# Towards improving white clover establishment on farms

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## Abstract

The establishment of new clover-based pastures takes a full year and has two distinct components; seedling emergence from sowing, and subsequent grazing management. A Ministry of Agriculture and Forestry (MAF) Sustainable Farming Fund (SFF) project to investigate the causes of inconsistency of white clover establishment concluded this came primarily from a lack of knowledge of white clover in both sowing and grazing management skills, and reflected how far modern farming technology has moved away from clover-based systems towards nitrogen (N)-boosted systems in recent years. Typically, less than half the seed being sown emerges, for both ryegrass and clover, although good results do occur. A trial looking into seedbed conditions on a dairy farm highlighted the importance of good seedbed consolidation in order to accurately control sowing depth, lifting white clover emergence by 50% and ryegrass by 25% using a roller drill. Consolidation did not affect emergence using a triple disc drill, but it did improve quality of sowing by reducing soil drag and spill by the rear coulters causing excessive burial of the front coulters rows. Differences in emergence were still evident in the performance of the clover in the following summer with 14% clover in the areas that had been hard rolled compared to 4% where it had not. In another trial on a hill soil of lower N fertility status, the taking of hay crops in the first summer, not a normally recommended practise, enhanced clover establishment compared to rotational grazing all year. The roles of clover, N fixation and quality feed, are discussed in the context of how and where clover may fit into modern farm systems.

**Keywords**: emergence, establishment, grazing management, seedbed preparation, sowing methods, white clover

## Introduction

In response to the often heard comment from farmers that "*We can't get enough white clover in our pastures*", a MAF SFF project was set up in 2001 to investigate the problem of white clover establishment under current farming practices. Results from the first year (Brock & Kane 2003) indicated that modern methods of establishment were less 'clover friendly'. Minimal seedbed preparation and method of sowing combined with inappropriate management during the establishment year were seen as the main causes.

Results for the second year of the study were no better (Table 1) highlighting that the ryegrass was also adversely affected with only half the seed sown emerging, the difference being that with the generally high sowing rates used ($\approx$ 20 kg/ha) there was still sufficient ryegrass plants to dominate in the high soil fertility conditions on these high producing farms. Consequently, it was decided to take a closer look at 1), aspects of ground preparation and sowing that may affect seedling emergence, and 2) management factors that may improve survival of white clover plants on-farm.

**Table 1** Variability in white clover and ryegrass emergence on 16 farms.

| Year | Clover % emergence | (range) | Ryegrass % emergence | (range) |
|---|---|---|---|---|
| 2002 | 35 | (9-73) | 44 | (22-84) |
| 2003 | 23 | (9-42) | 50 | (33-78) |

## Methods

### A. Pasture sowing

John McKenzie, a dairy farmer near Shannon in the Manawatu, had widely disparate seedling emergence (42, 30 and 16%) from sowings in 2003 on three paddocks of the same soil type all prepared and sown identically. In 2004, it was decided to compare various ground preparation and sowing methods on the three paddocks of the same soil type (Kiwitea silt loam) up for re-sowing after summer turnip crops. All paddocks were flat to gently rolling and prepared by normal farm practice of spraying with glyphosate for weed control, cultivating with power harrows and finished by a single pass with a light Cambridge roller. Each paddock was split for the following treatments.

1. Seedbed consolidation (main plots).
   a) Light rolling, normal practice.
   b) Heavy rolling (Cambridge roller plus three concrete posts) to compact the soil until the roll form held under normal walking pressure.
2. Sowing method (sub-plots). All sowing treatments were sown with white clover at 5kg/ha coated seed.
   a) V-roller drill (8 kph) and covered by light chain harrow.
   b) Triple disc drill (8 kph), no harrow.
3. Grass sowing rate (sub-sub-plots).

a) Matrix perennial ryegrass 18 kg/ha (normal rate).
b) Matrix perennial ryegrass 9 kg/ha.

Seedling emergence counts were made 6 weeks after sowing. During sowing with the triple disc drill it was evident that definition of the drilled rows from the front row of coulters was poorer in the lightly consolidated soil compared to that heavy consolidated. Consequently seedling counts were made across four sets of 6 drill rows on both consolidation treatments.

Pastures were grazed through the winter by young stock then by mature stock once the milking season had started. No fertiliser N was applied. In late summer clover performance was measured using pasture cores to assess growing point density and stolon mass, and herbage cuts made to grazing level for clover content (%).

