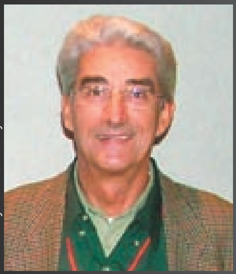

Photo by Jana Lindley

No-Tillage & Mulch Cover

by Rolf Derpsch

SCIENCE

Derpsch is a no-tillage consultant, based in Germany and Paraguay.

Rolf Derpsch has studied and consulted on no-till systems for 35 years, frequently traveling to far-flung places on his consultancies. Derpsch is one of the world's foremost authorities on no-tillage cropping.

Although no-tillage is at present practiced on roughly 100 million hectares (2.5 million acres) around the globe, the basic principles of the no-till system are not fully understood by many farmers worldwide. Some no-till farmers still view crop residues as a waste product, or something that is causing trouble at seeding, and only a few farmers have understood the importance of soil cover in the no-till system. The low levels of soil cover in many places, because the straw and stalks have been eaten by animals, baled and hauled away, or burned, demonstrates that crop residues are not viewed as a valuable product that enhances soil fertility and increases yields. In other cases, significant opportunities to grow more cover are neglected while the fields are maintained in a sterile fallow condition with multiple herbicide applications.

Low levels of soil cover lead to higher evaporation and lower water-use efficiency. A no-tillage adoption with low amounts of crop residues, limited crop diversity, and high amounts of soil disturbance will plateau and does not attain the full potential of the no-tillage system. Under these practices and/or the use of occasional tillage, it is difficult to move the system a step further. To be able to move a no-tillage system to the next level it is necessary to implement quality no-till, which includes: full stubble retention and maximizing soil cover; use of low-disturbance seeding equipment; development of more diverse crop rotations including cover crops; and instead of using rotational tillage, practice a permanent no-till system. This will result in higher carbon content of the soil and consequently in higher yields of crops. The development of higher carbon levels in the soil will be an indicator of the quality of the system.

Photo by Unknown, via Rolf Derpsch.

Favorable no-till results as well as long-term soil productivity depend on maintaining an adequate mulch covering the soil.

Importance of Soil Cover

It is always necessary to be reminded of the importance of soil cover in a no-tillage (zero-tillage) system. *Many of the benefits and advantages of the no-tillage system come directly from the permanent cover of the soil, rather than from not tilling the soil.* In other words it is not so much the absence of tillage, but the presence of crop residues on the soil surface that results in a better performance of no-tillage in comparison to tilled systems. (*Editors' Note: Both mulch cover and continually undisturbed soil are necessary.*) Failure to pay attention to soil cover has resulted in poor performance of the system (lower yields, increased runoff and erosion, low biological activity, etc.). There is plenty of scientific evidence that no-tillage without soil cover results in poor crop yields.[1]

[1] J.E. Ashburner, 1984, Dryland tillage practices and studies in Algeria, in Proceedings: FAO Panel of Experts on Agricultural Mechanisation, 6th Session (Adana, Turkey, October 1984); P. Wall, 1999, Experiences with crop residue cover and direct seeding in the Bolivian highlands, *Mountain Res. & Development*, 19 (4): 313-317; K. Sayre, B. Govaerts, A. Martinez, M. Mezzalama & M. Martinez, 2006, Comparison of alternative conservation agriculture technologies for rainfed production in the highlands of Central Mexico, in Proceedings of the 17th ISTRO Conference (Kiel, Germany, 28 Aug. – 3 Sept. 2006).

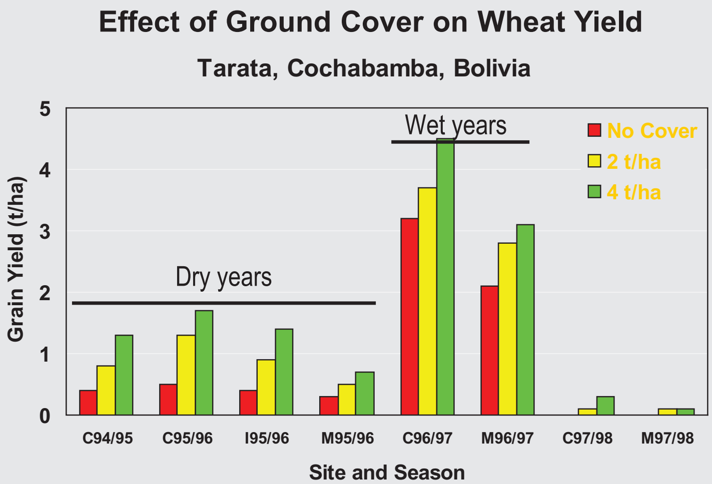

Figure 1. Effect of mulch cover on no-till wheat yield. In both wet and dry years, wheat yields were higher with greater mulch levels. Annual rainfall averages for sites are 500 – 650 mm (20 – 25 inches); elevation is 2,500 m (8,300 ft). Source: Wall, 1999.

