REDESIGNING CROP ROTATIONS

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Introduction

Modern no-tillage management and technologies have created many new opportunities for farmers and growers. Despite wide publicity of these new opportunities, options and needs, adoption rates have been lower than desirable. Perhaps one reason for this has been a lack of willingness to move from traditional management practices, even although these traditional practices themselves mitigate against, and thereby limit, the performance of conservation agriculture. In many cases, cropping systems must be substantially redesigned or, at least, restructured to fit the opportunities and limitations created by no-tillage.

Rotations for conventional tillage systems

Figure 1

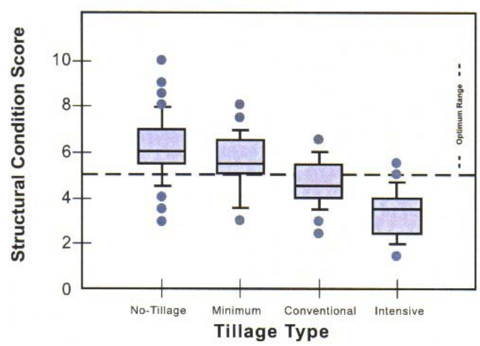
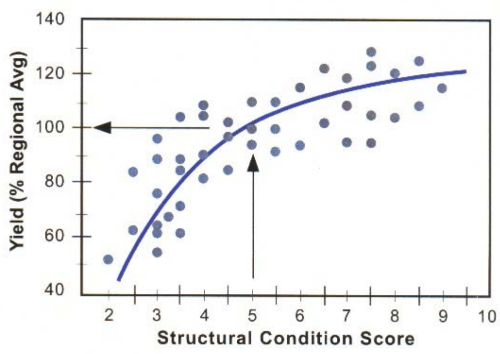


Figure 2



Figures 1 and 2 show that increasing tillage intensity leads to degraded soil structure which, in turn, leads to declining crop yields (1). Few regions of New Zealand experience the continuous annual cropping systems seen in vast areas of the world's arable land. Most New Zealand annual cropping has historically been in a rotation with pasture, creating the perception that our system is sustainable. But, if the "cropping" component of this system was truly sustainable the "pasture" phase would not be necessary. The increased emphasis on short-term, compared with "permanent", pasture has created new opportunities that conventional tillage is not well suited to capture.

There is considerable evidence that New Zealand's traditional rotations are not sustainable. In most cases the period in permanent pasture only equates to the period in crop (1 year of pasture for 1 year of crop). A 4-5 year period of annual cropping requires longer than 4-5 years of permanent pasture to fully repair soil structure and soil carbon (2). Cropping for periods of 10 years or more requires 3 years of pasture per year of crop. But how many 10-year crop rotations are spelled for 30 years? The other implication is that if the returns from annual crop are better than pasture then the maximum economic return from the land has not been achieved by including pasture in the rotation.

Rotations are imposed on annual cropping systems in order to achieve a number of goals. These include soil structure repair, replenishing soil organic matter and weed, disease and pest control (3). If the need for soil structure repair is removed by the use of no-tillage systems (1,5) then the emphasis can be more effectively placed on crop management factors. Greater options exist to rotate monocotyledonous and dicotyledonous crops. Pasture, either short-, medium- or long-term may, of course, be part of the new rotation. But the decision to include pasture should be made on economic or crop management grounds, not for reasons of soil sustainability.

Rotations for no-tillage systems

Crop rotations under no-tillage may need to change from those traditionally used under conventional tillage. If soil structure considerations are effectively eliminated from the equation then other factors, some specific to no-tillage, assume greater importance.

1. Weed, pest and disease control

No-tillage systems can present a different weed spectrum to conventional tillage. Timing of knock-down herbicide applications, different physiological characteristics of weed species and their response to herbicides and/or soil disturbance can all impact on the weed spectrum. Rotating crop varieties can be an effective weed management tool.

The same principle applies to pest and disease control. Understanding the characteristics of the pest/disease, the characteristics of the control measures and the management system will all contribute to an effective rotation.

The principles associated with weed, pest and disease control are the same for rotations for conventional tillage and no-tillage but the specific management strategies may differ.

