods of incorporating plant residues to improve soil tilth.

Crop Rotation

Rotate crops to prevent the formation of pressure pans in the same spots each year. Certain crops, because they are deep rooted, are effective in improving water penetration and aeration.

Pasturing Cattle

If it is necessary to pasture land for row crops, it is most desirable that the animals be allowed on the land only when it is dry. Animal hoofs can seriously puddle wet soil.

"Don't let the silent robber, soil compaction, pick your crop yield pocket book of profits".

ACKNOWLEDGEMENT

The author wishes to thank Mr. Carl Harris of the USDA, ARS, in Arizona for his kind and helpful suggestions in preparing the diagrams and providing data for this paper.

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