Soil cover is needed to increase water infiltration into the soil and to reduce runoff and erosion. Research conducted in Brazil and other parts of the world has shown that the percentage of soil covered with plant residues is *the* most important factor that influences water infiltration into the soil.[2] Non-infiltrated water is lost to production, reducing water-use efficiency.

Research conducted in a low-rainfall area of Bolivia showed that in all seasons the highest yields were

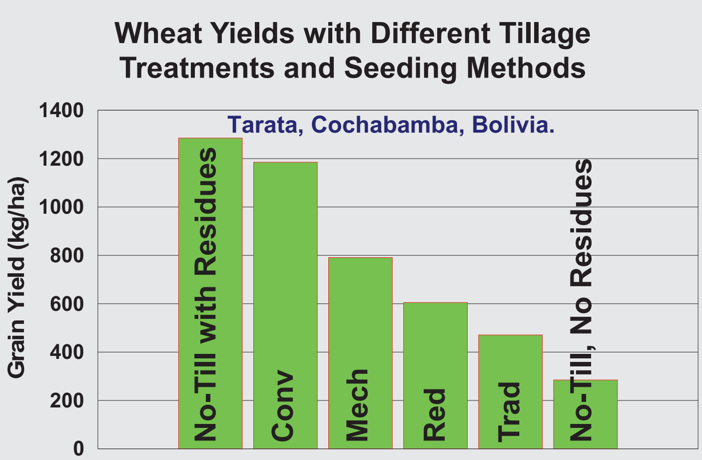

Figure 2. Depending on mulch cover, no-till plots were either the best or the worst. 'Conv,' 'Mech,' 'Red,' and 'Trad' all involved substantial tillage, representative of typical practices in the region, and of these, 'Mech' was the only one using a mechanical seeder—the others were broadcast and incorporated with shallow tillage. Source: Wall, 1999.

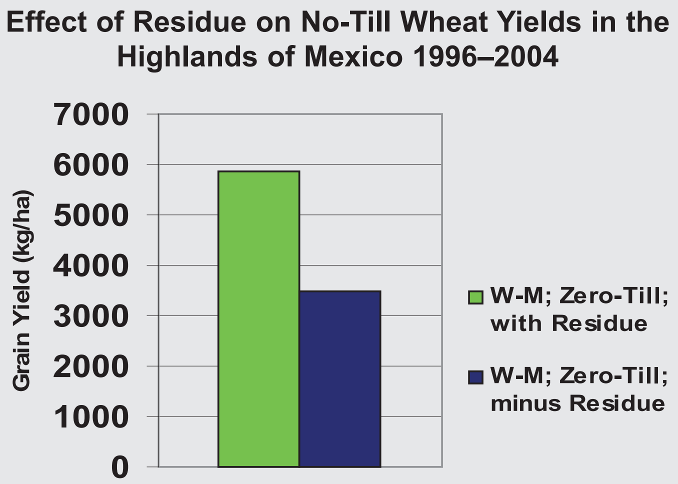

Figure 3. In rainfed cropping in the central Mexico highlands, no-till wheat yields were higher with residues retained. A still greater disparity existed for economic returns over direct costs: Retaining residue at ~ 2,900 pesos, without residue at only 300 pesos. Crop rotation was a 2-year cycle of wheat >>maize (corn). Similar yield and economic advantages were found for the maize component: 5,100 kg/ha for residues retained, versus 4,000 kg/ha without mulch, and returns above variable costs were 2,250 pesos for retained residues, versus 1,800 without residues. The various management practices for the plots had been in place for 5 years prior to this data being collected, so that the systems could stabilize. Average annual precipitation during the trial years was 633 mm (25 inches); elevation is 2250 m (7,400 ft); replicated plots. (Source: Sayre et al., 2006.) Researcher Ken Sayre explains the results: "Lack of water retention in the soil is the main problem with zero-till without residue retention. We can receive 15 – 20% of the total rainfall in 20 minutes during a July afternoon. If the water can't infiltrate rapidly, it runs off. Practicing zero-till with no residue retention leads to marked degradation of most soil physical properties, like aggregate structure and stability. The soils become seriously compacted; water just runs off with associated erosion." See photos, p. 425. (Source: Ken Sayre, personal communication, March 2008.)

obtained from the plots with no-tillage plus full crop residue retention, intermediate yields were obtained with different tillage systems from conventional to minimum-tillage, and the lowest yields were from the plots with no-tillage *without* residues (see Figures 1 & 2).[3]

Similar results have been obtained by CIMMYT researchers under rainfed production systems in the highlands of central Mexico (see Fig. 3).[4] Wheat and maize (corn) had their yields and economic returns drastically reduced when residues were removed in the no-till system. The researchers concluded that *no-tillage without crop residues on the soil surface leads to disaster.* Comparing production systems, the researchers found that no-till practices (with residues retained) had much greater profitability than the typical farmer practices in the area (tillage, plus removal of residues for livestock).

[2] C.H. Roth, 1985, Infiltrabilität von Latossolo-Roxo-Böden in Nordparaná, Brasilien, in Feldversuchen zur Erosionskontrolle mit verschiedenen Bodenbearbeitungs-systemen und Rotationen, Göttinger Bodenkundliche Berichte, 83: 1-104.