**B. Establishment management**

The 2003 sowing (9 March) on the sheep/beef hill country property of Stephen Pound at Mauriceville, northern Wairarapa, using a higher than normal white clover sowing rate (4 kg/ha bare seed) with 15 kg/ha Impact perennial ryegrass, resulted in a reasonably good white clover seedling density (167/m$^2$) despite poor emergence (30%). The gently rolling paddock (Whetakura sandy loam), was cultivated by discs, levelled, and sown by Baker Boot Cross slot drill. Thistles were controlled by spraying with Tropotox at 4 l/ha in May. The paddock was split to compare the effect of establishing pasture under 1) rotational grazing all year, or 2) rotational grazing but with taking a hay/baleage crop over the summer. Fertiliser N was applied to both treatments in June (25 kgN/ha as diammonium phosphate (DAP), December prior to closing (50 kgN/ha as urea) and April (30 kgN/ha as DAP and ammonium sulphate). These treatments were repeated over the second year.

Seedling emergence counts were made in early-May and clover performance measured on both treatments by pasture cores for growing point density and herbage cuts for clover content (%) at the beginning (early-December) and end (late-January) of the hay crop, then in the following April and June, with a final assessment in April of the following year after a second hay crop. Annual rainfall for the two years was 1814 and 1524 mm, including 476 mm during the February 2004 floods.

## Results

**A. Pasture sowing**

Halving the grass sowing rate reduced grass seedling density by 30% from 495/m$^2$ to 340/m$^2$ but had no effect on the density of white clover seedlings (350 and 315/m$^2$ respectively). There was however, a strong interaction between seedbed rolling and method of sowing (Table 2). The only treatment with higher clover seedling density was the V-roller following heavy consolidation where clover seedling emergence was 90% compared to around 65% for all the other treatments. Grass emergence was not high (55%) with lowest values from the V-roller on lightly consolidated soil (40%).

**Table 2** The effect of seedbed consolidation and sowing method on grass and clover seedling density/m$^2$.

| | Consolidation | Sowing method: V-roller | Sowing method: Triple disc |
|---|---|---|---|
| Clover | Light | 240 b* | 270 b |
| | Heavy | 375 a | 255 b |
| Grass | Light | 285 b | 390 a |
| | Heavy | 360 a | 410 a |

* Values followed by a different letter are significantly different at P = 0.05.

**Table 3** The effect of coulter position and soil consolidation on grass and clover emergence sown by the triple disc drill (seedlings/250 mm row).

| | Consolidation | Coulter row: Front | Coulter row: Back |
|---|---|---|---|
| Clover | Light | 2.0 c* | 9.0 b |
| | Heavy | 8.0 b | 13.3 a |
| Grass | Light | 13.0 a | 14.0 a |
| | Heavy | 13.3 a | 14.3 a |

* Values followed by a different letter are significantly different at P = 0.05.

**Table 4** The interaction of sowing method and level of seed bed consolidation on white clover performance a year after sowing.

| Sowing method | Consolidation: Light | Consolidation: Heavy |
|---|---|---|
| Growing point's/m$^2$ | | |
| Triple disc | 930 b* | 1420 ab |
| V-roller | 1165 b | 1675 a |
| Stolon dry weight (DW) (g/m$^2$) | | |
| Triple disc | 21.1 c | 32.4 a |
| V-roller | 23.8 c | 29.1 b |
| Clover % | | |
| Triple disc | 5.5 b | 14.4 a |
| V-roller | 6.2 ab | 14.0 a |

* Values followed by a different letter are significantly different at P = 0.05.

Comparing the seedling emergence from the front and back rows of coulters of the triple disc drill showed a clear difference in pattern between the lightly and heavily rolled areas (Table 3). Clover seedling density was higher under heavy rolling and from the back row of coulters, whereas grass seedling emergence was unaffected.

