CONTROLLED TRAFFIC - SOIL MANAGEMENT OPPORTUNITIES

Gordon Spoor, Silsoe College, Silsoe
Bedford, England MK45 4DT.

The prime objective when developing soil management systems for the future is to identify systems which will achieve the following:

1. reduced inputs in terms of time and energy

2. improved soil conditions for crop production, maintenance of soil fertility, and reduced erosion and environmental pollution.

Controlled traffic systems open up new horizons for the development of soil management systems to meet this objective and some of the opportunities and implications are discussed in this paper in terms of the conference themes.

Soil Management Development Through History

In both past and current situations where manual labour constituted the only energy input, soil tillage inputs are minimal, often amounting only to hole formation for seed placement. In these natural situations when water supply, drainage, weed control and temperatures are adequate, there is no evidence to indicate that crop production or soil conditions can be improved by increased soil cultivation; the result is often the reverse. If conditions for production are, therefore, satisfactory, there is no gain from unnecessary cultivation.

With the introduction of animal power, the amount of tillage increased, often ceasing to be local and almost always increasing in depth. This trend has continued following the introduction of tractors, although there has been the occasional reversal, usually of relatively short duration. Such a change occurred in the 1970's - 80's with the introduction of paraquat, allowing the direct drilling of cereals. The results achieved were successful initially, but tillage became necessary again later, as equipment size and soil compaction in particular increased.

The two major factors which have dictated this increased tillage and working depth trend, are the continuing increases in soil loading from larger and heavier tractors and equipment, and the action of the soil engaging tools themselves, particularly when working under moist or wet conditions. The tool effects, manifest in the form of soil pans and smeared layers, required only small increases in working

depth to overcome them. The loading effect, however, extends much deeper, the relatively weak soil deforming and compacting to greater depths to support the increased loads.
Until recently, there have been two main management approaches to avoiding these compaction problems, the first being to reduce tyre and contract pressures to reduce the depth of compaction. The second, regular deeper loosening operations to alleviate the compaction itself. The combined use of both approaches has been successful up to certain loading limits, but it is not a permanent solution and is only achieved at the expense of increased energy and time inputs. The major problem affecting permanence is that the loosening operation unfortunately makes the soil even more vulnerable to recompaction, hence with uncontrolled subsequent traffic recompaction can occur very rapidly. By effectively removing loads from the cropping area, the controlled traffic approach offers the opportunity to avoid these problems, so reversing this most unsatisfactory trend of deeper and deeper tillage, with a continually increasing cost penalty.

Soil Management Aims

Prime soil management aims are to provide optimum soil conditions for the crop, water application systems, water conservation, drainage, erosion control and machinery operation wherever appropriate. The ease and extent to which many of these requirements can be achieved is very dependent upon the machinery operating system and the prevailing soil condition, particularly the nature of the soil structure and its stability. The aim must always be for a continuing improvement in soil structure, for everything stemming from a good soil structure is advantageous.

The risk of soil structural unit or aggregate breakdown is very dependent on the magnitude and timing of any loads applied to them and on soil organic matter content. The units are much more vulnerable to mechanical breakdown under a given load, when loaded under wetter conditions, particularly in more compact denser soil situations. They are usually very resistant to breakdown when dry. Greatest handling care, therefore, needs to be taken when working at higher moisture contents.

Whenever soil aggregates or clods are moved, even without being broken, they are weakened, making them more vulnerable to breakdown if re-loaded soon afterwards. Allowing a period of time. 2 - 3 days or more, without further disturbance, particularly if there is also some drying, will enable them to regain much of their lost strength and breakdown resistance. The timing of further disturbance has, therefore, an important influence on the final result.

Soil organic matter contents not only depend on the amount of organic material left after the previous crop, but also on the amount lost during soil preparation for the next crop. Soil cultivation and stirring is an ideal way of maximising organic matter loss and hence of reducing structural stability. Organic matter levels are critical for the safe working of soils when moist or wet, since it is the organic related bonds which provide most of the aggregate strength and breakdown resistance at higher moisture contents. This is the time when aggregates are most vulnerable to loading damage. Zero or minimal tillage techniques to conserve organic matter are, therefore, almost essential for a continuing improvement in structure with time.

