Influence of Soil Compaction on Emergence and First-Year Growth of Seeded Grasses

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Highlight

Adequate soil preparation will eliminate any compacted layers formed under cultivation and aid in securing a vigorous stand of grass on land converted from cash crop to pasture. Seedling emergence is not affected, but a compacted soil layer depresses the vigor of young grass plants by limiting root penetration and the volume of soil from which moisture for growth can be extracted. The curtailment of forage production is more pronounced with time.

Farmers and ranchers changing from a cash crop to perennial grass often have difficulty in establishing a satisfactory stand of grass. Minimizing the risk of establishing a stand of grass adequate for livestock forage and soil protection will benefit many segments of agriculture, especially livestock producers. Cooperative work was undertaken at the Big Spring Field Station between the Texas Agricultural Experiment Station and the Soil and Water Conservation Research Division, Agricultural Research Service, to determine some of the causes for the limited success in establishing grass on cultivated land.

Compacted soil zones or pans occur widely in cultivated soils. These soil pans usually are formed immediately below normal tillage depth in sandy as well as in fine-textured soils. The pans are very persistent in loam, fine sandy loam, and loamy fine sand soils of the Southern Great Plains.

Compacted soil zones and pans have been shown to restrict the yields of many crop plants. Cotton and grain sorghum (Taylor et al., 1964), corn (Phillips and Kirkham, 1962), tomatoes (Flocker et al., 1959), sugarcane (Trouse and Humbert, 1961), and sudangrass and soybeans (Zimmerman and Kardos, 1961) have shown depressed yields when grown on soils with compacted layers. Roots of sudangrass penetrated compacted cores more readily than did soybean roots under laboratory conditions.

The restrictive influence of compacted soil layers on production of many field crops is well documented, but very little is known concerning the reaction of forage plants to similar soil conditions. Few roots of native grasses growing in a prairie sod were present in the dense subsoil found at a shallow depth (Fox, Weaver, and Lipps, 1953). A compacted soil layer was shown to be associated with a depression of livestock production after 20 years of relatively heavy grazing use (Rhoades et al., 1964). In view of these findings, it seemed reasonable that a compacted soil pan would influence the establishment of seeded grasses.

Procedure

An Amarillo sandy clay loam, which had been cultivated for a number of years, and on which sorghum had been grown the previous season, was selected for this study. Sorghum stubble was still present when the following soil treatments were established:

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(1) disc-plow to 10 inches deep; (2) sweep tillage to a 4-inch depth on soil at normal field density; (3) sweep tillage to a 4-inch depth on soil compacted with wheeled tractor traffic; and (4) sweep tillage to a 4-inch depth on soil that was compacted with a 10-ton roadroller. The compaction treatments were applied while the soil was at field capacity and were followed by the appropriate tillage.

On May 28, giant or big cenchrus, *Cenchrus myosuroides* H.B.K.; green sprangletop, *Leptochloa dubia* (H.B.K.) Nees; and sideoats grama, *Bouteloua curtipendula* (Michx.) Torr., were planted on the various compaction treatments in 4-row blocks. All plantings were made using a 2-row tractor-mounted grass seeder equipped with double-disc furrow openers and press wheels. A rain of 0.80 inch fell immediately after planting, and 1.47 inches of precipitation fell within the next two weeks. To maintain growth, sprinkler irrigation was applied as needed until the emergent plants were well established.

FIG. 2. Stands of giant cenchrus 70 days after planting on Amarillo sandy clay loam soil having a compacted layer 4 inches below the surface (above) and tilled to a depth of 10 inches just before planting (below).

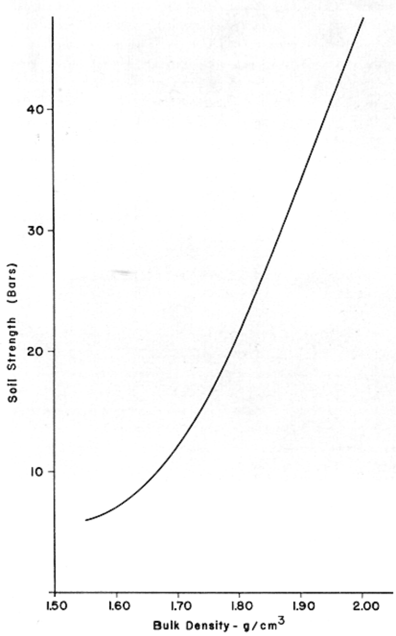

FIG. 1. Relationship of soil strength and bulk density in Amarillo sandy clay loam measured at 1/3-bar soil moisture tension.

Measurements of plant response during the first season after planting included a count and height measurement of seedlings, average height of leafage extended vertically, number and average height of heads exserted, and yield of caryopses and forage at the end of the growing season.

In November, bulk density was determined with a clod method (Johnston, 1945) on 10 clods from the highest strength zone within the upper 6 inches of soil. These bulk density data were combined with data from Taylor et al. (1964) to provide estimates of soil strength at field capacity as measured with a force gauge penetrometer (Fig. 1).

The experiment was organized in a split-plot design. The main plots consisted of the various compaction treatments, and the grass species planted were considered as subplots. Since considerable variation in soil strength occurred between plots given the same compaction treatment, the data were analyzed using the least squares method.

Results and Discussion

Giant cenchrus came up to good stands. Initial stands of the other two species were spotty, but this spottiness did not appear to be related to the experimental treatments. Consequently, sideoats grama and green sprangletop were replanted, and satisfactory stands were obtained using a combination of hay mulch and sprinkler irrigation. Only the relationships established for giant cenchrus will be reported in this paper, although the other two grasses responded similarly to the imposed soil compaction treatments.