[3] Wall, 1999.

[4] Sayre et al., 2006.

In the no-till system, the researchers found that retaining residues produced additional grain yield such that *the residues should be valued at 4 to 6 times the current market price of fodder.*

Crop Diversity

Cover crops and crop rotation play a very important role in a no-till system in order to achieve the high amounts of soil cover needed. The development of cover cropping along with no-till systems has been a major factor in the unprecedented growth of this technology in Brazil and Paraguay.

Photos by Ken Sayre, CIMMYT.

Weed pressure in monoculture maize, no-tillage with residues removed (left photo) as compared to a maize >>wheat rotation with residues retained, in the studies reported by Sayre. Herbicide applications were the same in both plots, although Sayre reports, "With no-till where residues have been retained, herbicide use can be dramatically reduced. . . . We have observed a tremendous reduction in weed populations (both annual grass and broadleaf weeds including yellow nutsedge) where we are practicing zero-till under the maize-wheat rotation combined with adequate residue retention on the soil surface, especially compared to the common farmer practice of tillage, continuous maize, and residue removal for fodder." Ken Sayre, personal communication, March 2008.

In drier climates, farmers are often concerned that cover crops will take moisture out of the soil, making it unavailable for the primary crops. This is and should always be a concern in drier climates. Managing cover crops at the right time, in the right way, and using species that use less moisture are ways of getting around this problem. It must be remembered that while the cover crop removes some soil moisture, the additional mulch from the cover crop will improve water-use efficiency later in the cash crop, as shown by recent research performed in Argentina.[5]

Long-Term Benefits of No-till

While more than 70% of South American farmers are using permanent no-tillage systems, this is only the case with 10 – 12% of farmers in the USA. Yet research and farmer experience have more than adequately demonstrated the long-term benefits of a no-tillage system.

Figure 4 illustrates the evolution of a long-term no-till system as understood by the esteemed soil scientist J.C.M. ('Juca') Sá of the University of Ponta Grossa, Brazil. In the Initial Phase (Years 0 – 5), the soil starts rebuilding aggregates and measurable changes in the carbon content of the soil are not expected. Crop residues are low and extra nitrogen (N) needs to be added to the system.

In the Transition Phase (Years 5 – 10), an increase in soil density is observed. Soil carbon and extractable phosphorus start to increase.

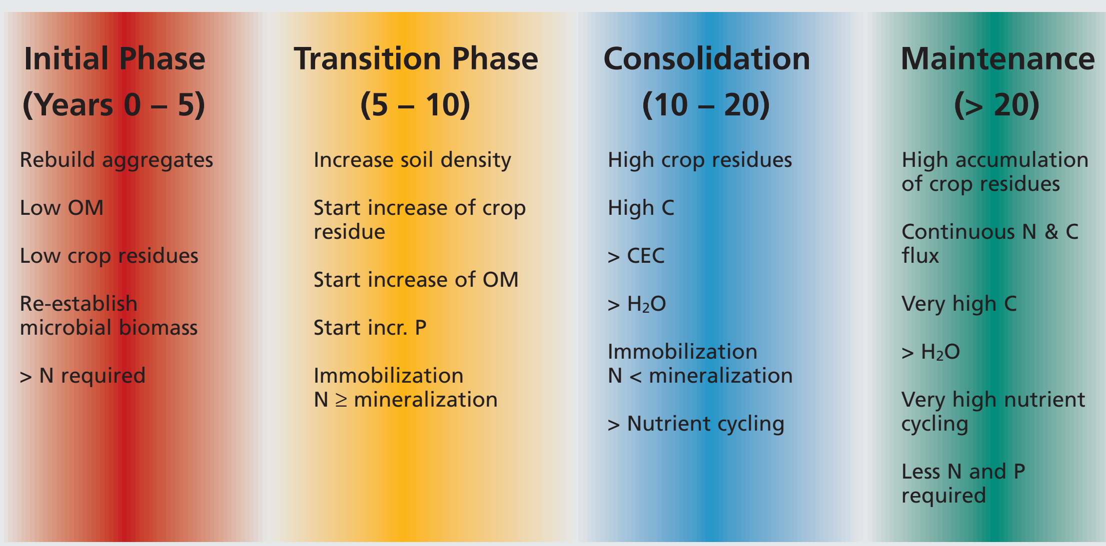

Figure 4. Progression of a no-tillage soil. Years are approximate and only apply to continuous no-tillage with full stubble retention. Too many low-carbon (low-biomass) crops such as broadleafs will also hinder the progression of the system. Source: J.C.M. Sá, 2004, Adubação Fosfatada no Sistema de Plantio Direto, in *Fósforo na Agricultura Brasileira*, ed. T. Yamada & S.R.S. Abdalla, Sao Pedro-SP, Associaçao Brasileira para a Pesquisa da Potassa e Fosfato, Piracicaba, SP.

