The Tillage Revolution and the Impact of Conservation Mandates in the Southern Region

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In the 1930's, Hugh Hammond Bennett and the dust bowl captured the nation's attention and dramatized soil erosion problems. Some 50 years later, Congress enacted the Food Security Act. This act is creating an entirely new approach to agricultural resource conservation. Title XI1 of the Food Security Act makes conservation practices on certain erosion-prone land an eligibility requirement for participation in many USDA programs. In the past, conservation practices were installed on a voluntary basis and administered separately from commodity programs. Since a high percentage of farmers participate in commodity programs, tying conservation to program participation provides a powerful economic incentive to comply. Program payments equaled 40 percent of net income for all of agriculture in 1987-88.

During the time since passage of the Act, highly erodible land has been defined as having an Erodibility Index (EI) > 8, and acceptable soil loss has been set at predetermined tolerance (T), which ranges from 1 to 5 tons per acre per year. There are some exceptions to this, with greater soil losses acceptable under certain conditions. Farmers have been notified of the Act and its details, including sodbuster and swampbuster provisions for erodible and wetlands, respectively. The Universal Soil Loss Equation (USLE) has been selected as the vehicle to estimate soil loss and to plan for reduction of soil loss to target levels. A monumental task remains; plans for nearly a million farmers with highly erodible fields must be completed by 1990 and these plans implemented before 1995.

A local farm planner with SCS outlined his approach to bringing highly erodible fields into compliance by using the following steps:

- **1.** Eliminate fall tillage.
- 2. Plant on the contour (P=0.6).
- **3.** Install grass strips on the contour (P=0.4 plus the contribution of the grass strip).
- 4. Terraces (cost=\$250/A).
- 5. Suggest the last be enrolled in the Conservation Reserve Program.

This seems to be both a practical and workable approach. With an escape into the CRP if application of practices are insufficient to reduce erosion to acceptable levels, this planner was doing little to propose modifying tillage practices except to eliminate fall plowing. Most of the soils in his area are in the Black Belt and, seemingly, he did not think that no-tillage or any other from of tillage that maintains surface residue cover was highly desirable. Productivity often suffers with these limited tillage systems on the Black Belt soils. Further, unless the operator requested terraces, he would probably skip these and suggest the CRP After all, that highly erodible field may have already lost much of its topsoil and not be very productive.

A part of the title of this paper involves the tillage revolution. This might be defined as a radical change in practices made over a short period of time and an example might be moving from conventional tillage to no-tillage. At this point, we might ask several questions:

- 1. Has a tillage revolution taken place?
- 2. What might we gain toward meeting the conservation mandates by such *a* revolution?
- 3. If the revolution has not occurred, what would be needed to create conditions to foster the process?

In reflecting on the first question, 1 thought about my grandfather who was born 129 years ago and who farmed just a few miles south of Tupelo in the Black Belt. He grew cotton and some corn to feed the mules and to make bread. He never owned a tractor, although there were some in the neighborhood. In growing cotton, he used a turning plow to throw last year's row into the middles which formed a bed. A middle buster completed the bed formation. The bed was dragged and planted. When the crop emerged, hoes were used to thin the stand. As the crop grew, rows were cultivated frequently and weeds that were missed by cultivation were eliminated by hoeing. Corn was produced using similar techniques.

If someone from that era came back today, what changes would they see and would they recognize the operations used to grow crops? Today, fields are much larger than the 2 or 3-acre patches worked with mules. Disks and plows are used to prepare the soil for planting and sweeps to cultivate after crop emergence. These same kinds of tools were used 50 years ago. Soil is worked as intensely today and often tilled deeper than 50 years ago because power is available to do so. There has been a revolution in how the implements are pulled, but this should not be confused with degree or intensity of tillage. There has been another revolution. During this time, chemicals have completely eliminated hand hoeing of weeds.

