SOIL TILLAGE INTENSITY RATINGS (STIR) FOR CONSERVATION CROPPING SYSTEMS

Tillage is used to control weeds, incorporate crop residue and fertilizers, and prepare land for planting. However, minimizing soil disturbance by tillage and maintaining soil cover during tillage are critical production practices needed for improving or maintaining soil health (see below definition).

Soybeans in Mississippi are grown on a variety of soil series, from sandy loam to clay. Each of these soils has unique properties and/or conditions that may benefit from some sort of tillage. There is no set rule for if, when, and how much of a particular type of tillage should be used to grow soybeans or any other crop on any of these soils. However, all trips across a field, whether for tillage or a non-tillage operation such as spraying, cause some level of soil disturbance and likely affect surface residue as well.

The Soil Tillage Intensity Rating (STIR) is a measure of soil disturbance developed by NRCS to reflect all field operations. A STIR value is assigned to each field operation, both tillage and non-tillage related. The STIR is a numerical value calculated using RUSLE2 (Revised Universal Soil Loss Equation 2). It is a stand-alone rating used to evaluate the kind, severity, and number of ground-disturbing passes on parameters of soil quality other than traditional ground cover and surface disturbance. High STIR numbers indicate more soil disturbance, whereas lower numbers indicate less overall disturbance to the soil.

STIR uses the various operations' database parameters in RUSLE2 to calculate tillage intensity rating for the system used in growing a crop or in a rotation (The RUSLE2 program and databases are available here). The STIR ratings tend to show the differences among systems across the spectrum from true no-till through "conventional plow" systems. It accomplishes this by rating the kind, severity, and number of ground disturbing passes rather than just the end result from a set of passes; i.e., the STIR rating applies to the entire tillage system used in producing a crop.

The following factors affect operation-specific STIR values.

- **Operational speed of tillage equipment and how this affects crop residue (see below) burial.** RUSLE2 can compute how speed of an implement affects residue burial. The recommended speed is that suggested by the manufacturer for a particular implement.
- **Tillage type (disk, chisel, bedder, no-till, etc.)–describes how a tillage operation mixes the soil and associated residue.** This variable refers to the type of mechanical disturbance to the soil, and how that affects the distribution of residue within the soil. Values of 1.0 (inversion with some mixing), 0.8 (mixing and some inversion), 0.4 (lifting and fracturing), 0.7 (mixing only), and 0.15 (compression) are assigned to individual tillage types in the STIR rating (NRCS TN Agron No. 50).
- **Depth of tillage operation and the depth to which residue is incorporated**. Typical tillage implements (NRCS Equipment Guide) work best at a particular tillage depth recommended by the manufacturer.
- **Percentage of the soil surface area disturbed by a tillage operation**. For example, a plow is designed to disturb 100% of the soil surface, whereas a no-till planter disturbs approximately 10% of the soil surface. The fraction (percent) of the total soil surface that is disturbed is the value used in the calculations. Higher STIR ratings are assigned to systems with greater soil disturbance and more frequent operations.
- Click here for the article "Soil tillage Intensity Rating STIR" by David T. Lightle, NRCS Conservation Agronomist, and here for NRCS TN Agronomy No. 50 that provide more detail about the above factors and how they are calculated.

The STIR for a field is the simple sum of STIR values for all field operations that are performed from harvest of a previous crop through harvest of a current crop. The STIR is an index (without units) that typically fall in the range of 0-200, with low scores preferred; high values are associated with higher tillage intensity.

Conservation tillage (see below) systems typically will have STIR values <80. No-till (see below) operations require a STIR of 30 or less.

Low STIR values reduce the likelihood of erosion; other benefits of low STIR values include the potential of increasing organic matter (OM) content of soil, less OM breakdown, lower carbon losses from soil to atmosphere, and improved water infiltration capacity. Tillage operations greatly affect STIR ratings; i.e., reducing tillage and choosing no-till operations will lower STIR ratings. Additional management decisions such as using cover crops between cash grain crops and adding soil-conserving crops such as alfalfa and grass crops in a rotation will also lower STIR values. Below is the calculated STIR rating for a 2-year rotation of corn and soybean produced with indicated tillage operations.