[5] Roberto Gil, INTA (Argentina), personal communication, 2006.

In the Consolidation Phase (Years 10 – 20), higher amounts of crop residues as well as higher soil carbon contents are achieved; higher cation-exchange capacity and higher water-holding capacity are measured. Greater nutrient cycling is observed.

It is only in the Maintenance Phase (Years > 20) that the ideal situation with the maximum benefits for the soil is achieved and less fertilizer is needed.

Any tillage performed in Phases 2 – 4 means a return to the Initial Phase. Tilling the soil once in a while means that the soil is in constant transition and farmers will never get to see the full benefits of the system. Farmers practicing a no-till system without full stubble retention, i.e., letting animals graze their stubble, baling and removing the residues, and/or burning the residues, will probably never leave the Initial Phase. Also if the climate is one where residues decompose rapidly and no cover crops are used, the system may never leave the Initial Phase. (*Editors: If too many broadleaf crops and too few grass crops are grown in the rotation, the system will not progress. Also, chronic nutritional deficits in the crops will hinder the system's progression.*) If some residues are occasionally removed but otherwise fields are well-managed, leaving a reasonable amount of soil cover, the fields eventually may start entering the Transition Phase.

Landlords in South America in general will only lease their land to a no-tiller to ensure protection against erosion, avoid soil degradation, and not only maintain but improve soil fertility over time. It is astonishing that many landlords in the USA have not yet understood this.

It is estimated that farmers using a tine seeder (hoe or knife opener), even when practicing no-tillage with full stubble retention otherwise, will only reach the Transition Phase and perhaps just those who manage to handle higher amounts of residues and have a higher biomass yield may start entering the Consolidation Phase. It is the opinion of the author that only with disc-opener seeders, full stubble retention, and adequate crop rotations, will it be possible to reach the Maintenance Phase, reaping the full benefits of a no-till system. Practicing adequate crop rotations and using cover crops once in a while will help in reaching the Maintenance Phase.

In general, the main reasons why farmers in the USA persist in occasionally tilling the soil are the following: 1) lime incorporation, 2) phosphorus redistribution, 3) soil compaction, and, 4) mindset. One important factor that influenced the quick growth of no-tillage in South America is the fact that there virtually nobody believes in the necessity of incorporating lime with tillage implements after no-tillage has been started. Surface application of lime, especially in combination with cover crops such as black oats and/or oilseed radish, allows the mobility of lime in the soil profile, and this has been widely understood in South America for many years now. (*Editors: Lime is mobile with percolation of water, even without cover crops.*) This is still something of intensive debate in other parts of the world, even though lime mobility in soils operates by the same mechanism everywhere.

Soils which have been many years under no-tillage show a higher concentration of phosphorus in the upper soil layer. In the USA, many researchers, extensionists, and farmers believe that one has to perform tillage once in a while to redistribute phosphorus that concentrates near the soil surface after a few years in the no-till system.

Photos by Ken Sayre, CIMMYT.

Ken Sayre's plots, 2004. Both were maize >>wheat rotation under no-tillage, but the plot in the photo on the right had residues removed.

This is not the case in South America, where farmers have learned that the concentration of this element in the upper soil layers is not a problem at all for obtaining high yields of crops. (*Editors: See the stratification article in the Sept. '07 issue for an exhaustive review of the research in the U.S. and Canada on this subject.*)

Most farmers in South America have found that there is no need to till the soil every so often after no-tillage has been established and that the best way to avoid compaction in the no-tillage system is to produce maximum amounts of soil cover, and to use cover crops and crop rotations, so that roots and biological activity as well as earthworms and insects, etc., will loosen the soil as well as to secrete substances that bind the soil particles into stable aggregates and a beneficial soil structure.

Long-term no-tillers in general report mellower soils after many years of continuous no-tillage. Plentiful soil cover is also essential to maintaining higher moisture levels at the soil surface and this will result in better penetration of cutting elements of the seeding equipment, as well as of crop roots. Field traffic should be reduced and carefully managed in this system and no heavy trucks allowed indiscriminately in the fields. Low-pressure tires are also a 'must' in the no-tillage system.

When practicing quality no-tillage, soil erosion must be banished from farmland. No erosion of any kind should occur.

An additional factor is mindset. Often landlords in the USA will not lease their farm to a no-tiller because they don't like the "trash" that is left on the soil surface. Thus, the long-term benefits of continuous no-till will never happen. Contrary to this, landlords in South America in general will only lease their land to a no-tiller to ensure protection against erosion, avoid soil degradation, and not only maintain but improve soil fertility over time. It is astonishing that many landlords in the USA have not yet understood this. Something has to be done to educate landlords so that they understand the benefits of long-term no-tillage for their soil and for increased productivity of their land.

Quality No-tillage

Seeding without tillage does not necessarily mean no-tillage seeding. Poor-quality no-tillage, that can hardly be called as such, is often practiced by farmers in many parts of the world. High soil disturbance at seeding, low percentage of soil cover, monoculture or low cropping diversity, and rotational tillage characterize poor-quality no-tillage.