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Someone from that era would not recognize a no-tillage planter. If they saw one operating in wheat stubble, they wouldn't know what was happening and wouldn't believe that a crop could be produced in that manner. This would constitute a revolution! In the mid-South today, no-tillage seems to refer to the specific system of planting soybeans following wheat harvest. Although there is research devoted to production of major crops by planting into crop residue or cover crops, little of this seems to be standard production practice. In contrast, in some parts of Ohio more than 50 percent of the corn acreage is no-till planted. That constitutes a revolution; the revolution has not yet arrived in the South.

What could tillage contribute towards meeting the conservation mandate?

In predicting erosion, the USLE addresses a number of factors. These include rainfall characteristics of the area, the slope length and steepness, the erodibility of the soil, the crop itself, and the practices used to grow the crop. Many of those factors are determined by the inherent characteristics of the site and cannot be changed. The practices (P) used to grow the crop, such as row direction (straight, or contour, up and down slope), can be modified as can some of the crop (C) factors (soil residue cover, tillage, crop grown). Modifying practices may provide a 2x reduction in erosion; adopting no-tillage with a high amount of residue cover can reduce erosion by as much as 4x, according to the handbook values for the USLE.

Unfortunately, the current version of the USLE may understate the value of no-tillage in reducing erosion by a factor of several fold. In experimentally derived C factors for corn, McGregor and others (1982, 1983) reported only 1/16 to 1/22 as much soil loss with no-tillage as with conventional tillage. Soil losses for soybeans grown with no-tillage were cut by 80 to 97 percent when compared to conventional tillage systems (McGregor, 1976, and Mutchler & Greer 1984). In work with no-tillage cotton, the best no-tillage treatment had soil loss of < 2 percent of the amount from conventional tillage (Mutchler et al., 1985). Van Doren el al. (1984) reported that amount of erosion decreased with time since the last tillage. They also reported C values for no-tillage much more favorable than those listed in the USLE handbook. Thus, untilled systems could decrease in their erodibility with passage of time.

Field technicians charged with developing erosion control plans for individual farmers have no authority to modify USLE values to reflect new information; this will have to come from a higher administrative level. I am told a new means of predicting erosion is being developed (WEPP), but no details are generally available. Values shown above, however, indicate that no-tillage with suitable mulch cover could reduce erosion to acceptable levels for most crop, soil, and slope combinations. The Conservation Reserve Program may be an excellent solution for today's use of the most erosive land, but programs change and the prices or profitability of various commodities change. Within the past decade, high commodity prices brought erosive land into production and this could happen again. Suitable tillage practices would permit cropping much of this land without unacceptable soil loss.

A revolution in tillage practices—the adoption of systems that leave the soil surface undisturbed and covered with mulch during the production of annual crops—could decrease soil loss to acceptable levels on much of our cropland. Sites and crops with a yearly soil loss potential of 20 tons per acre could have these losses reduced to less than 2 tons per acre. Further, this could be done on many sites without resorting to terraces or other structures that are expensive to install and difficult to maintain.

The tillage revolution could solve most erosion problems for this region, but are we ready for it? What would foster a tillage revolution?

To be adopted, any management practice must offer advantages without unacceptable disadvantages. No-tillage has a clear advantage over conventional systems in erosion control. We must also be sure that it is dependable and that we can maintain productivity with its use. At least a part of the dependability factor involves intimate knowledge of how to make the system work. The system must also be profitable. High on a grower's list of priorities is staying in business. Most growers have mortgage payments to make and other debts to service, as well as a family to feed and clothe. Adopting a practice that reduces yields and, in turn, profits may be unacceptable, no matter what other advantages the practice may have. In many parts of the Southern Region, profitability of no-tillage has not been demonstrated to the satisfaction of many producers.