Example calculation of the STIR value for a 2-year corn-soybean rotation (see reference here).

Crop	**Operation**	**STIR**
	Chisel, straight point	45.50
	Disk, tandem secondary operation	32.50
	Disk, tandem light finishing	19.50
Corn, grain	Planter, double disk opener w/fluted coulter	2.43
	Harvest, killing crop	0.15
Soybean	Drill	2.43
	Harvest, killing crop	0.15
	STIR rating (102.55/2 years)	**51.33**

A USDA-NRCS tillage practice guide provides STIR values for selected conservation tillage operations.

Practice Standard 329–No-Till/Strip-Till/Direct Seed. No-Till leaves the soil and crop residue undisturbed except for the planted row. No-till planters typically disturb less than 25% of the row width, but surface residue remains relatively undisturbed. Strip-Till uses coulters or row cleaners to till up to 30% of the row width. Surface residue is disturbed in the tilled strip. Typical STIR values are <15.

Practice Standard 345–Mulch Till (see below). This is full-width tillage with an implement such as a chisel plow or secondary tillage implements such as a field cultivator or disk harrow. All surface residue is disturbed to some extent. Typical STIR value exceeds 15, but is less than 80.

In the past, tillage practices were evaluated based on the soil residue cover that remained at planting time. This system determined the effect of tillage based on the tillage implement used and the "fragility" of residue from a previous crop. This meant that two fields with different crops could be categorized into different tillage systems based on the properties of the residue from those crops. As expected, then, estimates of tillage effect on soil will differ between the STIR and Residue methods.

A good summary of these differences is presented on p. 16-17 of the article linked here. A few of the basic differences between the two systems follow.

- Since no-till is the absence of tillage, no-till designation is unchanged when using either method.
- The Residue method relies on tillage up to planting and the STIR method relies on tillage and other field operations for the entire season.
- The STIR method is more likely to accurately categorize soil disturbance due to tillage.
- In soybeans, the STIR method categorizes more fields as conventional tilled than does the Residue

method.

- Classification of tillage using the Residue method depends on the amount of residue produced by a previous crop and whether the residue is "fragile". Thus, using the Residue method for classification will result in different designations depending on whether or not a previous crop produced a high amount of non-fragile residue or a medium to low amount of fragile residue.
- Where soybeans follow a high-residue crop such as corn, the Residue method is more likely to categorize the tillage system as mulch till (see below) than is the STIR method. Where soybeans follow a medium-residue crop, the Residue method is more likely to categorize the tillage system as conventional tillage (see below).

Many of the linked resources in this article were provided by Michael Kucera, Agronomist, National Soil Survey Center, Lincoln, Nebraska. He also provided the following linked articles that are additional resources for the STIR subject.

Soil Tillage Intensity Rating (STIR), USDA-NRCS, Jan. 2018
A Soil Conditioning Index for Cropland Management Systems, D.T. Lightle, NRCS-NSSC, 2015
Overview of Tillage Implements for Use in RUSLE2 Calculations, Giulio Ferruzzi, USDA-NRCS

According to Mr. Kucera, "NRCS plans to replace RUSLE2 with WEPP which is a more current process-based erosion prediction model. STIR and SCI (Soil Conditioning Index) are also incorporated into the WEPP model, along with water budget and energy use. We plan to fully implement WEPP and archive RUSLE2 on Oct. 1, 2019."

Definitions of terms used in above narrative:

- ***Conservation Tillage***: *Tillage management practices that result in a STIR of less than or equal to 80, and do not use a moldboard plow. Conservation tillage practices can include mulch-till, no-till, and strip-till.*
- ***Conventional Tillage***: *A combination of tillage management practices that result in a STIR >80.*
- ***Mulch-Till***: *A type of conservation tillage where soil is tilled (for example with a chisel plow or disk) but soil disturbance is low (STIR <80).*
- ***No-Till***: *The practice of refraining from tilling the soil from harvest of a previous crop to harvest of a current crop.*
- ***Crop Residue***: *Plant material from a crop, such as cornstalks or soybean stubble, that remains after harvest.*
- ***Soil Health***: *The continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. Soil health benefits from conservation tillage may be fully realized only when practices such as no-till or strip-till that minimize soil disturbance are used consistently over time.*

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