By the following autumn the amount of clover in the

**Table 5** A comparison between 1) all-year grazing and 2) taking a summer hay/baleage crop and during the establishment year on the subsequent performance of white clover in a new ryegrass/white clover pasture sown 9 March 2003.

| Date | Growing points/m² | | Stolon DW (g/m²) | | Herbage content (%) | |
|---|---|---|---|---|---|---|
| | Grazed | Hay | Grazed | Hay | Grazed | Hay |
| 18 December 2003 | 2100 | 1640 | 18 | 16 | 19 | 4 |
| 26 January 2004 | 3040 | 740 | 23 | 28 | 18 | 30 |
| 14 April 2004 | 2300 | 3120 | 41 | 72 | 19 | 33 |
| 22 June 2004 | 1910 | 4400 | 42 | 108 | 16 | 12 |
| 7 April 2005 | 3930 | 4440 | 47 | 72 | 19 | 23 |

pastures tended to be higher in the low grass sowing rate areas compared to the high (1310 cf 1010 growing points/m², 31 cf 22 g stolon/m² and 9.9 cf 7.8% of herbage composition respectively, significant at $P<0.1$). Clover growing point density and stolon mass was 40-50% higher in the heavy rolled areas, which resulted in twice the level of clover in the herbage composition of the pasture (Table 4).

### B. Establishment management

Seedling emergence 6 weeks after sowing was low but with the higher sowing rate of 5 kg/ha, white clover seedling density was adequate (165/m², 30% emergence; ryegrass 365/m², 50% emergence). A high density of thistles (75/m²) required controlling with Tropotox.

The performance of the clover over the following two years is summarised in Table 5. During the growth of the hay crop (January 2004), clover growing point density fell while clover herbage content increased and remained high through the following autumn while growing point density recovered and stolon mass increased. The net result was the development of a stronger clover base at the end of the establishment year by taking a hay crop in summer compared to rotational grazing throughout. There was less advantage to taking a further hay crop in the second summer as the difference between the two treatments was narrower, but still in favour of the hay making option.

## Discussion

Because of slow seedling growth, low winter activity and the constraints of having to progress through several growth stages, white clover plants take a full year to establish. Where modern high production farming systems 'demand' new pastures are back into full production within 3-6 months, the chances of white clover establishing successfully are reduced. This is made even more difficult if conditions for initial emergence are not maximised.

### Pasture sowing

The trials on the dairy farm sought to compare the more traditional sowing techniques epitomised by the roller drill with the newer direct drilling technology now in widespread use, but even here there has been change. The old technology was based on firm consolidation of the soil using the Cambridge roller which has a rounded profile that crushes and compacts the soil to form a firm seedbed. Using the Cambridge roller drill, the seed was then broadcast into the shallow indentations and covered by a light chain harrow. A problem encountered was that most roller drills are now equipped with a deep V profile roller, which tends to cut deeper rather than consolidate. These drills were developed for use in the light pumice soils of the Central Plateau where the white clover seed had to be placed deeper to find adequate moisture for germination. In the heavier loamy soil more typical of most agricultural soils in New Zealand, the net result of using these drills is that unless the soil is very well consolidated before sowing, the seed ends up being placed too deep for high emergence. Hence the 25% increased emergence (Table 2) shown by using the V-roller drill on the heavily consolidated treatment, where even the grass emergence benefited.

For the triple disc drill, the effect of heavy rolling before drilling was not so much in improved emergence, but rather in the quality of the drilling. The observation made by the contractor was the increased control and ease of drilling accuracy in the firmer soil. Soil drag by the rear set of coulters was reduced in the firmer soil with better distribution of the emerging seed, particularly the white clover (Table 3). Keeping drill speed to approximately 8 kph appeared optimal.

### Management

In both the dairy farm and the hill farm, grazing management was organised to favour the clover in the best manner possible within each enterprise. Over winter, pastures were mob-stocked with either young heifers or hoggets respectively as required, then rotationally grazed with milking cows or ewes and lambs through the remainder of the season. No fertiliser N was applied on the dairy farm but was used three times during the year on the sheep farm.

Taking a hay crop during the establishment year of pastures is not a recommended farm practice, but on the

**Table 6** Total soil C and N content of the trial sites on the Shannon dairy farm and the Mauriceville sheep/beef farm.

| | Dairy | Sheep/beef |
|---|---|---|
| Soil C (%) | 5.0-6.4 | 5.5 |
| Total soil N (%) | 0.47 - 0.61 | 0.45 |
| Soil C:N ratio | 10.2 - 10.9 | 12.2 |

hill farm it proved to be beneficial overall. Initially white clover appeared to be adversely affected as the high competition from the grass reduced growing point density (Table 5), but as can happen in such long-spelled situations, available soil N can run out and the clover, albeit sparse, came through with very large leaves to dominate. Once the hay crop was removed, the clover was able to capitalise on the low grass density/low N status soil and rapidly colonise the open spaces. The grazed pasture, while doing well, was nevertheless under more pressure from the higher density of grass encouraged by the sheep grazing. A further hay crop in the second year was less beneficial as the grazed area had developed sufficiently to catch up.

