Lane, P.M.S., 2022. Preventing soil loss from hill country cropping, comparing Helicropping to crops established by cultivation. In: *Adaptive Strategies for future farming*. (Eds.C.L. Christensen, D.J. Horne and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 34. Farmed Landscapes Research Centre, Massey University, Palmerston North, New Zealand. 12 pages.

PREVENTING SOIL LOSS FROM HILL COUNTRY CROPPING, COMPARING HELICROPPING TO CROPS ESTABLISHED BY CULTIVATION.

P.M.S. Lane

Ballance Agri-Nutrients, 58a Butcher Road, RD 4, Hamilton.

Contact: Murray.lane@ballance.co.nz

Abstract

When soil is lost from the farm due to inappropriate soil, crop and stock management, we all lose.

Cultivation disturbs soil structure, leaving it less able to support an animal's weight and more likely to be lost by overland flow with heavy rain. No-tillage crop establishment and Helicropping (aerial no-tillage) leaves the soil structure unaffected.

Results from the MPI Sustainable farming fund project: Helicropping - Saving our soils, will be discussed showing that there are numerous tools that can be introduced to reduce soil loss with winter cropping.

Options include leaving the soil structure undisturbed with Helicropping, sowing plantain as a companion species with swedes, establishing cover crops with surface sown bird repellent treated seed soon after grazing and multi-day block grazing compared to the more intensive strip grazing.

Almost no soil was lost on a 20 degree Helicropped slope, when compared to a 10 degree cultivated slope. In the Helicropped treatment areas soil structure had been left undisturbed, the swede crop was grazed not by concentrating hooves behind a hot wire, but by dispersing hooves with multiday block grazing and a grass cover crop established following grazing.

Introduction

The most important asset on a farm is its topsoil, not only to the farmer but also to the community, who are an affected party due to muddied streams and flooding as a result of mismanagement.

To over winter sufficient animals to control the expected spring flush requires good winter forage crops such as swede, kale or fodder beet. These crops are generally rationed with electric break fencing, resulting in hoof concentration and soil damage. The extent of soil damage depends on soil type, slope, rainfall, crop establishment technique and animal class.

The goal of the Sustainable Farming Fund (SFF) project "Helicropping – Protecting our soils" was to find solutions to the loss of soil that occurs when these forage crops are grazed in winter conditions.

Options included changing the way the crops are established by leaving the soil undisturbed (e.g. Helicropping, no-tillage), changing how they are grazed so that hoof pressure is dispersed not concentrated and protecting the soil after grazing by establishing "cover crops".

Brendon Malcolm and his team from Plant and Food Research Christchurch, have carried out trials to identify the value of cover/catch crops at preventing nitrogen loss from topsoil following grazing (Malcolm *et al*., 2018). Their very specialized trials required machinery to sow specific seed rates of various selected cover crop species in winter conditions. Their work was invaluable to identify the role of cover crops in nitrogen retention.

This project accepts that successfully established cover crops will recover nitrogen relative to the amount of dry matter grown. The primary goal was to identify a means of establishing a cover crop regardless of terrain and season and to assess its ability to prevent soil loss.

Three primary programs of work were conducted:

1. How to successfully establish a cover crop with surface sown seed in the middle of winter, following forage crop grazing. What species, what seed rate, was fertiliser required?
2. Can a post grazing cover crop of plantain *(Plantago lanceolata)* be established as a companion planted species with a forage crop such as swedes.
3. Monitoring effects of establishment technique, cover crops and buffer strips on soil loss.

Along with the large scale paddock seeding trials, bird feeding studies were conducted with dry seed in trays to evaluate bird preference to the various seeds and seed treatments being evaluated.

The trials were carried out over four winters (2018-2021). In the central North Island (CNI) for the first two seasons, then covering both the CNI and the Southland areas for the latter two winters.

Methods

Cover crop establishment post grazing.

In June 2018 using Helicopters large scale (0.5 ha) plots were confidently laid down immediately following grazing of swede crops on variable terrain hillsides in the CNI. Numerous species were evaluated in this first year, with annual ryegrass (Lolium multiflorum) both bare and Superstrike™, oats *(Avena sativa)*, plantain *(Plantago lanceolata)* and mustard seed *(Brassica spp)*, at a range of rates, applied immediately post-grazing of swedes *(Brassica napus)*. Winter conditions existed with good frosts and wet soil. Seedling establishment counts were conducted in August/September and in late October, assessments of vegetation cover were carried out. Early results indicated bare annual ryegrass as a possible solution, but required 50 kg seed/ha, twice the standard seed rate. Bird feeding was suspected as empty oat husks were apparent all over the oat treatment.

Results from these treatments led to a modified program in winter 2019, where a blue/green colouring agent was used to deter birds (Mastrota & Mench 1994). Using a diploid Italian ryegrass *(Lolium multiflorum)* from PGGWrightson Seeds, bare seed was compared to the blue/green Superstrike treatment, and the blue/green Prillcote^{TM} treatment. (Prillcote is a lime coating that doubles the seed weight improving ballistics). It was thought that the colour would be enough to get the seed through. It should be noted that both the Prillcote and the Superstrike treatments contain a fungicide to protect seedlings from pithium and fusarium damping off diseases. Also Superstrike contains an insecticide for control of Argentine stem weevil *(Listronotus bonariensis)* and African black beetle (*Heteronychus arator)*.