The great challenge in soil management is to identify systems which satisfy, with a minimum of compromise, all the optimum requirements for the crop, water regime, aeration, soil conservation and tractor and machinery operation. This is extremely difficult to achieve with random traffic systems, where serious conflicts arise between traffic needs and almost all the other requirements. The ideal traffic requirement is for a very well compacted soil condition, very different to the other needs. Whilst a compromise soil condition may be reasonably satisfactory for low pressure, light to medium traffic and machinery , it certainly is not possible for heavier equipment. The adoption of a controlled traffic system removes this major conflict immediately, leaving only much more minor ones, such as conflicts between surface residues for erosion control and seeding machinery, to be resolved.

By removing the heavy loads from the cropping area, the controlled traffic approach is a very positive way of reducing direct soil structural damage, of significantly reducing if not eliminating tillage requirements, so improving soil structure through reduced organic matter loss and of enabling almost all the soil management aims to be met with a minimum of compromise. Whilst the ideal system to maximise the gains from these potential benefits is a permanent controlled traffic system, substantial benefits are still achievable with temporary systems, providing they are established on the first pass of seedbed preparation. Soil compaction, requiring later eradication, does occur in the wheeled area with temporary systems, but its location is clearly identifiable, thus allowing lower cost local rather than general alleviation measures to be taken.

Soil Management Opportunities

A change to a controlled traffic system changes the soil situation immediately and hence if maximum benefits are to be achieved, there is a need to re-look at tillage practices to see if modifications are needed. It is highly unlikely that traditional ideas on tillage depths, timings, frequencies and operations will necessarily be the most appropriate for the new situation. The changed circumstances are now reviewed to identify where pitfalls may occur, but particularly where opportunities exist for improving efficiency and production. Maximum benefit will, however, only be achievable, if strong well drained traffic lanes are prepared, allowing efficient trafficking as soon as possible after rainfall or irrigation.

Soil condition/compaction issues

The main current soil compaction concern is usually associated with excessive compaction, a condition which has arisen from general uncontrolled trafficking. Once traffic is removed, unless tillage practices are changed, there could in numerous situations be the opposite problem of under-compaction. Under-compaction can sometimes seriously reduce water availability and may in other cases induce nutrition problems such as trace element deficiencies. Early zero traffic trials in UK with the same cultivation systems, regularly reduced cereal yields on some clayey soils by about 15 - 20%, this was due to induced manganese deficiency. This is a change which certainly needs watching and rectifying as appropriate.

Removing the major cause of soil compaction namely, traffic should, certainly on the more stable structured soils, allow much shallower tillage and in some cases direct drilling. The need for and depth of tillage now is more likely to depend on requirements for crop residue incorporation, weed control or seedbed production. On weakly structured soils tillage depth will depend on the depth of soil slumping which has to be alleviated. In almost all cases working depth requirements will be less than previously, an advantage to be capitalised on .

Once into a permanent controlled traffic regime, soil conditions can be expected to improve with time. the intensity and depth of tillage operations required can, therefore, also be expected to change, decreasing with time and advantage should be taken of this. Soil improvement tends to be rather quicker in the surface layers than at depth and it would be unfortunate if improved topsoil was lost unnecessarily to depth. This can easily happen during deeper loosening operations, which may be necessary to overcome inherent deep compaction in the early transition years of the system. Deeper working tine depths, spacings and winged tine lift heights should be adjusted to lift and fissure the soil in the problem area at depth, but without rolling out large clods and creating major cavities at the surface, down which surface soil can fall. Progressive multiple depth tine arrangements loosening from the surface downwards can achieve this requirement and they are also most suited for loosening temporarily installed traffic lanes since they minimise the extent of large clod production.

