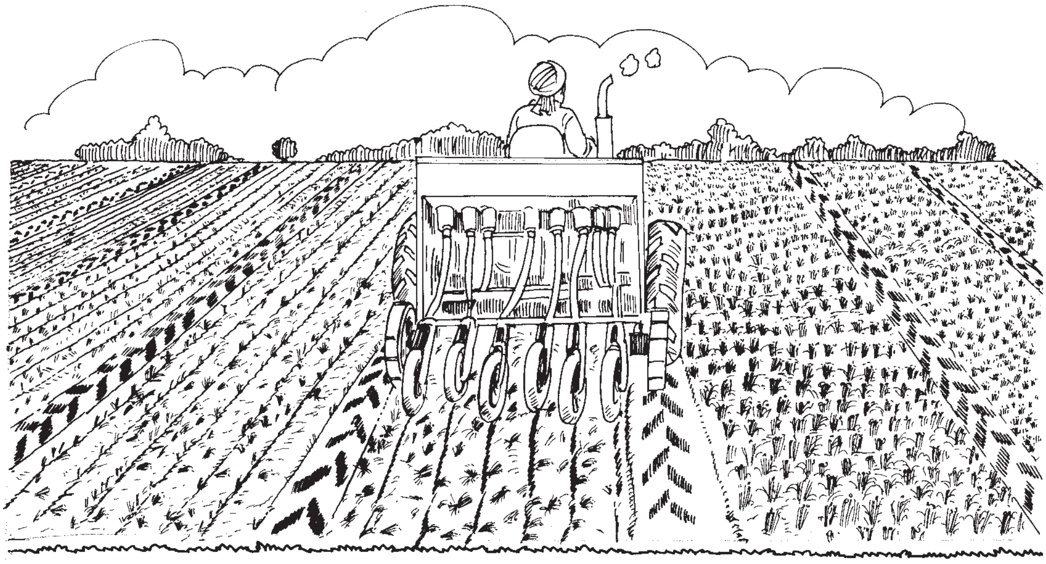
Improving Zero-tillage by Controlled Traffic



Conventional crop production practices of the 1960s were asociated with substantial soil and water erosion. To overcome the problem of runoff and soil erosion, resource conservation technologies were developed. These have replaced the frequent tillage and fallow practices that characterized conventional tillage.

Role of Zero-tillage in Conservation Farming

Conservation tillage refers to various practices that provide better protection for the soil. These practices include stubble mulching (maintenance of residue cover with mechanical weed control), minimum tillage (using a mixture of herbicide and mechanical weed control) and zero-tillage (soil disturbance occurs only at planting). Conservation tillage has been widely adopted over the past 20 years in Australia and also in other countries.

Zero or minimal tillage systems are optimal in terms of productivity and sustainability for most grain cropping. Despite overwhelming evidence in favor of this practice, excessive crop residue levels and soil compaction prevent farmers from maintaining zero-tillage production for more than one or two crops. Continuous zero-tillage farming is still rare, except where soils are highly resistant to compaction, and crop residues are minimal due to low yield, grazing, or burning.

Practice with Care

Zero-tillage is the key to improvement of crop productivity and sustainability. But it will be futile unless crops are planted without plowing, burning crop residues, or soil compaction.

What is Controlled Traffic?

Additional effort is required to disturb soil that has been compacted manually or mechanically during tillage. Traditional agricultural systems such as those described by Chi Renli and Zuo Shuzhen (1988) can sometimes avoid this energy penalty by maintaining separate zones for traffic and crop growth, but this is not easily achieved over the full cycle of operations involved in current crop production systems. The negative effects of traffic on infiltration, tilth, and penetration resistance of clay soils in Australia were first quantified by Arndt and Rose (1966), who advocated the use of improved traffic systems to minimize the problems.

Wheeled traffic is unavoidable in current crop production systems. Soil subjected to normal wheel traffic treatment is referred to as "wheeled" and that managed in controlled traffic as "non-wheeled". Optimum conditions for crop production, i.e., soft, friable, and permeable soil are quite unsuitable for efficient traffic and traction, and vice versa.

Wheel traffic increases soil strength and the draft requirement of subsequent tillage, while tillage reduces soil strength and the efficiency of subsequent traction (Tullberg, 2000). It also leads to degradation of soil physical properties (Yuxia Li *et al.*, 2001). Where field traffic follows a different pathway for each of a series of operations, the processes of tillage and traffic are contradictory. These contradictions are avoided in controlled traffic farming (Taylor, 1983), where all field traffic is confined to permanent lanes, and all crops are grown in permanent beds.

Wheeling Problem and Solution

Tractor and implement wheels drive over a large proportion of the field area every time a crop is produced. This proportion is more than 50%, even in zero-tillage. With one or two tillage operations, the total area wheeled, per crop, is greater than the area of the field. Implements (even zero-tillage planters) disguise the effect of wheels on the soil surface. Most of the damage is subsurface, so one has to dig to see it, but because the whole field area has been wheeled, a difference is seen only if there is a nearby non-wheeled area.

Research in the heavy clay soils of northern Australia has shown that most damage in the 10-30 cm depth zone occurs the first time a wheel passes over the soil. The damaging effects last for 2-4 years even in these self-mulching soils, which recover their structure during wetting and drying. The major effects of this damage are:

- Runoff from wheeled areas increases dramatically, increasing erosion and loss of nutrients.
- Infiltration of rainfall into wheeled soil is reduced by 5%-20% (overall); internal drainage is also reduced. Waterlogging is a greater problem.
- Plants can extract ~50% less water from wheeled soil.
- Wheeling kills more earthworms and other beneficial soil organisms than most tillage operations.
- Planting or tillage of wheeled soil requires much greater tractor power.

