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Abstract

The ambiguity of current tillage nomenclature has led to much confusion. This report explains a uniform, comprehensive tillage index that was developed to avoid that ambiguity. It is based on row topography, residue cover, roughness, and tillage depth that result from passage of the tillage tool rather than on the tillage tool used. Examples of the use of this tillage index are presented. This index, because of its percentage crop residue cover and potential surface water storage components, will be useful when the Universal Soil Loss Equation is to be used for estimating erosion potential on a given field.

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Comments

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Tillage Index Based on Created Soil Conditions

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ABSTRACT

THE ambiguity of current tillage nomenclature has led to much confusion. This report explains a uniform, comprehensive tillage index that was developed to avoid that ambiguity. It is based on row topography, residue cover, roughness, and tillage depth that result from passage of the tillage tool rather than on the tillage tool used. Examples of the use of this tillage index are presented.

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INTRODUCTION

Description of soil conditions after tillage which are based solely on the tillage system used on a given soil is vague and may be misleading. For example, soil conditions resulting from the moldboard plow, chisel plow, or lister system may vary from farm to farm, depending on soil type, soil water content at time of tillage, tool adjustment, and speed of tool operation. Different soils do not necessarily respond similarly to common tillage practices (Triplett et al., 1970).

Important soil conditions affected by tillage are those that either directly or indirectly affect plant growth and/or soil erosion. Various tillage-affected soil conditions, such as the amount of soil surface covered by plant residue and the surface roughness, directly affect soil erosion. Plant growth is indirectly affected by tillage through the effect of tillage on soil environmental conditions: soil water content, soil aeration, nutrient or fertilizer position, soil temperature, and soil strength. The interaction between tillage-created soil conditions and the atmosphere determine the soil's environmental conditions.

This paper proposes a solution to ambiguous tillage nomenclature. An easily understood tillage index which disregards the ground-engaging tool used during tillage and considers only the created soil conditions that have appreciable potential to affect soil erosion or the soil's environment was developed. That index should provide a common language for scientists, engineers, and policy makers.

The four parameters chosen for use in the tillage index, along with the scalar values for each parameter, are shown in Table 1.

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HEIGHT DIFFERENCE PERPENDICULAR TO DIRECTION OF TILLAGE

Differences between soil height in row and interrow zones have direct effects on above-ground storage capacity, soil temperature, and soil water content in each zone as well as direct effects on soil erosion. Differences between temperature of the soil in ridges and furrows of a ridge-furrow system may vary as much as 4 °C (Buchele et al., 1955). The water content of soil in the ridges tends to be lower than in the furrows (Buchele et al., 1955). Soil-erosion and water-runoff losses are inversely related to row-interrow zones that run perpendicular to the land slope (USDA Technical Bulletin No. 558, 1937).

Soil-height differences between row and interrow zones may be determined in the field by placing a meterstick vertically in the furrow and sighting from ridge to ridge. Frequency of measurements will depend on research or production objectives, or both.

PERCENTAGE OF SOIL SURFACE COVERED BY PLANT RESIDUES

Soil erosion losses after planting are inversely related to the amount of soil surface covered by plant residues, regardless of preplanting tillage operations (Laflen and Colvin, 1981). Surface residues also affect soil temperature by shading the soil surface (Burrows and Larson, 1962) and water content by affecting heat and water transfer at the soil surface.

Several methods are available for determining percentage of soil surface covered by residue (Laflen et al., 1981; Hartwig and Laflen, 1978; Sloneker and Moldenhauer, 1977). The line transect method is the most accurate of the available methods and is recommended for that measurement. A 15.2-m (50 ft) cable, containing 100 beads spaced 15.2 cm (6 in.) apart, is stretched across crop rows and oriented such that each end of the cable is over a row. The estimated percentage of soil surface that is covered by plant residue is equal to the percentage (or number) of beads directly over plant residue (Laflen et al., 1981).

ROUGHNESS OF THE SOIL SURFACE

Soil porosity, which influences aeration, water

TABLE 1. PARAMETERS FOR TILLAGE INDEX

Height difference: row vs. interrow zone, cm	Amount of soil surface covered by plant residue, %	Roughness of soil surface, cm	Depth of tillage, cm
I. 0- 5	A. 75-100	04. 0.0- 4.0	a. 0- 8
II. 6-10	B. 50- 74	08. 4.1- 8.0	b. 0-16
III. 11-15	C. 30- 49	12. 8.1-12.0	c. 0-24
IV. 16-20	D. 0- 29	16. 12.1-16.0	
V. 21-25		20. 16.1-20.0	

infiltration, and evaporation, tends to correlate with soil-surface roughness (Burwell and Larson, 1969; Allmaras et al., 1967; Allmaras et al., 1966; Burwell et al., 1963). Surface roughness also influences radiation absorption and soil temperature (Allmaras et al., 1966; Arkin and Taylor, 981). In freshly tilled soils, mean aggregate (soil structural unit) size tends to correlate positively with surface roughness. Soil conditions are optimum if the structural units of soil in the row zone are small enough to promote good seed-to-soil contact and if the structural units in the interrow zone are large enough to promote infiltration and aeration.

Techniques for evaluating surface roughness are explained by Allmaras et al. (1966), Currence (1970), and Burwell et al. (1963).

DEPTH OF TILLAGE

Tillage operations tend to alter soil bulk density (Bolton et al., 1981), soil strength (Wells and Tressuwan, 1978), and aggregate size distribution (Emmond, 1971) in the tilled zone. Those soil properties potentially affect aeration (Arkin and Taylor, 1981), soil water movement (Arya and Paris, 1981; Gupta and Larson, 1979), soil resistance to plant root growth (Hallmark and Barber, 1981), and fertilizer nutrient distribution (Hallmark and Barber, 1981).

Tillage depth is defined as the vertical distance from the initial soil surface to a specified point of tool penetration (Agricultural Engineers Yearbook, 1982). The depth of primary tillage tool operation or depth of the deepest operation is the recommended measurement for this index.

DISCUSSION

The four parameters that have been outlined provide the basis for a uniform tillage index. They are easily remembered by the acronym HARD. H represents Height difference: row vs. interrow zone; A represents Amount of soil surface covered by plant residue; R represents Roughness of soil surface; and D represents Depth of tillage.

Following are examples of using the specified parameters as shown in Table 1 instead of using such terms as chisel-plow system or a reduced system to describe a tillage system:

IAO4a—A tillage method leaving very small ridges (0-5 cm) and 75 to 100% of soil covered by residue. The roughness of the soil surface was from 0.0 to 4.0 cm with a 0- to 8-cm depth of tillage.

VD20c—A tillage method leaving ridges with a height of 21 to 25 cm and 0 to 29% of soil covered by residue. The roughness of the soil surface was 16.1 to 20.0 cm with a 0- to 24-cm depth of tillage.

From a soil conservation standpoint, the basis of the system is not the tillage tool used, but rather the amount of plant residue left on the surface and the potential surface water storage. The tillage index described can aid in computation of the management factor in the Universal Soil Loss Equation for predicting erosion potential by providing values for residue cover, surface roughness, and row vs. interrow height differences. These values, of course, can be obtained in the field; but, when literature is being reviewed, it is sometimes difficult to determine appropriate values if the reader wished to make an independent evaluation of the soil loss potential for systems or parts of systems.

Several factors that affect soils are not currently included in the proposed index system. These include fertilizer application and its influence on soil aggregation, as shown by Emmond (1971), and the significant difference in soil bulk density under various cropping systems, as shown by Hageman and Shrader (1979).

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