In successful crop management systems, the factors that limit crop growth are identified and corrected as well as possible. These factors include soil suitability, water, nutrients, crop establishment, plant populations, proper timing of operations and the control of weeds and other pests (Triplett, 1986). Tillage is not a requirement, although it can affect several of the other factors, either positively or negatively. As tillage is changed, these growth requirements must be met or yields suffer. For successful no-tillage, new methods of planting, pest control, and fertilizer application, among other factors, must be devised and evaluated. This commonly requires the formulation of new management systems. Often the new management system requires several modifications before it is successful. Inadequate stands and poor weed control are common causes of failure. In fact, tillage systems should not be compared until stand and weed control requirements arc satisfied and all practices are equal in this regard!

Once the basic management requirements for growing crops are satisfied, other factors may become important in how crops respond to tillage. In the Midwest, soil characteristics are considered so important in crop response to tillage that soils are rated according to their suitability to tillage systems (Griffith et al., 1986). Basically, the better-drained soils are the best candidates for no-tillage. This is fortunate because well-drained soils often occur on slopes where soil erosion is more of a problem. In various studies, crop yield decreases have occurred with reduced tillage on poorly-drained soils with clay texture (Triplett, 1986). Fortunately, crop rotation helps mitigate yield decreases on these soils so that no-tillage may be acceptable under some circumstances. Further, more recently, some have begun to think that different soils may require varying amounts of tillage to create optimum conditions for crop growth. There is no reason this should not be so; only recently have we been able to remove weed control as a reason for tillage and to evaluate soil tillage solely for its effect on the crop.

Mulch cover emerges as another major factor determining response of crops to tillage on some cornbelt soils, but not on others. This mulch effect is largely related to rainfall infiltration on soils that have poor structural stability and seal during rainstorms. On better-drained Alfisols with this characteristic, 50 to 60 percent mulch cover at planting may be required for yield equivalency with tilled systems (Van Doren and Triplett, 1973). Crop yields increase for greater mulch cover and decrease for less, with corn yields changing by as much as 1/2 bushel per acre for each percent change in mulch. On these soils, the amount of mulch cover must be considered when deciding whether or not to till. On soils with high clay content and with shrink-swellpotential, cracks form when the soil dries and the response to mulch cover is much less.

The soil texture and mulch relationships that seem important in the cornbelt may not be the same in other areas. In the low-rainfall areas of the Texas Panhandle, where land may be kept fallow for a year or so to conserve water for the next crop, no-tillage works only if there is a suitable mulch cover. Sorghum grown with no-tillage, for example, should follow a wheat crop that produced at least 25 bushels per acre and a corresponding amount of straw. Further, the soils used for crop production with no-tillage include clay and clay loam texture; soils that are not considered the best suited to notillage production in the cornbelt.

The soil-tillage-drainage-crop-climatic relationships indicated above, while obviously important, have not been well defined for many geographic areas. Further, they reflect our current level of understanding. Future developments may permit use of reduced or no-tillage on sites or soils now considered unsuitable for these practices.

The development and adoption of new practices follows a fairly well-defined chronology. First, research workers investigate a practice and try to develop a workable system. No matter that the idea sometimes comes from farmers. Complete success with these first efforts is usually accidental. If the practice shows promise, research continues to refine and develop the practice to increase its dependability. Often there is considerable publicity at this stage and a few farmers may try it. These are watched by other farmers for a radius of at least 50 miles and successes or failures are communicated rapidly in the community. If the practice proves useful, neighbors begin to adopt the new method. All of this takes time. All parts of the system must work together satisfactori-

ly or yields suffer. Hybrid corn, a development few of us question, took 20 years from introduction to 95 percent adoption. Modern no-tillage research started in 1960.

