THE EFFECTS OF NO-TILLAGE AND SUBSOIL LOOSENING ON SOIL PHYSICAL PROPERTIES AND CROP PERFORMANCE

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ABSTRACT

Much of New Zealand's lowland agriculture integrates animal and crop production on poorly drained, easily compacted soils. Over the years, conventional cultivation has given rise to degraded soil structure on many farms. No-tillage has been shown to avoid many of these problems but the question remains: "Where soils are compact, what combination of deep tillage and/or drainage systems and no-tillage allow for the most efficient transition from conventional cultivation to no-tillage crop establishment?" The objective of this study was to ascertain if soil properties, and crop (*Brassica campestis* x *Brassica napus* cv "Pasja" followed by wheat *Triticum aestivum* cv "Kohika") establishment and yield on land converted from a conventionally tilled system to a no-tillage system could be improved by various subsoiling and mole plough operations. Plots on a Milson silt loam (Argillic Perch-Gley Pallic Soil) (Typic Ochraqualf) were paraplowed (PP), straight-legged subsoiled (SL), mole ploughed (M) or were left as non-subsoiled controls (C) in the autumn of 1997. Forage brassica was then sown with a Cross-Slot™ no-tillage drill. Wheat was established on the same plots with the same no-tillage drill in the spring of 1997.

Subsoiling initially reduced soil strength by a significant amount. Shortly after subsoiling cone indices showed disruption to 300 mm with PP, 350 mm with SL and 100 mm with M. At the same time, approximately 20% of profile cone indices from subsoiled treatments were greater than 2 MPa, compared to approximately 52% for C and M. At 267 days after subsoiling, PP continued to have lower cone index values than C and M.

Subsoiling initially reduced bulk density. When measured in May, the bulk density of PP plots was significantly lower than SL, M and C although reconsolidation in all plots was observed in February 1998 after the wheat was harvested. Air permeability in PP, SL and M was significantly greater than in C.

Despite the differences in soil strength and bulk density (but not air permeability), subsoiling and mole ploughing did not produce differences in plant populations or

yield for either the winter brassica or spring-sown wheat crops. The lack of any differences for brassica crop performance criteria were in spite of the vertical rooting depth being greater in the PP treatment. The lack of differences in plant establishment and yield was thought to be due to the relatively dry autumn and winter soil conditions and the use of the Cross-Slot™ no-tillage opener which is reported to be tolerant of variable soil conditions.

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1. INTRODUCTION

Soil compaction has reduced crop yields in countries around the world, including the USA (Adams *et al.* 1960; West *et al.*, 1996), Canada (Raghaven *et al.*, 1979; Carter *et al.*, 1996), Australia (Delroy and Bowen, 1976) and New Zealand (Greenwood and Cameron, 1990; Harrison *et al.*, 1994; Sojka *et al.*, 1997). Soils may be compacted by both natural and human-induced processes. Natural processes, such as consolidation and shrinkage, which are largely dependant on moisture regimes, can result in surface crusts, subsurface compaction and pans (Hillel, 1980). In a fine textured soil, the subsoil is often naturally compact and may limit plant growth.

Controllable compactive processes consist largely of trampling, wheel traffic and tillage. Vehicle and implement traffic is considered to be the main source of compaction in arable agriculture with its use of heavy field equipment such as tractors, harvesters and transport equipment. Untimely operation of machinery (*i.e.* when soil moisture corresponds to the plastic state) can deteriorate aggregate stability and give rise to soil compaction. Arguably, the most harmful practice to soil structure is tillage.

Until recently, tillage with mouldboard ploughs and subsequent secondary operations was the only realistic option for farmers seeking to establish new pastures and crops. Such tillage relies on repeated passes with tyned and/or powered machinery to create a suitable seedbed for crop establishment. In so doing, soil aggregates are disintegrated, not shattered and re-arranged along natural lines of cleavage as they would normally be through natural processes (Baker *et al.*, 1996). Such massive aggregate reorientation occurs until ultimately a "plough pan" or compacted layer is formed. Plough pans occur at ploughing depth and result from repetitive smearing as the plough shares slide over the same surface year after year. Some plough pans are not even smeared but are simply a flat sheared surface (Culpin, 1992).

Recent developments in machinery, herbicides and management have re-established no-tillage as an alternative method for establishing crops. Despite its benefits, no-tillage has been identified by some authors (*e.g.* McLaren and Cameron, 1996) as leading to higher soil bulk densities and soil strength. Smaller root systems, and reduced crop vigour and yield, have been observed with no-tillage when compared with crops established by tillage (Baker *et al.*, 1996). It should be noted, however, that the former observations have been reported in soils that have already lost much of their structure through repetitive and untimely tillage. In this case short-term amelioration of soil structure may be necessary until the natural processes by which soil structure is repaired can predominate. Such processes are encouraged by no-tillage. Some authors (*e.g.* Evans *et al.*, 1996) have illustrated the need for deep loosening to alleviate compaction and improve the agronomic performance of crops or pastures established without cultivation. This observation is especially pertinent in finely-textured soils that have been subject to intensive tillage and its inherent problems.

Increased awareness of the problems associated with subsoil compaction has generated widespread interest in subsoiling as this technique has been reported to provide short-term benefits in soil physical properties. A range of subsoiling implements are available for commercial use and include straight-legged subsoilers, slant-legged subsoilers and mole ploughs. While all three types of implement perform some degree of soil loosening and shattering, the latter design has the primary function of drainage and is commonly used in conjunction with subsurface pipe or tile drainage systems. Authors including Evans *et al.*, (1996) and Sojka *et al.*, (1997) have reported subsoiling effects under tilled treatments but none have previously concentrated solely on no-tillage.

The hypothesis tested here was that subsoiling and moling, in combination with no-tillage would improve soil conditions and increase crop yield.