

History of Crop Production, With & Without Tillage

by Rolf Derpsch

PERSPECTIVE

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Derpsch has witnessed and played a significant part in the development of no-till in South America, with work spanning four decades. He continues to have influence in many corners of the world.



Photo by Rolf Derpsch.

Small landholder in Paraguay using a planting stick, much as the ancient peoples of the Americas did—no plowing was done.

No-tillage¹ and minimum-tillage have been used since ancient times by the so-called “primitive cultures” for the production of crops, simply because man has not the muscle force to till any significant area of land to a significant depth by hand. To think that tillage is inherent in, or synonymous with, agriculture is a more recent and erroneous idea.

The Incas in the Andes of South America, the ancient Egyptians, as well as most indigenous cultures around the world, routinely used a stick to make a hole in the ground, put seeds in the soil by hand, and covered

the seeds with the foot.² Even today hundreds of thousands of farmers in Central and South America seed their crops using the same technology. Moreover, millions of hectares of land have been traditionally sown with a hand jab planter without tilling the soil, after burning, in the shifting agricultural system in Brazil and neighboring countries, long before the term no-tillage was introduced into the modern vocabulary. The slash mulch or “tapado” system in Central America and Mexico is another example of no-tillage developed by pre-Columbian cultures and has been used for centuries.³ In this system, after a rain, seeds are thrown on top of the soil underneath a dense stand of Mexican Sunflower (*Thithonia diversifolia*) or other voluntary (or



Photo by Matt Hagny.

Teotihuacán, just east of present-day Mexico City, was the sixth-largest city in the world in 600 AD, and was built entirely by hand labor. Teotihuacán was the center of a civilization sustained by an agriculture that also consisted solely of hand labor (no suitable native animals were available for domestication for pulling implements). Here, the view is from atop the Pyramid of the Moon, looking along the Avenue of the Dead with the Pyramid of the Sun on the left. The Pyramid of the Sun was the largest structure in pre-Columbian America, containing over 1 million cubic meters of material; tourists appear to be specks on the enormous structure. Much of the city remains unexcavated.

¹ ‘No-tillage’ is defined in this paper as the planting of crops in previously undisturbed soil by opening a narrow slot, trench, or band only of sufficient width and depth to obtain proper seed coverage. No other soil preparation is performed. We also refer here to *permanent* no-tillage rather than not tilling the soil occasionally. “No-till” is the most common term used in the United States, while “direct-drilling” or “zero tillage” is used in the United Kingdom and Europe.

² (Editors’ Note: The “hill planting” of placing seeds in individual holes—as well as weed removal and harvesting by hand—permitted the use of mixed cultures, such as with beans, maize, and squash in the same garden or field. [from J. Harlan, 1995, *The living fields*, Cambridge Univ. Press. See also J. Diamond, 1997, *Guns, Germs, and Steel*, Norton & Co.])

³ H.D. Thurston, M. Smith, G. Abawi & S. Kearl, 1994, *Los sistemas de siembra con cobertura*, CIFAD, Cornell Univ.

seeded) vegetation. Then the plants are cut and left on top of the seeds. After a few days the vegetation dries out and the seeds germinate and take root. In this case no tillage is performed at all.

Likewise, prehistoric cropping in Europe, Asia, and Africa proceeded from simple gathering of grains from wild stands to intentional propagation, often with planting sticks. However, by 4000 BC, the first farmers in Europe (the Linearbandkeramik) were using ox-drawn ploughs to dramatically expand their cropping, as were the societies in China at that time.⁴

Power requirements for soil tillage are considerable, and the ploughing system is considered to be an inefficient use of time and energy, and causes much wear and tear to the machines.⁵ In modern agriculture this may be a technical challenge or an economic problem, but formerly this meant hard long-lasting labour for a large percentage of all the people that ever lived on earth. Forces required are so great that animals were used very early to make the physical stress endurable.⁶ But a small farmer ploughing his field with animal traction has to walk 30 to 40 km (19 to 25 miles) behind his plough for each hectare (2.47 acres) tilled. Therefore, the reduction of tillage to the minimum necessary to produce a crop has probably been in the minds of many farmers for a long time. But when the tractor appeared, where effort is reduced because the operator is sitting, the tendency went the other way—farmers started believing the more tillage you do, the more yield you get. Truth was: The more tillage you do, the more erosion and soil degradation you get, especially in warmer areas.