Operating conditions and procedures

Although rarely recognised, in uncontrolled traffic systems, the earliest starting time for tillage operations following rainfall or irrigation, is governed more by the likely compaction and rutting damage that will be caused by the tractor wheels, than by whether the following implement will do its job. It is possible to work soils satisfactorily without causing serious structure and compaction damage, at higher moisture contents than would be the case if they were trafficked. With the wheels removed from the cropping area, much greater flexibility, therefore, exists in the timing of soil operations. There are obviously limits as to how moist or wet soils can be and still be worked satisfactorily, but within these limits, the moister the soil the lower the energy requirement and the easier it is to break clods, bonuses worth exploiting.

This greater flexibility in the timing of cultivations opens up two timeliness options. When weather conditions are likely to remain difficult or deteriorate, work can commence earlier with controlled traffic. If there is a strong chance of weather improvement, the start can be delayed to optimise conditions, with the knowledge that if the weather does go wrong an earlier start on drying again is possible.

The natural weathering processes are still the most efficient of all methods for producing optimum seedbeds, often at zero cost, but sometimes they need assistance. Leaving the soil in a condition after tillage, where after weathering it can be drilled without any further tillage operation, is the condition to be aimed for. This may require a little further soil manipulation to get the condition right, such as levelling a rough surface. Working from controlled traffic lanes, such operations can be easily carried out at the optimum time, without wheeling damage in the crop production area. The traffic lanes provide the flexibility to time other operations carefully, such as allowing the soil to age if necessary before further manipulation, thus preserving structure, or a rapid following operation to break excessively large clods before they strengthen.

Implement smear and panning risks increase when working under moister conditions. These risks are, however, much less in controlled traffic regimes, where the soil at depth is much less compact. Narrow tines fitted behind and operating slightly deeper than the discs on susceptible disc implements, will also effectively remove any potential disc panning problems immediately.

Production issues

The quality and uniformity of crops are becoming increasingly important issues influencing saleability and profitability. They are particularly dependent on having uniform soil conditions, which can readily be achieved with controlled traffic systems. Other critical issues influencing production include the timeliness of crop establishment, the ability to manipulate the soil to relieve crusting problems which could effect emergence and timely operations for mechanical weed control. The ability to work under moister soil conditions from traffic lanes significantly increases the chances of operating within the desired time periods for all these operations. Under intermittent rainfall conditions, the possibility of working even one day earlier after rainfall, could often avoid a delay of 1 - 2 weeks, if the weather pattern turns foul.

The harvesting and removal from the field of soil borne crops without severe soil structural damage, becomes much easier, whatever the moisture conditions, when working from traffic lanes. This system also offers an additional advantage in situations where the following crop has to be established rapidly after harvest. Even in wet seasons, the soil working necessary after harvest for the following crop will be much reduced with controlled traffic as compared with uncontrolled traffic, allowing much more timely crop establishment.

Erosion / water infiltration / drainage issues

Erosion control is closely associated with the management of crop residues. In certain circumstances, particularly under wet conditions on heavier soils, unfavourable seedling/straw interactions may occur in the presence of straw, reducing plant populations. This problem is greatest when the seed is placed in smeared slots in contact with straw or chaff. With appreciable rainfall during the germination and early seedling growth periods, anaerobic conditions can develop which can kill the seedlings. The risks of this occurring are very dependent upon seed drill coulter design and soil condition at the time of drilling, but they are greatest when the seed is drilled into compact soil with little seedbed tilth. These soil conditions are least likely to occur in minimum tillage, higher organic matter level controlled traffic situations. Increased possibilities, therefore, exist for the adoption of direct drilling practices with effective residue cover for erosion control in controlled traffic situations.

Erosion risk is likely to be highest in sloping areas in the traffic lane itself, due to water flow along the track. Experiments where chopped straw has been anchored into the track using the tractor wheels, are showing considerable promise in reducing this soil loss problem.

Conclusions

Controlled traffic offers many advantages for improved soil management, whilst at the same time reducing time and energy inputs. In particular, it offers opportunities for much more timely operations over a wide range of soil moisture contents, with reduced tillage inputs. Changes to traditional tillage practices will frequently be necessary to maximise the benefits from the system.