Photo by Unknown, via Rolf Derpsch.

Derpsch advises: "Strip-till is half-hearted no-till; a half-step in the right direction." —Indeed, why not get the full benefit?

Criteria to determine the quality of no-tillage:

1. The percentage of soil covered with plant residues, especially after seeding.
2. The amount of soil disturbance while seeding or fertilizing.
3. The number of years in continuous no-tillage without tillage of any kind.
4. The length of fallow (non-crop) periods, and the diversity of crop species, including cover crops.

(*Editors' Note: In measuring whether the non-crop period is appropriate for an area, calculate the average precipitation during that time, i.e., from the maturity of the previous crop until the next crop is established. Then calculate the water-holding capacity of the soil to a depth of 4 feet [if soil is shallower than this, use the smaller number], e.g., a silt loam may hold 2.2 inches of plant-available water per foot of soil depth, which is 8.8 inches to a 4-ft depth. If average precipitation is greater than the soil's water-storing capacity, then a cover crop is needed. Note that the next grain crop yield is generally not negatively affected by growing the cover crop, since the water-use efficiency increases due to the mulch effect.*)

In quality no-tillage, fallow periods without crops must be avoided and living roots should be present as long as possible.

The importance of soil cover was highlighted earlier in this article. Management practices should consequently be directed towards maximizing biomass production for a certain location (adequate fertilization, sufficient weed as well as pest and disease control, use of high-biomass-producing species and varieties, etc.).

Full stubble retention, the use of disc-opener seeders with ability to cut through high amounts of crop residues while causing little soil disturbance, many years under permanent no-tillage, and the inclusion of cover crops in rotation systems (cropping diversity) are the basis for high-quality, sustainable no-till systems. Quality no-tillage is essential to reap the full benefits of this system and to experience the benefits more rapidly.

When practicing quality no-tillage, soil erosion must be banished from farmland. *No erosion of any kind should occur.* Most of the erosion control will need to be achieved with high residue levels, improving soil structure with no-tillage, and high cropping intensity including cover crops. On steep slopes in high-rainfall areas, additional protection against rill erosion must be used, such as contour bunds, terraces, or buffer strips at adequate intervals. Roads on the farm have to be placed in such a way that they follow the contour and an adequate water-capturing structure should be in place in areas where erosion could occur. In southern Brazil, many farmers have made a big mistake by leveling all their contour bunds (terraces) and are now facing the problem of erosion because the residue levels they achieve in soybean monoculture are much too low for adequate soil protection. Adequate levels of crop residues must also be maintained where wind erosion is a problem.

A sustainable agricultural system will have soil carbon inputs equal to or greater than outputs. Carbon inputs are achieved through vigorous growth of plants and by the plant roots remaining undisturbed in the soil as well as plant residues remaining on the surface. Large C outputs or losses occur with any type of tillage or by harvesting the aboveground biomass.

In quality no-tillage, fallow periods without crops must be avoided and living roots should be present as long as possible. Roots of crops or cover crops and organisms living in the soil contribute to biological soil preparation. Instead of using horsepower, diesel, and iron to till the soil, biological soil preparation works day and night without using fossil fuels. Soil organisms just need to be fed with mulch. Finally,

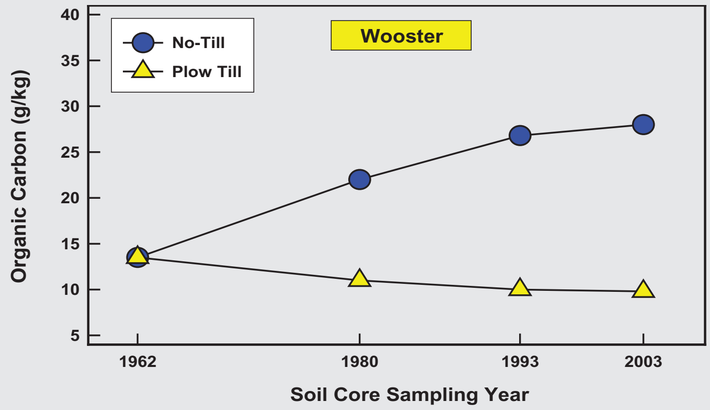

Figure 5. Development of the organic carbon content (g/kg) in the upper 3 inches of soil in long-term no-till versus tillage (Plow Till) at Wooster, Ohio. Source: Warren Dick, 2006.

consider avoiding indiscriminate traffic of heavy vehicles on the field, especially on wet soils. In very flat terrain, controlled traffic may be useful. In undulating topography, random traffic must be used, but heavy equipment should stay out of the field. Low-pressure tires (14 psi or less) should be used. An automatic pressure-regulating system for travel on roads is advisable, so that the higher inflation pressures necessary for safe transport at high speeds can be quickly readjusted to low pressure in the field. These systems are becoming commonplace on European tractors.