When no-tillage is viewed in these terms, progress is reasonable in some areas and slow in others. Other than wheat-soybean doublecropping, there is little farmer adoption of no-tillage crop production in the lower South. Research with full-season soybeans, corn, and cotton has not resulted in development of dependable, high yielding no-tillage management systems, although this seems to be changing. Recently published research reports from the Piedmont region of Alabama (Edwards et al., 1988) and Georgia (Wilkinson et al., 1987) indicate equal or better corn and soybean yields with no-tillage than with conventional systems. In a very recent report, Unger (1988), in west Texas, evaluated sorghum varieties for forage production using no-tillage. This study did not contain a tilled treatment, which implies the researcher considered no-tillage as a standard management practice for that crop and area. No-tillage is well developed and has been adopted by a significant number of farmers in the upper southern states of Kentucky, Virginia, North Carolina, and to some extent, Tennessee.

Few current agricultural research topics polarize research workers more than crop production with no-tillage. Some workers are sold on the practice while others report decreased yields and poor dependability with no-tillage. Published reports sometimes do not provide enough information to reliably determine reasons for poor performance of the system. Those reporting either good or poor performance of no-tillage must be assumed to be careful and objective in their work. It follows, then, that there may be some factor or factors that vary between the good and the poor locations for no-tillage, and thus, account for these differences in results.

Weed control has been a major barrier to no-tillage in the lower South. In the Midwest, a single, low-cost herbicide, atrazine, would control practically every important weed in cornfields—until fall panicurn populations increased. There is no atrazine equivalent for any mid-South crop. Fortunately, recent herbicide developments are expanding the weedcontrol spectrum and making weed control less difficult for crops grown in untilled soil.

Soil compaction in untilled fields is a barrier to no-tillage crop productivity on certain lower Coastal Plains soils. This problem is being managed by using subsoil planters to penetrate the compacted layer. Compaction may very well be a barrier to no-tillage crop production on other soils, but these have not been clearly defined. Interestingly, at the 1987 meetings of the American 'Society of Agronomy, a session dealt with no-tillage and soil conditions. In several reports, as penetrometer resistance readings increased, yields increased. This is hardly the relationship one might expect where significant compaction problems exist. Perhaps there are more meaningful ways to measure compaction. Where compaction problems exist, controlled traffic might help to minimize these.

Mulch cover is needed in untilled fields to reduce soil ero-

sion. The value of mulch cover in improving soil moisture storage and crop yield is clearly defined under west Texas conditions but not so well defined elsewhere in the South. Mulch is burned in some doublecrop systems to facilitate planting. This practice could influence soil moisture late in the season. Few studies from the region report mulch cover levels present in tillage studies or the influence of mulch on crop yield. Mulch may be relatively unimportant for water conservation on soils that shrink and crack open.

Soil differences may represent an important factor in crop response to tillage systems in the mid-South. Positive responses reported for no-tillage have often been located on better-drained soils. No-tillage crops have often yielded less than crops grown with conventional tillage systems on soils with poor drainage. However, ridges, raised beds, and crop rotation seemingly help overcome these soil limitations. Finetextured soils also may contribute to poor crop response of no-tillage. There should be an adequate amount of experimentation already performed on different soils throughout the region to indicate how soils and soil characteristics might influence crop response to different tillage systems if the information was pooled and evaluated. Such an effort could provide information regarding soils and conditions where notillage crop production is most likely to be successful and other conditions where no-tillage should not be recommended to farmers until better systems are developed.

An important question that follows the one of soil suitability for no-tillage is: *if some soils are not suited to a no-tillage production system, how much tillage is necessary to maintain yields?* Tillage systems, from conventional to no-tillage, represent a continuum. Tillage intensity is decreased by eliminating operations. Often conventional tillage and notillage are the only treatments present in crop productiontillage studies, and these do not address the question of how many operations are needed for a particular soil or site. Other unanswered questions include: What tools should be used to what depth, should the tillage be before planting, afier crop emergence, or during both times?

In summary, the tillage revolution has not reached much of the Southern Region. We may not be ready for it from the standpoint of having well developed and dependable crop management systems that can be recommended to growers. Moving the tillage revolution ahead in this region could help greatly in meeting the conservation mandates in the 1985 Food Security Act. There is, however, more work to be done before the revolution can be successful.

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