The plough of ancient times has little in common with modern ploughs of the 19th century. The ancient plough was nothing more than a branch from a tree that scratched or scarified the soil surface without much mixing of the soil layers, and in many areas of the world this type of ploughing is still used. Ploughs that inverted the soil layers and thus gave better weed control were not developed until the 17th century. Only

in the 18th and 19th centuries did ploughs become more and more sophisticated. But it was not until the end of the 18th century that

German, Dutch, and British developments of this tool led to the shape of the mouldboard, which turned the soil by 135° and was very efficient for weed control. It is this plough that avoided famine and death at the end of the 18th century, since it was the only tool that could effectively control

quackgrass (*Agropyron repens*), a weed that had spread all over Europe and could not be controlled with 'conventional' tools. Because the modern plough saved Europe from famine and poverty it became a symbol of

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Monte Albán, near Oaxaca, was another center of power in 600 AD, although in opposition to Teotihuacán's. Here, the entire mountaintop was sheared off to build these temples, pyramids, and ballcourts. Again, it was built on agriculture using planting sticks—to have created the food surpluses to support such grandiose cities, the native agricultural methods were anything but primitive or ineffective.

⁴ Diamond, 1997. (Editors: Some of these early cultures tended toward "broadcast" seeding, in which seeds were scattered onto a shallowly tilled seedbed and then mixed with the soil, with sizeable areas in a single crop species. Harlan, 1995.)

⁵ C.W. Waydelin, 1994, Practical experience with reduced tillage farming, in Proceedings: EC Workshop II: Experience with the applicability of no-tillage crop production in the West-European countries (Silsoe, 15-17 May 1995), Wissenschaftlicher Fachverlag (Giessen, Germany).

⁶ H. Kuipers, 1970, Historical notes on the zero-tillage concept, *Neth. J. Agric. Sci.*, 18: 219-224. (Editors: For this reason, plowing became widely dispersed technology in Europe, Asia, and Africa many centuries ago—large animal species were available for domestication and could be used for pulling tillage tools. In the Americas, large animals suitable for domestication and draft work were almost non-existent by the time agriculture was being developed, which was partly due to extinction by hunting. Diamond, 1997.)

‘modern’ agriculture and is used as such by many agricultural research institutes, universities, agronomy schools, etc. One of these early ploughs of 1884 is displayed at the agricultural museum of the University of Hohenheim, in Stuttgart, Germany, and in a festival is taken around the city of Hohenheim each year, to commemorate the invention of this implement. By knowing the history of this tool, it becomes understandable why Europeans and especially Germans are often such fervent advocates of the plough, which has turned out to be the most frequently used symbol of agriculture worldwide.

Against this background, the European colonial powers took the modern plough to North and South America, Asia, and Africa, where it became an important tool for the development of newly cultivated land. But it took many decades to discover that the same tool that brought food and wealth to Europe (temporarily), would bring soil erosion and degradation to the warmer environments.

European colonial powers spread the culture of the plough to developing countries, while the native methods have been classified as primitive and unproductive.

Often the experts (mainly from Europe) have spread the misconception that tillage makes the soil fertile and therefore cannot be replaced. They have not understood the significance of soil erosion, as well as intensive weathering under hot, humid conditions. This has resulted in widespread erosion of soils all over the world. Economic interests and the inexperience of some of the expatriate experts (first from the colonial powers and later the aid-donor countries) have spread the culture of the plough to developing countries, while the native methods have been classified as primitive and unproductive.

Mechanised No-till is Born

In modern mechanised agriculture, no-tillage production of crops was attempted a long time ago, but it was not until the advent of modern herbicides that the technique could be put into practice. The first possibility of growing crops without tillage on large-scale farms occurred when 2,4-D, a broadleaf weed killer, was made available to farmers in the 1940s. Later, atrazine and paraquat also became available, these being the only herbicides accessible by early farmers engaged in no-tillage agriculture.

⁷ E.R. Phillips & S.H. Phillips, 1984, *No-tillage Agriculture, Principles and Practices*, Van Nostrand Reinhold Co. (New York).