While tillage destroys soil aggregates, a no-till system greatly increases aggregate stability. This makes the soil more resistant to erosion and also allows for a higher trafficability of the soil with farm machinery since the soil is more structured and supportive, and may also have higher density. A higher soil density should not be confused with soil compaction, but is instead a natural condition of untilled soils. This higher soil density allows farm machinery to drive on the fields in situations when it would not be possible under tillage practices.

Photo by Rolf Derpsch.

Derpsch thinks "invisible seeding" is the ultimate for attaining the best results with no-till.

Organic Matter as an Indicator

Any agricultural or livestock production system that contributes to constantly reducing the organic matter content of the soil is not sustainable and results in poor soils that eventually fail to support agriculture entirely. Soil organic matter is *the* most important factor that indicates fertility of a soil. Low values of organic matter mean low fertility while the same soil with high values is a more fertile soil, where higher crop yields can be obtained. Soil tillage is the typical management praxis which results in decline of soil organic matter as well as the corresponding emissions of carbon dioxide into the atmosphere. No-tillage, on the contrary, can result in sequestering carbon from the atmosphere and increasing carbon content of the soil.

A sustainable agricultural system will have soil carbon inputs equal to or greater than outputs. Carbon inputs are achieved through vigorous growth of plants and by the plant roots remaining undisturbed in the soil as well as plant residues remaining on the surface. Large C outputs or losses occur with any type of tillage or by harvesting the aboveground biomass (some C is also lost during normal decomposition, although at a slow and non-exhausting rate if quality no-tillage is used).

A light disk-harrow is sometimes used in South America to incorporate seeds of black oats as a cover crop. In this case it has been demonstrated that the total loss of carbon due to the use of the disk-harrow is 0.90 t/ha, while the return of carbon from the cover-crop residues is only 0.52 t/ha.[6] This is clearly a negative balance. Also soybean monoculture or a (one-year) two-crop system

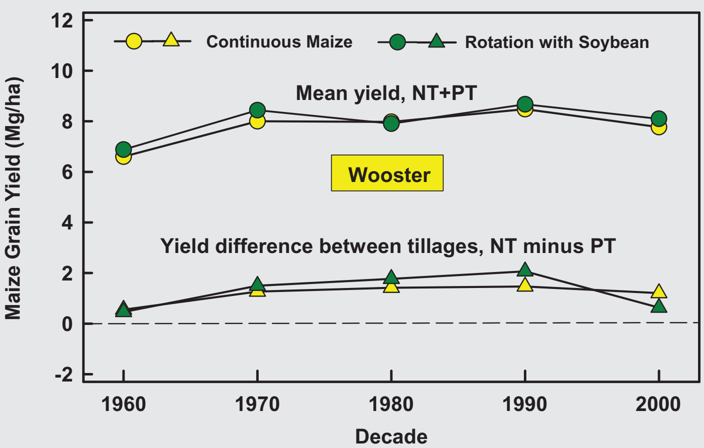

Figure 6. Results from Wooster in northern Ohio, one of two sites for the longest-running no-till experiment in the world. Corn yields were higher for no-tillage in all decades, regardless of crop rotation (or lack thereof). Source: Warren Dick, 2006.

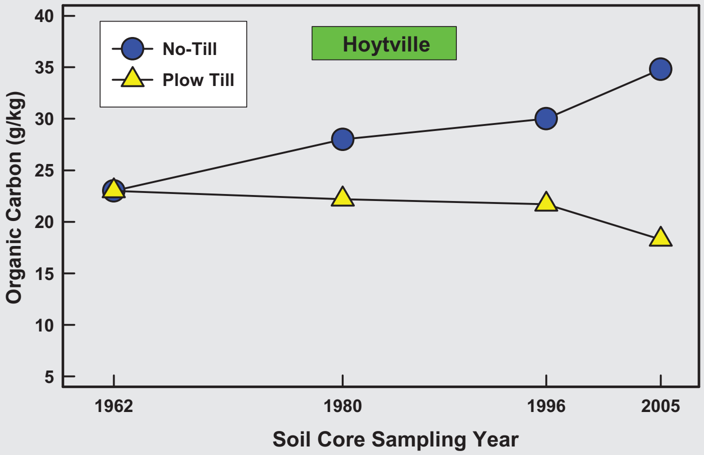

Figure 7. Development of the organic carbon content (g/kg) in the upper 3 inches of soil in long-term no-till versus tillage (Plow Till) at Hoytville, Ohio. Source: Warren Dick, 2006.

of wheat /double-crop soybeans has a negative balance because the amount of carbon added (3 – 4.5 t/ha/yr in Brazil) is insufficient to sustain the system in a tropical region with high decomposition rates that remove carbon (in this case) at rates higher than what is being added by the crops. According to Juca Sá, additions of more than 8 t/ha/yr of carbon from plant residues (shoots and roots) are needed in this part of Brazil to maintain a stable equilibrium and ensure the sustainability of the system.[7] Therefore, high-biomass-producing crops such as corn should be part of a rotation, and that low-biomass and low-carbon crops such as soybeans and most other broadleafs (dicots) should be used sparingly in crop rotations, especially in warmer and wetter regions, and these should be used in conjunction with high-carbon cover-crop species (grasses).