Lower tyre pressure might help to reduce soil damage, but lower pressures usually require wider tyres, which affect a greater area. The best solution is controlled traffic farming, where all heavy wheels are restricted to permanent laneways, and all crops grown on permanent beds. This is most easily done where the permanent laneways are in the furrows. In controlled traffic fields, 25% or more of field area is lost to permanent laneways, but farmer experience has usually been an overall yield increase of >10%, combined with a significant reduction in costs.

REMEMBER: Plants grow best in soft soil, and wheels work best on hard surfaces.

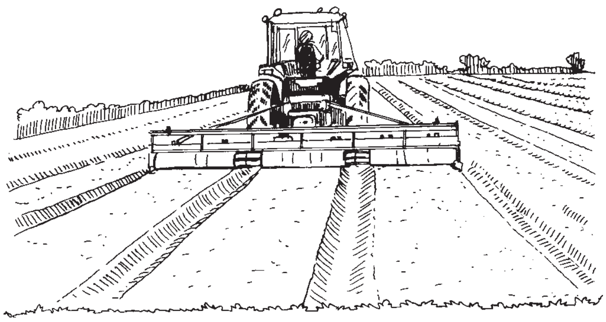
Need for Controlled Traffic

While there are biophysical and insect/disease conditions which can restrict zero-tillage, the major single constraint is the simple issue of planting. Effective zero-tillage planters available in Australia and North America are all complex, large and heavy, and their high cost and power requirement has been a major impediment to the adoption of improved systems even in capital-intensive agriculture. They are quite unsuitable for use in developing country systems, where tractor power and lifting capacity are limited (Murray and Tullberg, 2002, Zero-tillage planting: Project proposal, unpublished).

The cost and complexity of the machinery is a direct consequence of the need to plant through residue into a soil surface that is hard and sometimes uneven. There are many residue soil interactions, but soil surface issues can be overcome by permanent bed or controlled traffic cropping systems. Crop residues left in the field can be reduced by avoiding interrow planting, baling, or cutting; these activities are influenced by residue type, quantity, and condition. Some multinational farm machinery companies have ceased research on zero-tillage equipment in response to limited adoption. Controlled traffic avoids the contradictions inherent in most mechanized farming systems to provide substantial, demonstrable, and consistent improvement in the economics and sustainability of cropping.

Beneficial Effects of Controlled Traffic

Permanent Bed System



Permanent bed system allows soil conditions in the beds to be optimized for crop production, and the lanes optimized for traction. The advantages of controlled traffic include an indirect energy economy which occurs because there is less need for deep tillage. The direct effect occurs because non-compacted soil requires less tillage energy than compacted soil, and traction is more efficient when tyres are working on compacted permanent tracks (Tullberg, 2001).

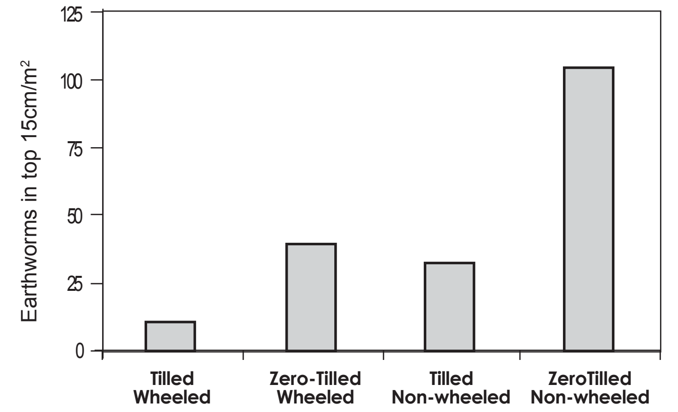
Thus, permanent bed systems provide all the advantages of controlled traffic in terms of reduced energy input and improved soil condition (structure, hydrology, soil life, and crop yield). Bed or controlled traffic systems avoid the problems of leveling and planting tractor wheel tracks, but the permanent wheel tracks also provide a place for the temporary storage of excess residues, and an alternative to residue burning. Permanent bed systems also provide major advantages in direct costing and timeliness in rice production, where the cost of reforming beds for every crop is high and the operation may not be possible if the rains have started.

Soil Response to Traffic

In controlled traffic systems, all field traffic is restricted to permanent, defined traffic lanes. Traffic lanes are normally untilled and not planted to optimize traction and trafficability. Soil in the intervening beds is managed to optimize crop performance, uncompromized by traffic.

Controlled traffic farming avoids the situation where a large proportion of tractor power is dissipated in soil degradation. It is a system in which the management of different soil zones is optimized to provide maximum benefit in terms of:

(1) energy requirements to allow a reduction in fuel use, tractor size, and production cost;
(2) soil structure and health to provide reduced runoff and enhance crop/soil performance; and
(3) spatial precision in the soil/plant/machine relationship to improve crop management.



Wheeling and Tillage Effects on Soil Health: Worms Don't Enjoy Traffic or Tillage!

Farmers Control Field Traffic

Controlled traffic is a prerequisite for zero tillage. Hundreds of Australian farmers using controlled traffic now find they can zero till for many years without the need for expensive deep tillage to undo soil compaction problems. They are saving money, getting better yields, and helping the environment.

Direct Benefit to Farmers

Controlled traffic demands and promotes the use of greater precision in field operations. In northern Australia, farmers practicing controlled traffic have experienced 10% to 20% reduction in time and material input to cropping operations. When permanent wheel tracks are accurately installed, the elimination of double coverage and/or gaps also has a positive effect on yield.

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