⁸ Also, in the 1960s M.A. Sprague, in New Jersey, reported on pasture renovation using chemicals as a substitute for tillage. (Phillips & Phillips, 1984.) L.A. Porter, in New Zealand, reported on strawberry production without tillage in the early 1960s, followed by A.E.M. Hood and R.S.L. Jeater at Jealott's Hill, England, for small grain. (Phillips & Phillips, 1984.)

Research on “conservation” or reduced tillage, with early versions of a chisel plough, was started in the Great Plains of the United States in the 1930s to alleviate wind erosion after the occurrence of the famous “Dust Bowl.” Stubble mulch farming was developed, and can be seen as a forerunner of no-tillage.

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Edward Faulkner's book *Plowman's Folly*, first published in 1943, was a milestone in the history of agricultural practices—he questioned the wisdom of ploughing. Some of his statements are: “No one has ever advanced a scientific reason for plowing”; “There is simply no need for plowing in the first instance. And most of the operations that customarily follow the plowing are entirely unnecessary, if the land has not been plowed”; “There is nothing wrong with our soil, except our interference”; and, “It can be said with considerable truth that the use of the plow has actually destroyed the productiveness of our soils.” The statements were questioned by both farmers and researchers, because alternatives to ploughing at that time did not allow farmers to control weeds or plant into the residues. According to *Reader's Digest*, “Probably no book on agricultural subject has ever prompted so much discussion in the United States, at the time it was written.” Five editions were printed in the first year of publishing.



Camel and oxen plowing in northern Africa, where the operator must walk along behind the plow. Plowing for many millenia was done this way in Eurasia.

In the late 1940s, with the introduction of plant growth regulators developed during World War II, reduced tillage was becoming feasible.⁷ Klingman reported on no-tillage practice in N. Carolina in the late 1940s. In 1951, K.C. Barrons, J.H. Davidson, and C.D. Fitzgerald of the Dow Chemical Co. reported on the successful application of no-tillage techniques.⁸ The invention of paraquat in 1955 and its commercial release in 1961 led the Imperial Chemical Company, ICI, and others to ini-

tiate rigorous no-tillage research in the UK, the USA and elsewhere.⁹ More intensive research on chemical seedbed preparation started in the United States in the early sixties. In 1960, experiments were begun in Virginia: killing bluegrass sod with paraquat, using atrazine for residual control and 2,4-D for post-planting cleanup. These experiments were soon repeated in Ohio, Illinois, and Kentucky.¹⁰

In 1961, demonstration trials were run on several farms in the USA. These plots led Harry Young and his brother, Lawrence, of Herndon, Kentucky, to apply the novel technology on their farm in 1962, and they became one of the first mechanised farms in the world to use no-tillage crop production. A metal plate at the site remembers the event: “First practice of no-tillage crop production in Kentucky occurred on this farm in 1962. Harry and Lawrence Young of Christian County were among first in nation to experiment with no-tillage techniques which use herbicides in providing seed bed in residue stubble. Conserves soil and water, saves time, labor, fuel and often produces higher crop yields.”

Soon thousands of visitors were traveling to the farm to learn about the new technology,¹¹ and other farmers in the region began testing no-tillage corn production. At this time machinery manufacturers started developing adequate equipment, and in 1966 Allis-Chalmers introduced the fluted coulter no-tillage planter. As no-tillage

Permanent no-till is now used on 45% of cropland in Brazil, 50% in Argentina, and 60% in Paraguay, with Paraguay now leading the world in percentage of no-tillage adoption. Access to adequate herbicides and seeding machines, as well as sufficient knowledge of no-tillage methods, were necessary in each instance for widespread adoption of the system.

enabled the farmer to sow seeds immediately after harvest, soybeans produced by the no-tillage method started to be double-cropped after wheat in 1967.¹²

Shirley Phillips wanted to prove that no-tillage was not suitable for adequate crop production. But after seeing the results, he became one of the pioneer researchers of no-tillage (most of his work was at the University of Kentucky), as well as becoming one of the strongest advocates and most successful propagators of no-tillage, not only in the United States, but abroad as well. Because of his commitment to the system, and his scientific, extension, and lecture work, Shirley Phillips can be regarded today as the father of no-tillage technology for mechanised agriculture. In 1973, Phillips and Young published the book *No-Tillage Farming*, the first of its kind in the world. It has been translated into other languages and had widespread impact.