Any agricultural production system that gradually reduces organic matter content of the soil is not appropriate for that site, will result in soil degradation, and is not sustainable.

Management practices that are directed to obtaining maximum possible amounts of crop residues for a specific location (e.g., crop rotations including corn if possible, cover crops, sufficient fertilization of crops, adequate weed and pest management, etc.), will increase yields of crops and enhance carbon content of the soil.

6 J.C.M. Sá, J.B. dos Santos, E.G. Cardoso, S. Siuta Jr., C.F. Ferreira, A. Oliveira, M.F.M. Sá, L. Seguy, S. Bouzinac, 2006, Balance de carbono y nitrógeno en rotaciones bajo sistemas de siembra directa, in Proceedings: XIV AAPRESID Congress (Rosario, Argentina, Aug. 2006).

7 Sá et al., 2006.

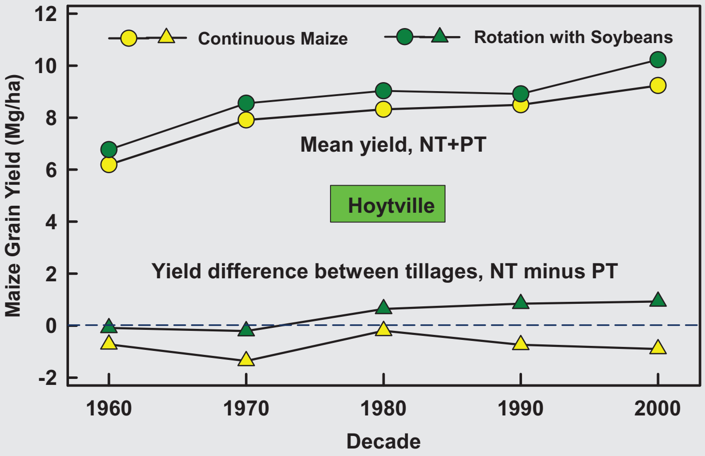

Figure 8. Results from the Hoytville site showed no-till corn approximately equal to or slightly outyielding plow tillage if rotated with soybeans, but lagging if monoculture corn was grown. Source: Warren Dick, 2006.

Yields Related to Soil Carbon

An ongoing experiment was begun in 1962 at Wooster, in northern Ohio, USA, thus being (with 46 consecutive years) the oldest mechanized no-till experiment in the world (results discussed in this article are through 2003; more recent data are not available). Figure 5 shows that carbon content of the upper 7.5 cm (3 inches) of soil increased steadily in no-tillage from 13 to 27 g/kg while it decreased steadily in conventional tillage from 13 to less than 10 g/kg.[8] The carbon pool in the upper 31-cm (12-inch) soil layer was greater under no-tillage (6.75 kg/m^2) than for plow tillage (5.56 kg/m^2).[9] As contrasted with Brazil, a temperate climate such as in Ohio allows for a crop rotation with one-half soybeans (but in rotation with high-yielding corn) to have adequate carbon inputs to cause an increase in soil organic matter. However, rotations with higher carbon inputs would improve the soils more quickly.

For the Wooster site, maize (corn) yield results through 2003 are shown in Figure 6. Several crop rotations were in this experiment; highest corn yields occurred in the rotation where corn was grown after hay (in a 3-year rotation, with oats following corn). No-tillage consistently produced higher yields than plow tillage, regardless of crop rotation. The authors conclude that continuous, long-term no-till management can sustain or even enhance crop yields and soil quality as compared to long-term plow tillage management.[10]

During the same years, a similar experiment was conducted at Hoytville, Ohio, again with the carbon content of the soil increasing continually in no-tillage from 23 to 34 g/kg, while decreasing continually in conventional tillage from 23 to less than 18 g/kg (see Fig. 7).[11] Several crop rotations were used at Hoytville, with corn yields shown in Figure 8. Corn yields in no-tillage in a corn >>soybean rotation were slightly lower in no-till compared to plow tillage in the first decades of the experiment, but no-till yields have been higher since 1980. When using continuous corn, yields were always lower in no-tillage compared to plow tillage, thus highlighting the importance of crop rotation.[12]

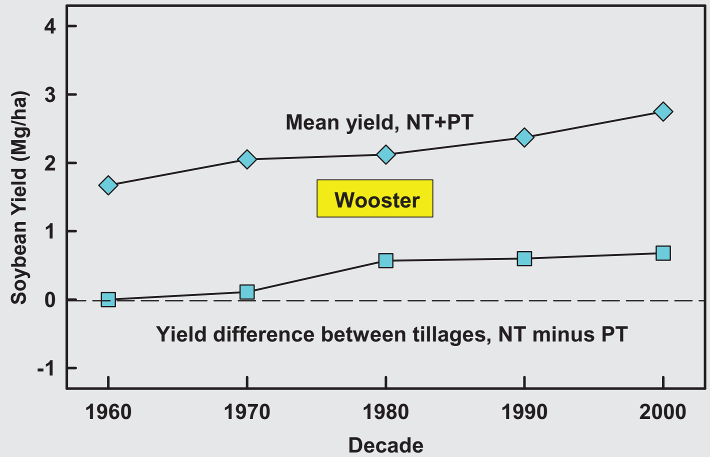

Figure 9. Soybeans under no-till have continually outyielded plow tillage at Wooster. Source: Warren Dick, 2006.

