Initial trials of a crimper roller in New Zealand. March 2007. Charles Merfield

This is a copy of a final report to the Sustainable Farming Fund (SFF) of the New Zealand Ministry of Agriculture and Forestry.

1. Summary

A helical blade crimper roller was tested for its ability to kill five overwintered green manures: oats and peas; ryecorn; ryecorn and tares; tares; and tick beans in Canterbury, New Zealand. Only tick beans and ryecorn were effectively killed, with vetch having strong regrowth. Ryecorn, tares and ryecorn and tares mixture had the greatest weed suppressing effect. However, based on the proportion of clover to grass growth it appears that ryecorn is locking up considerable amounts of soil nitrogen making it unsuitable for use on its own or without use of banded fertilizers. A mix of ryecorn with tick beans may have the better weed suppression effect of the ryecorn with the nitrogen fixation of the tick beans, both of which are effectively killed by the crimper roller. Grass and clover that germinate with the green manures in the autumn are not effectively suppressed. The long mulch left by most of the green manures was too thick to drill into, post crimping. An alternative may be to drill into the standing green manure using advanced no tillage drills, e.g., inverted T slots using a winged disk opener. More research is required, ideally in a long term trial, to compare winter fallow with winter green manures that are either mulched or crimped. Identifying an optimal ratio of tick beans to ryecorn or similar cereal and the earliest date that the plants can be effectively killed is also required along with determining successful drilling approaches.

2. Introduction

The crimper roller project (previously referred to as a crusher roller) had five key aims:

1. Creating and field testing a new design of crimper roller
2. Trialling five cover crops to see how they respond to rolling at different maturities under Canterbury climatic conditions;
3. Measure the effects of the crimped cover crops on a following crop;
4. Assess weed dry matter;
5. Evaluate the efficiency of the operations in terms of cover green manure regrowth.

Communication failures lead to the crimper being built to the helical North American design (Figure 1) rather than the stepped helical design as described in the proposal. The American design has been both effective and easy to use, however, it meant that the alternative design has not been evaluated. Since this work was undertaken a reference to the stepped helical design has been found which notes that it is an improvement over the single straight blade design (Baker *et al.*, 2007).

The following green manures were planted on 9 may 2006:

- Oats 80 kg ha^{-1} (*Avena sativa*) and maple peas 180 kg ha^{-1} (*Pisum sativum*);
- Ryecorn 120 kg ha^{-1} (*Secale cereale*);
- Ryecorn 100 kg ha^{-1} and maple peas 60 kg ha^{-1} ;
- Ryecorn 100 kg ha^{-1} and tares 25 kg ha^{-1} (common vetch *Vicia sativa*);
- Oats 80 kg ha^{-1} and tares 25 kg ha^{-1};
- Tick beans 300 kg ha^{-1} (*Vicia faba*).

With a null control (bare earth). Unfortunately the contractor (Crop & Food) did not drill the trial correctly with a few beds not receiving a mixture. Further, the mixtures with Ryecorn or tares came to be dominated by these species. This resulted in the following green manures being available for treatment

- Oats and peas

- Ryecorn
- Ryecorn and tares
- Tares
- Tick beans

With a null (bare, cultivated earth) control. With the changes the numbers of replicates were unbalanced making statistical analysis by ANOVA problematic so the standard error of the means (SEM) are presented instead. As the differences are biologically clear this is considered sufficient.

Figure 1. North American helical crimper roller design as built for this trial.

There were delays building the crimper roller so the treatment dates were amended to the 11 December (early) and 9 January (late). This was later than desired because the green manures were well into flowering and even seed set rather than being rolled before during and after flowering. The delay also resulted in it being too late to plant a crop, especially with the wet and cold summer weather Canterbury experienced in 2006. This was further compounded by not being able to locate a seed drill that could cope with the very large levels of matted green manure mulch. Also there was considerable clover and grass growth through some plots which would of out competed a drilled crop. It appeared that the grass and clover germinated at the time of planting but was suppressed by the growing green manure but once the green manures were killed the grass and clover grew though the mulch. Spring germinating weeds were effectively suppressed except by the oat and pea mixture.

3. Results

Despite these setbacks a range of useful results have been achieved. The suitability of the different green manures was very clear. Ryecorn and tick beans were very easy to completely kill at both treatment dates. Tares was impossible to kill, with it regrowing very strongly after treatment. Oats and peas showed some limited regrowth. In terms of weed suppression both ryecorn and tares produced good weed suppression, especially in combination, however, for tares this was in part due to its continued growth. The oats and pea mixture and tick beans were less effective at suppressing weeds which is reflected in Figure 2 which shows the weed dry matter sampled on the 3 February, 54 days after the early crimp and 25 days after the late crimp.