Comparing the two farms, it was clear that despite the hill farm having lower seedling emergence to start with (165/m$^2$ cf 250-375/m$^2$ for dairy), at the end of the establishment year it had more than twice the content of clover (19 and 33% cf 14% for dairy). The most likely explanation is their relative position in the soil fertility development. Both farms had similar soil carbon (C) levels, but considerably more total soil N in the dairy farm (Table 6). The resulting C:N ratios, a measure of soil development and nutrient cycling capacity, were quite different. The lower value for the dairy farm (10.5) indicates a more developed soil with greater N cycling which favours grass growth and hence would be more competitive with white clover reflected in the lower clover content (14%) despite no fertiliser N being added. In the hill farm, the higher C:N ratio (12.2) indicates a less developed soil with lower capacity for N cycling with a greater need for N fixation inputs to maintain productivity and continue soil development, thereby allowing greater clover development (19-33%) despite the 100 kg N/ha applied over the year.

## Where does clover fit?

The comparison above raises the question of how does clover fit within modern high producing farms. It comes down to deciding what the clover is needed for, followed then by the farmers will to provide the right conditions. Clover has two major attributes of importance to the pasture ecosystem, N fixation and high quality herbage.

By virtue of its ability to fix atmospheric N for growth when required, white clover underpins the plant/soil complex building and maintaining soil fertility (N). There are however, biological constraints to how much N can be fixed (Brock 2001). Clover prefers to use soil N and if there is sufficient soil N available to supply its growth demands the need for N fixation is removed, and in reality, there is no biological role for clover in the ecosystem. In most of our high producing farmlands, with well developed soils and low C:N ratios, the first role of N fixation is greatly reduced, more so where fertiliser N is used. This is more prevalent in the dairy situation, being basically a grass production environment and the management systems of lax grazing off a high residual base (1200–1500 kg DM/ha) developed to maximise the grass, is not conducive to clover which will struggle from lack of light and decline to low levels in the pasture. Then there is the question of stocking rate. Higher productivity, particularly in dairy farming, is currently attained through higher stocking rate, with higher treading pressure. Pasture density is lower, reducing the strength of the 'turf' leading to significant damage to topsoil structure in wet weather, all of which is detrimental to white clover, which is known to have lower resistance to treading and 'pugging' (Edmond 1964).

If the reason for wanting more clover in the pastures is for the second attribute of high feed quality, it then becomes a question of management, providing the right conditions for the clover to thrive i.e. management as was practised before fertiliser N became so widely used. Simply put, clover needs light. For clover to succeed, grazing pressure must lower the base and let in the light i.e. perhaps to residuals of 800-1000 kg DM/ha. Even with fertiliser N, clover can be grown with the correct grazing management (Barr 1996). A corollary to such management is increased pasture density and perhaps better 'turf' bearing strength and less treading damage. A Dairy Exporter report (Anon 1991) of a Dairy Research Corporation milk production trial at Ruakura, showed fast 5-day rotations by dairy cows over spring and summer not only increased milk production from August to December, but also 'produced pastures with more clover, and greater tiller density than … 30-day rotational grazing' and was 'becoming more pronounced as the trial progresses'. Who knows, there may be a strong case for set stocking in dairying?

But whatever strategy is used, the chances of realistically growing enough clover in mixed pastures to really capitalise on the quality of white clover to satisfy the diet preferences of the grazing animal for maximum productivity (60-70% clover; Parsons *et al.*1994) are virtually nil. If however, the value of clover is critical to farming, then we need to continue improving our management skills and find better ways of using it.

## ACKNOWLEDGEMENTS

The authors extend their thanks and appreciation to the members of the 'Clover Up' farmer group for supporting this project, AgResearch for support facilities, the MAF Sustainable Farming Fund, the New Zealand Dairy Board Global Programme, and Agricom (New Zealand) Ltd for financial support.

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