The magnitude of each plant response measured, except number of seedlings per unit length of row, was inversely proportional to soil compaction; i. e., as the degree of compaction increased the plant yield declined (Fig. 2). The number of live seedlings 35 days after planting was independent of the compaction treatment imposed, but the influence of the compacted zone was noted in measurements of seedling height made at the same time as the stand counts. Seedlings growing in soils that were either deep tilled or utilized at field density were taller than those growing on soils having a compacted layer. Yields of both seed (Fig. 3) and forage (Fig. 4) at the end of the growing season show a curvilinear relation between soil compaction and the various measured plant responses.

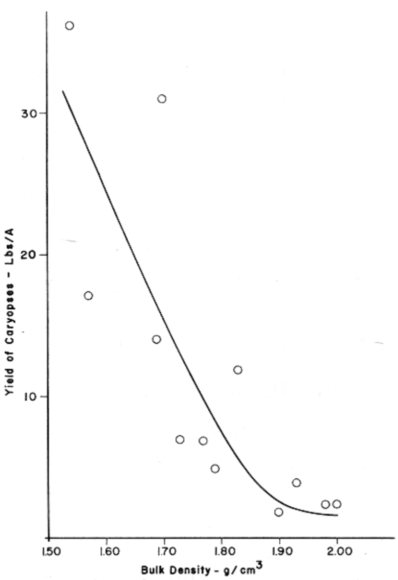

FIG. 3. Yield of seed (caryopses) of giant cenchrus grown on an Amarillo sandy clay loam soil subjected to several degrees of compaction.

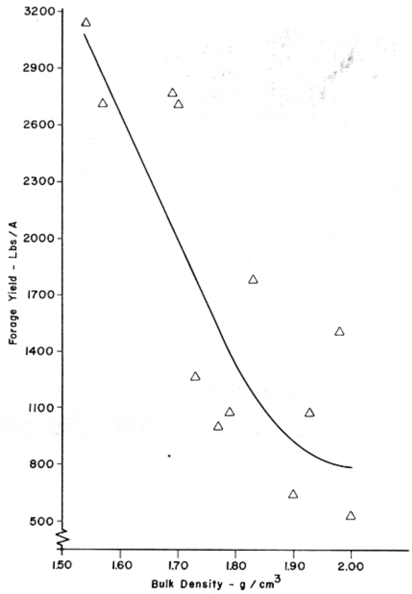

FIG. 4. Yield of forage from giant cenchrus at the end of the first growing season after planting in Amarillo sandy clay loam subjected to varying degrees of compaction.

Dryland cotton grown nearby during the same season showed curvilinear trends between soil compaction and growth rates and between soil compaction and lint cotton yield. In that experiment, Taylor et al. (1964) found that soil compaction increased soil strength to such an extent that cotton roots could not penetrate the high bulk density layers.

Periodic observations during the growing season showed that the grass roots were similarly stopped by the high strength layers (Fig. 5). Whenever Amarillo sandy clay loam soil bulk density exceeded 1.82 g/cm^3, few grass roots were able to penetrate the soil pan even when it was at field capacity. This corresponds to a soil strength of approximately 25 bars (Fig. 1). Experiments with cotton (Taylor and Gardner, 1963) have shown that a greater proportion of plant roots can penetrate soils at field capacity than at lower moisture contents.

The reduction in the growth rate of grass and, consequently, the yield reflects the limited moisture and nutrients available when plants are grown on high-strength pans. Most of the water and nutrients in and under pans are unavailable because roots do not grow through the pans. Observations during the growing season often showed available moisture in the second foot of soil while the grass plants grown on the compacted pans were suffering severely from moisture stress.

Thus, soil compaction alters the plant-soil-water relationships, and the vigor of the desirable plants is lessened. In this study, the measured responses of giant cenchrus and the observed responses of sideoats grama and green sprangletop were similar to those recorded for cotton (Taylor, Locke and Box, 1964). Under the conditions of this study, a soil pan approximately

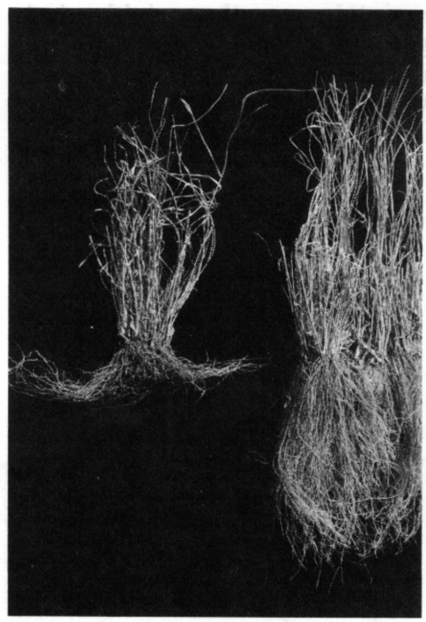

FIG. 5. Roots of giant cenchrus growing in soil with a compacted layer (left) were restricted to the 3-inch layer of soil above the pan. The greater vigor of giant cenchrus plants growing on soils without this compacted layer (right) is a reflection of the greater amount of moisture and nutrients available in this larger soil reservoir.

4 inches below the soil surface did not affect the number of emergent seedlings. However, the height of these young plants was associated with the imposed soil compaction, and the plant response to the restricted soil volume available for root growth became more pronounced with time.

The benefits from tillage to eliminate compacted soil pans are vividly demonstrated by this experiment. The compacted soil layers not only increase the risk of establishing an acceptable stand of seeded grass, but they reduce the vigor of the surviving plants.

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