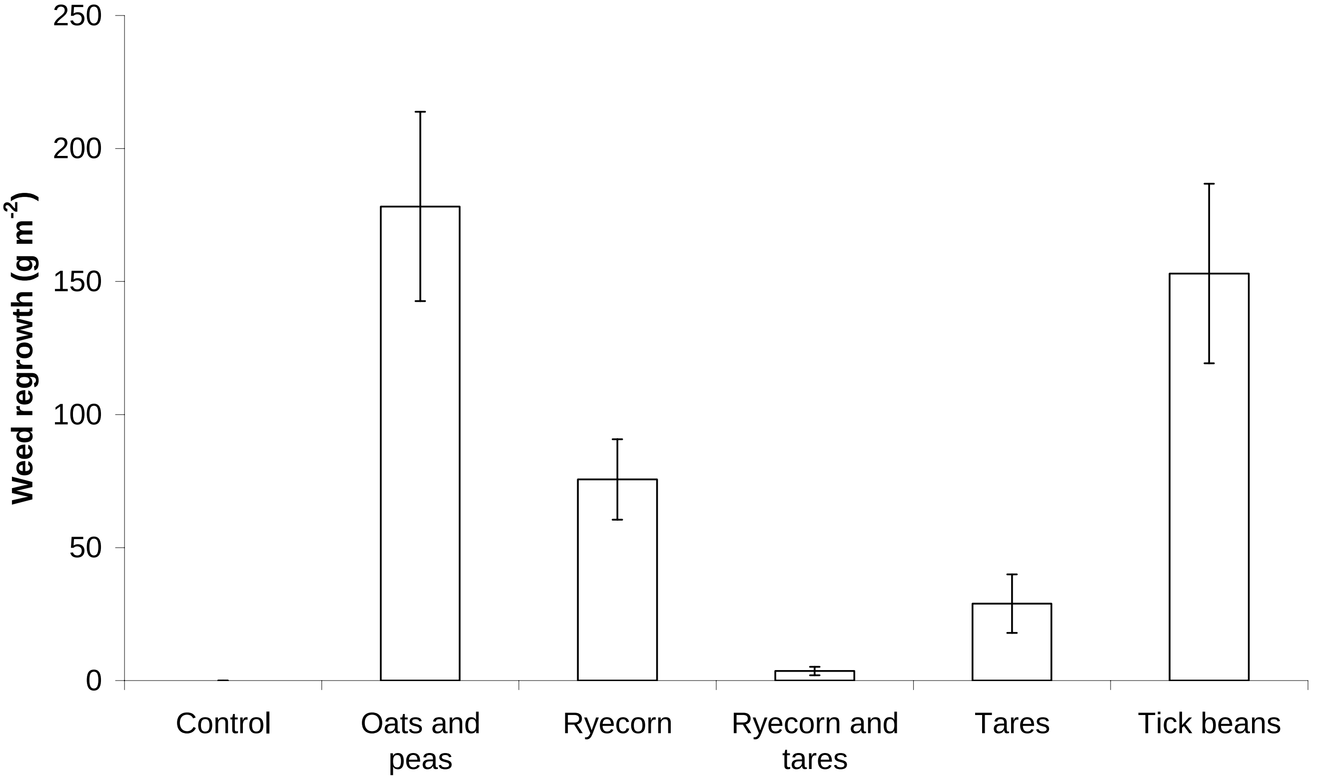

Figure 2. Weed regrowth (dry matter g m^{-2}) in five different green manure treatments and a null control after roller crimping (error bars are 2 SEM).

The poorer weed suppression of the oats, peas and tick beans is attributed in part to the lower bulk of the species, especially the oat and pea mixture which did not even manage to cover the ground. Figures 3-7 show the five green manures both standing and after crimping. The combination of being effectively killed by the crimper roller without regrowth and with good weed suppression means that only ryecorn and tick beans are considered suitable for use with the crimper roller.

There was also a clear difference between the early and late treatment times with mean weed dry matter being 112 g m^{-2} for early and 37 g m^{-2} for late with SEM 20.1 and 8.1 respectively, reflecting the 29 extra days of weed growth between the two treatment times.


Figure 3. Oats and peas


Figure 4. Ryecorn


Figure 5. Ryecorn and tares.

Figure 6. Tares.

Figure 7. Tick beans.