2. Managing fertility issues

One fundamental difference between tillage and no-tillage is the short-term availability of soil nutrients, especially nitrogen. The mineralisation associated with tillage releases nitrogen (and other elements) that is immediately available to the establishing seedling. By contrast, under no-tillage the microbial processes occurring in a decaying crop or pasture residue result in a short-term “lock-up” of soil nitrogen. The resulting “nitrogen deficiency” can seriously affect the performance of establishing seedlings unless adequate additional nitrogen can be applied at seeding. Since high levels of residue and organic matter are considered beneficial under no-tillage systems (4) (for moisture retention, weed control, soil microbial activity, etc), managing early crop nitrogen is an important component of successful no-tillage. Crop requirements for nitrogen vary considerably therefore offering the opportunity to match N availability with crop requirements.

Since N availability varies substantially between tillage and no-tillage systems (4) it follows that rotations may also need to vary between the two systems.

3. An example

Commonly used rotations under tillage in many North Island mixed cropping regions include ryegrass (for grazing or seed production), peas (process or seed), barley (malting, seed or feed), wheat (milling, seed or feed) and maize (grain or silage). An example under conventional tillage in Manawatu might be 4-5 years of pasture, wheat, winter crop (brassica or Italian ryegrass), process peas, winter crop, barley, winter crop, barley and back to pasture. While full tillage is unlikely to occur in both spring and autumn, it is likely that summer crop residues will be baled and the stubble burnt resulting in little organic matter return throughout the annual cropping phase of the rotation.

With no-tillage the rotation may differ if the principles outlined above are applied. Taking the same starting point (4-5 years of pasture), the knock-down herbicide applied in spring will result in considerable N "lock-up". Planting a high-N requiring cereal (e.g wheat) in this situation will require considerable additional N at seeding. Also, planting a monocotyledonous crop like wheat into sprayed pasture may present additional pressures from carried-over pests and diseases and less options for grass weed control.

An option is to bring peas forward in the rotation. Peas require less N and present far less potential for pest and disease carry-over from pasture. Grass weeds will be much easier to control. By the second spring of the summer crop rotation considerably more N will be available, pests and diseases will have had a "break crop" and there will have been several opportunities for grass weed control. The second spring of the rotation will present a much more attractive and lower-risk opportunity for wheat.

An example of 21 years of continuous cropping under a simple rotation of 2 years process peas and 2 years feed barley with winter forage brassicas or Italian ryegrass showed soil quality parameters under no-tillage were generally about 80% of those under pasture and significantly better than under cultivated cropping (5).

4. Autumn options

No-tillage may also offer new opportunities in the autumn due to more rapid crop turn-around compared with tillage systems. Drilling directly after harvest will result in earlier establishment of autumn crops that may influence the particular crop to be planted given that a greater proportion of the good autumn growth conditions will be available.

Minimum tillage systems

Surface working or strip tillage will fit somewhere in between the two systems outlined above but will likely be closer to the tillage end of the spectrum for most issues. The degree of surface soil disturbance associated with minimum tillage systems will determine the degree of N released from mineralisation and will vary between systems. Similarly, weed, pest and disease control may also be influenced by the degree of soil disturbance. Other issues such as erosion control, moisture conservation, labour, machinery and fuel costs will all be influenced by the degree of tillage applied. Rotations can be designed by applying the above principles to the specific minimum tillage system proposed.

Comparisons

For the reasons given above, caution must be exercised when attempting to compare tillage systems. Land preparation, timing, crop rotation, fertiliser requirements and weed, pest and disease management may all differ between optimal systems. Unless the strategy for each system in the comparison is optimised then the comparison loses objectivity. In a field situation balancing such requirements nears the impossible.

Summary

Rotations traditionally used for conventional tillage may create limitations and reduce opportunities for no-tillage management systems. If the benefits of no-tillage are to be fully gained then new strategies need to be imposed. This can only be done effectively if all the parameters are fully understood. Exercise caution when comparing systems because the requirements for optimisation differ considerably.

No-tillage is not a technique – it is a system!

References

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