Coming of Age

The area under no-tillage in the United States experienced a steady growth from 2.2 million hectares in 1973, to 4.8 million ha in 1983, to 22 million ha in 2003. Despite the impressive increase of no-tillage in the USA, the expansion has been much slower than anticipated. In 1975, USDA predicted that in the year 2000 about 82% of the cropland in the United States could be under conservation tillage and 45% under no-tillage.¹³ This predic-



Photo by John Griebel.

Erosion unleashed by tillage. Erosion is not an unavoidable process.

⁹ Among the earliest research publications on no-tillage crop production we can cite J.E. Moody, G.M. Shear & J.N. Jones, Jr., 1961, Growing corn without tillage, *Soil Sci. Soc. Am. Proc.* 25: 516-517; G.R. Free, S.N. Fertig & C.E. Bay, 1963, Zero tillage for corn following sod, *Agron. J.* 55: 207-208; G.B. Triplett, Jr., W.H. Johnson & D.M. Van Doren, Jr., 1963, Performance of two experimental planters for no-tillage corn culture, *Agron. J.* 55: 408-409; J.H. Lillard & J.N. Jones, Jr., 1964, Planting and seed-environment problems with corn in killed-sod seedbeds, *Trans. Am. Soc. Agr. Eng.* 7: 204-208; and, R.S.L. Jeater & H.C. McIlvenny, 1965, Direct drilling of cereals after use of paraquat, *Weed Res.* 5: 311-318. A report on a six-year comparison of no-tillage was published by Shear and Moshler in 1969.

¹⁰ G.W. Thomas & R.L. Blevins, 1996, The development and importance of no-tillage crop production in Kentucky, *Agronomy Research Report: 1996, Kentucky Agric. Exp. Sta. Progress Report* 385: 5-6. R.L. Blevins, R. Lal, J.W. Doran, G.W. Langdale & W.W. Frye, 1998, Conservation tillage for erosion control and soil quality, in *Advances in Soil and Water Conservation*, Ann Arbor Press.

¹¹ S.H. Phillips & H.M. Young, 1973, *No-Tillage Farming*, Reiman Assoc. (Milwaukee, WI).

¹² Phillips & Young, 1973.

¹³ USDA, 1975, Minimum tillage: A preliminary technology assessment, Office of Planning and Evaluation. USDA, 1985, Conservation tillage: Things to consider, *Agriculture Information Bulletin No. 46*.



No-till is routine in much of Brazil, such as shown here in the state of Paraná.

tion did not become reality; by 2000 only about 17% of the total cropland area in the USA was under no-tillage. Further, the 17% figure is overstated, since a large portion of those hectares is not considered to be in continuous or permanent no-tillage.

In South America, the first no-tillage experimentation began in Brazil in 1971, and the technology is now being applied to 45% of cropland in Brazil, 50% in Argentina, and 60% in Paraguay, with Paraguay now being the leading country in the world in terms of percentage of no-tillage adoption. Access to adequate herbicides and seed-

ing machines, as well as sufficient knowledge of no-tillage methods, were necessary in each instance for widespread adoption of the system. As more, better, and cheaper herbicides appeared on the market in the 1990s, no-tillage became easier to manage and this, together with the development of better no-tillage seeding machines by manufacturers in Brazil and Argentina, has had a tremendous impact on adoption rates by mechanised farmers in South America.

Compared to the Americas, no-tillage practice is adopted very little in Europe, Africa, and Asia, and in many countries this soil-conserving sustainable production system is virtually unknown. For instance, despite a wealth of research information generated at IITA, Nigeria since the '70s, the total area under no-tillage in Africa is still very small. Probably about 85% of the practical application of no-tillage by farmers worldwide takes place in the Americas.

In North America, despite decades of research and experience, the no-tillage system is still not well understood, nor accepted. This is most unfortunate, and demands our attention, since: "No technique yet devised by mankind has been anywhere near as effective at halting soil erosion and making food production truly sustainable as no-tillage."¹⁴

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Derpsch further notes, "It is very difficult to be always fair to all who have contributed over the years to the history and development of no-tillage farming over the world. Therefore I would like to apologize to those not mentioned in this paper."

¹⁴ C.J. Baker, K.E. Saxton & W.R. Ritchie, 1996, *No-tillage Seeding, Science and Practice*, CAB Int'l Publishing (Wallingford, Oxon, UK).

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