There were also considerable differences in the proportion of grass and clover regrowth between green manures (assessed visually) (Figure 8). Regrowth through the ryecorn was dominated by clover, while the other green manures had a more balanced proportion of grass to clover but with a trend for a higher proportion of grass in the tares and tares mixtures. It is widely known that the availability of nitrogen influences the ratio of grass and clover in pastures with the proportion of clover decreasing with increasing nitrogen due to the grass becoming more competitive. At low nitrogen levels clover dominates due to its ability to fix nitrogen and therefore gain a competitive advantage over the grasses. Based in this it would appear that the ryecorn has taken up a considerable amount of nitrogen from the soil over winter which has resulted mostly clover growing through it. This is a potentially serious issue for a following crop as the green manures are not being chopped and incorporated into the soil to allow them to return the nutrients they have taken up, back to the soil and the following crop. The aim of using the crimper roller is to leave the green manure on the soil surface to act as a mulch to prevent weed growth, conserve moisture and protect the soil surface. This means that the nutrients it has taken up during growth will be returned much more slowly to the soil with most not being available to the following crop, or at best later crop growth stages. In the case of ryecorn it is likely that low soil nitrogen could be a significant limiting growth factor for a following crop.

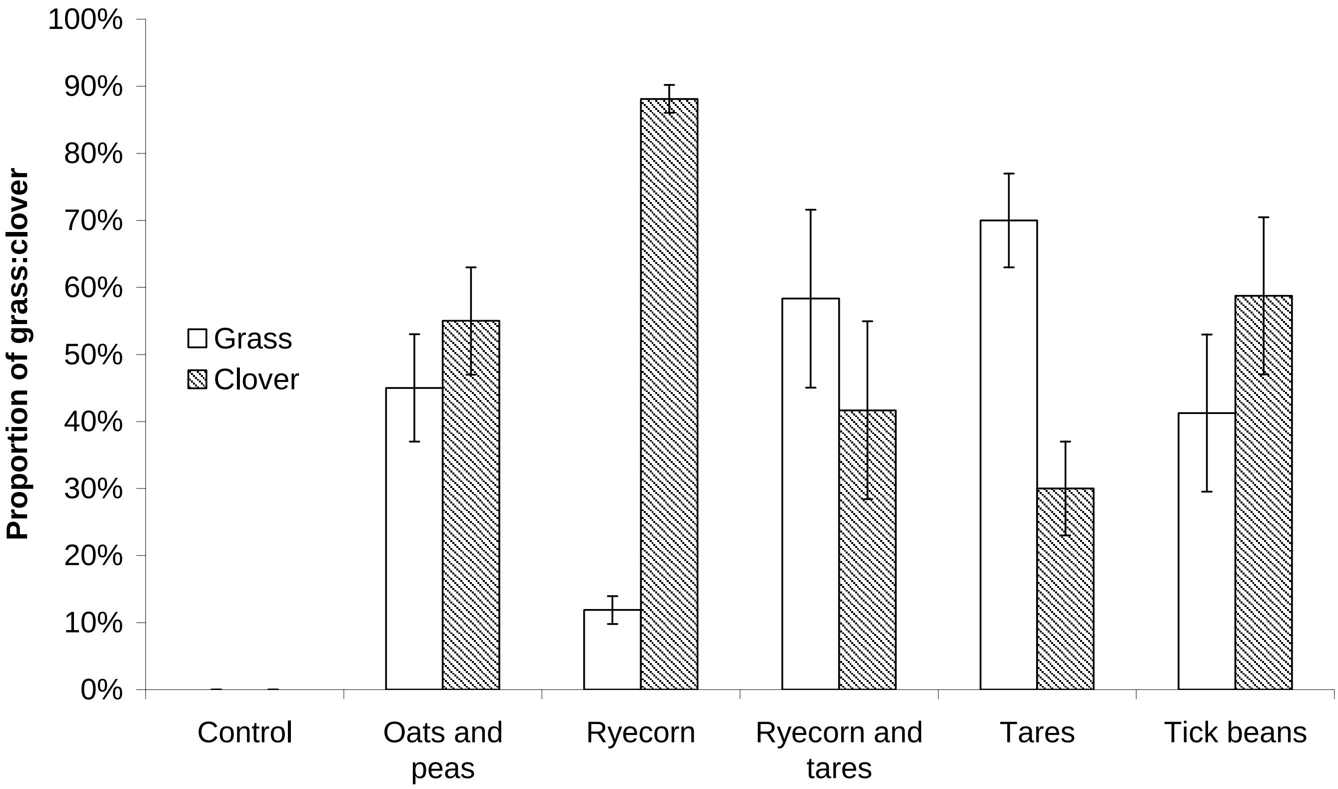

Figure 8. Proportion of grass:clover assessed visually after five different green manures and a null control of bare earth (error bars are 2 SEM)

Further information that has been discovered after the completion of this work indicates that the only drill design that is able to cope with the volume and length of the mulch is the winged disk version of the inverted T cross slot drill (Baker & Saxton, 2007). Even this may have difficulty with very long straw such as ryecorn. An alternative approach may be to drill into the standing crop using a disk cross slot drill and then crimp the green manures afterwards.