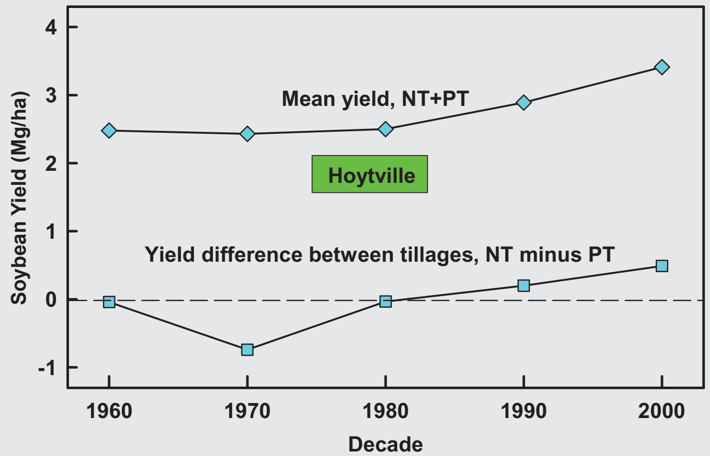

Figure 10. At Hoytville, OH, no-till soybean yields initially lagged plow tillage, but eventually equaled and then overtook yields from the tilled plots. Source: Warren Dick, 2006.

[8] Warren Dick, Ohio St. Univ., personal communication, 2006.

[9] S.A. Mestelan, N.E. Smeck, J.T. Durkalski, W.A. Dick, 2006, Changes in soil profile properties as affected by 44 years of continuous no-tillage, in Proceedings of the 17th ISTRO Conference (Kiel, Germany, 28 Aug. – 3 Sept. 2006). The carbon pool was also greater for no-tillage than plow tillage at depths from 31 – 148 cm deep.

[10] Mestelan et al., 2006.

[11] Warren Dick, personal communication, 2006.

[12] Warren Dick, personal communication, 2006.

Photo by J.E. Denardin, EMBRAPA, Brazil.

When grown too frequently, low-biomass crops such as soybeans do not produce enough residue to prevent erosion. The problem is avoidable.

For soybeans at Wooster, yields in no-tillage were only slightly higher in the first decade of the experiment, but after 1980 have been substantially higher compared to plow tillage (see Fig. 9). At Hoytville, soybean yields in no-tillage were significantly lower during the first decades of the experiment, although they equaled in 1980 and since then yields are getting continually higher in no-tillage compared to plow tillage (see Fig. 10).

It should be remembered that any agricultural production system that does not add sufficient organic material and/or gradually reduces organic matter content of the soil is not appropriate for that site, will result in soil degradation, and is not sustainable. Therefore we should think carefully before using crop residues other than for soil protection and enhancing soil fertility. Consequently, ethanol produced from plant biomass will not be sustainable agriculture. (*Editors: Removing biomass of* annual *crops will be particularly damaging*.)

Highly regarded Ohio State University researcher Rattan Lal (who is also the immediate past president of the Soil Science Society of America) in a recent paper concludes that: "Crop residue return to the soil is essential for maintaining soil quality. It provides numerous ecosystem services including recycling nutrients, sequestering C, moderating soil temperature and moisture regimes, providing food and habitat for soil fauna (e.g., earthworms), and protecting [the] soil surface against erosivity of water and wind. Use of crop residue mulch, in conjunction with no-till farming, has important implications to achieving sustainable use of soil and water resources and meeting [the] food needs of growing world population . . . . *Expansion of no-till farming, necessary for erosion control and soil C sequestration, necessitates use of crop residue as surface mulch. . . . For meeting [the] world's food demands[,] crop residues must be used as soil amendments."* (emphasis added)[13]

Important Task at Hand:

The public in general is not aware of the important contribution that the no-till farming community is making to society as a whole: Producing food without harming the environment and while improving the quality of the world's soils. It is our duty to inform society about the outstanding contribution that farmers who practice the no-tillage system all over the world are making to provide the population with low-cost, high-quality food while at the same time protecting the environment.

Editors: The reader might also wish to reference 'Understanding Water Infiltration' by Derpsch in the Dec. '03 issue, and Matt Hagny's 'Maximize Crop Residues' from March '05. For the long-term effects of no-till, see 'Cropland Owner's Manual' from Dec. '05. For a comprehensive review of no-till effects on corn and soybean yields in the U.S. & Canada, see 'Ending the Debate,' Sept. '06.

[13] R. Lal, 2006, Soil quality impacts of residue removal for bioethanol production, in Proceedings of the 17th Triennial ISTRO Conference (Kiel, Germany, 28 Aug. – 3 Sept. 2006).