It is also clear from Baker & Saxton (2007) that nutrient access is a know issue with no-tillage approaches such as roller crimping and that banding of fertilizers, especially nitrogen, at sowing is required to ensure the competitiveness of the crop in its early stages. This may be an issue in organics where use of concentrated / soluble forms of fertilizers are restricted. However, in the longer term continued used of no-till methods such as roller crimping has been show to dramatically improve soil health especially soil carbon (Baker & Saxton, 2007).

4. Conclusion

Based on the ability to completely die after crimping and weed suppressing ability only ryecorn and tick beans are considered suitable for use with a crimper roller. However, ryecorn appears to lock up large amounts of nitrogen which could significantly reduce yields in the following crop and tick beans have a lower ability to suppress weeds. A combination of ryecorn and tick beans may therefore be more promising, to gain the better weed suppression of the ryecorn with the nitrogen fixing ability of the tick beans. Further trials are clearly necessary to determine what the earliest dates are that such a mixture could be effectively killed by a crimping treatment and comparison with mulched green manures and standard cultivation. It may also be worthwhile to test other cereals with similar growth habits to ryecorn e.g., triticale (× *Triticosecale rimpaui*), for their susceptibility to crimping and early flowering date. In addition, in South America, Black Oat (*Avena strigosa*) and other species of tares (Vicia genus) are effectively killed so further investigations of these genera may be valuable.

There is an important methodological issues associated with overwinter green manure and no-till trials. Where there are high levels of soil nutrients, particularly nitrogen, at the start of the trial the cultivated plots often perform better due to higher availability of nutrients, even taking overwintered leaching into consideration. As a key aim of overwintered green manures is to lock up, or ideally, fix nitrogen over winter to prevent leaching. Therefore trials need to be conducted on ground that is low in nutrients, e.g., after several years continuous exploitative cropping, or that detailed measurement of nitrogen lockup, leaching and fixation are made. Further, the use of overwintered green manures is a strategy to improve soil health in the longer term. Single year trials are therefore clearly incapable of measuring such long term effects. A multi year or better long term trial needs to be conducted to compare the effect of overwintered fallow with overwinter green manures. This has clearly been demonstrated in other no-till research (Baker & Saxton, 2007).

It is also clear that plants, such as grass and clover, that germinate with the green manure in the autumn are not going to be suppressed by overwintered green manures. This can be viewed as a self sown undersown pasture. It is likely that soils with significant amounts of grass or clover seed that will germinate in autumn will not be suitable for used with overwintered green manures where there is no spring time cultivation. However, as the green manures will be of greater benefit further into the exploitative cropping stage of a rotation where the amount of viable clover and particularly grass seed would be expected to be considerably lower this may be less of an issue. In this trial where no following crop was planted there was no competition for the autumn germinated grass and clover, however, if a competitive crop, e.g., squash, was planted then grass and clover growth may also be less of an issue.

Additional work has been carried out using summer plantings of buckwheat (*Fagopyrum esculentum* Moench) and tick beans both of which were crimped in the autumn achieving a good kill. This may be a useful technique for planting autumn sown crops without tillage and also shows that buckwheat can be killed using this technique.

There is also an apparent lack of understanding in the English speaking world of why roller crimping is able to kill plants while mowing results in regrowth. There is a clear need for laboratory based research to determine the number and pressure of crimps required to kill a range of species. This information could then be extrapolated to indicate the best design, in terms of vanes and weight for a particular crop which may lead to more optimal machine design. It is also increasingly clear that most species need to be approximately halfway though anthesis (flowering) for the technique to be effective so this area probably requires limited further research for field use, although the biological reasons for this should be elucidated.

There are also anecdotal claims that the single, stepped and helical designs differ in their effectiveness, that the appropriate angle for the blades is disputed and that faster speeds increase the crimping effect. These should also be the focus of further research.

References

Baker, C. J., Ribeiro, F. & Saxton, K. E. (2007). Residue Handling. In C. J. Baker & K. E. Saxton (Eds.), *No-tillage Seeding in Conservation Agriculture, 2nd Edition* (pp. 134-158). Wallingford, UK: Food and Agriculture Organization of the United Nations.

Baker, C. J. & Saxton, K. E. (Eds.). (2007). *No-tillage Seeding in Conservation Agriculture, 2nd Edition*. Wallingford, UK: Food and Agriculture Organization of the United Nations.