Some treatments were applied over the established swede crop with the first rains in autumn (4th April 2019), about 8 weeks prior to grazing. The same treatments were applied after swede grazing in another area to well defined, one hectare plots of relatively flat land, on July 21st. Oats and an annual ryegrass were additional treatments. All ryegrass treatments were applied at 25 kg seed/ha. The oat seeding rate was 80 kg seed/ha. Again plant seedling counts were carried out approximately 6-7 weeks after sowing.

In October 2019, information came to hand that the Department of Conservation had moved from carrot baits for 1080 poison drops to control introduced feral animals, to using pellets made from compressed cereal grain. To protect native birds from the bait, they were using a bird repellent called anthraquinone (Clapperton *et al*., 2013) marketed in New Zealand as Avipel.

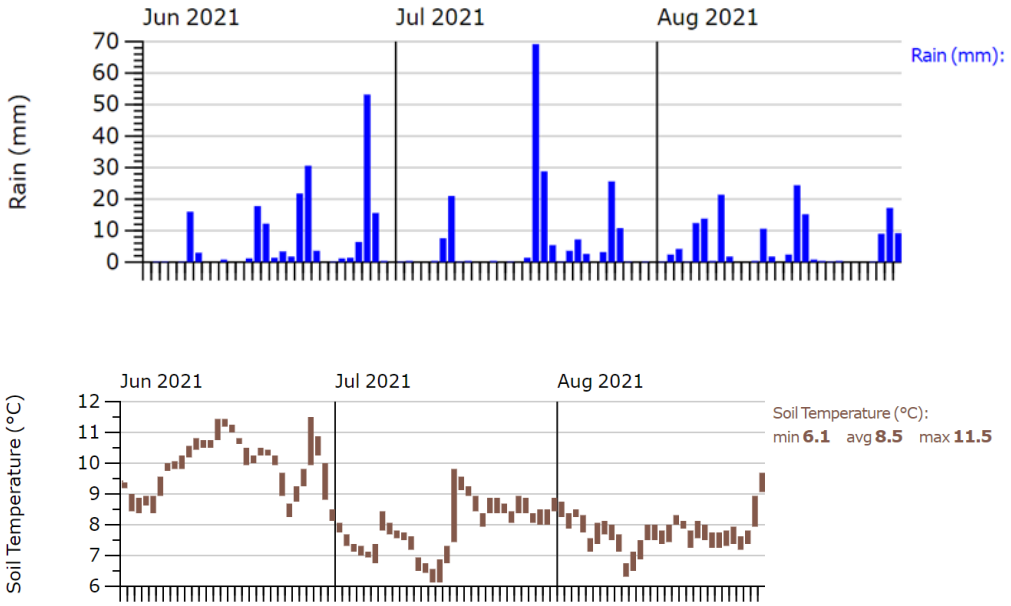
The 2020 winter treatments were subsequently designed around the Avipel bird repellent seed treatment. Large plots of various size depending on paddock topography, but largely 15-20 m wide and 40-60m long comparing an annual tetraploid ryegrass (Winter Star) as either bare seed, Prillcote seed or Avipel treated seed, all at 25 kg seed/ha. Fifteen trials were carried out in the CNI, five in the Southland region. Seed applications were made using chest mounted seed spreaders, capable of carrying up to 5 kg seed, with a spread width of 3-5m depending on seed/wind etc. Seed flow rate was restricted to ensure each plot had to be covered 3-4 times to ensure even seed spread. Soil conditions were typical of most post swede grazing, with very cold temperatures and dry mud. Areas of wet mud were avoided, we were evaluating the bird repellency of the seed treatment. Any seed buried in mud, was no longer in a bird repellency trial. Again seedling germination counts were carried out at 6-7 weeks post sowing. Observations were made, but no dry matter cuts were taken in October. However it was clear that Avipel provided a solution, with upwards of 180 seedlings/m^2 in Avipel treated plots. Bare seed failed and Prillcote seed resulted in around 80-100 seedlings/m^2.

In the final year (June/July 2021) another series of 16 trials were conducted, half in the CNI and half in the Southland region. This time both bare and Avipel treated seed lines of oats, ryecorn *(Secale cereale)* and Winter Star annual ryegrass were compared in now standardised 15m x 30m plots. Oat and ryecorn were sown at 80 kg/ha, with Winter Star at 25 kg/ha. A combination treatment of only Avipel treated seed was sown with oats at 40kg/ha + ryecorn at 35 kg/ha + Winter Star at 15 kg/ha. The CNI trials were laid over a three week period from 22nd June to 9th July in one paddock as the farmer progressively grazed the swede crop. As all treatments were in one paddock, bird predation pressure was assumed to be the same. Conditions were cold and moist, with snow falling during one application. Rainfall was not

limiting during the germination period, and soil temperatures at 100 mm depth varied over the July/August germination/establishment period from 6-8 ºC. (TABLE 1). Seeding counts were made at 6-7 weeks after sowing, varying slightly to accommodate the varying species effect. No dry matter production data was collected due to Covid-19 lockdown issues, however the farmer captured photographs of each plot and produced an eye assessment which largely reflected expected results.

Similarly in the Southland area, the 8 trials produced seedling establishment counts and only circumspect dry matter data.

TABLE 1: Climatic conditions from sowing to seedling counts (at 6-7 weeks)



An aerial demonstration was established in each region.

One trial in the CNI included evaluating the effect of applying 200 kg diammonium phosphate (DAP) fertilizer (N: 180 gm/kg, P: 200 gm/kg) in strips across the mid-winter sown seed, on the day of sowing. No visual evidence of benefit was observed.

Establishing cover crops through companion planting.

Farmers have led the way by demonstrating that Agritonic plantain, sown as a companion species with either brassica rape *(Brassica rapa)* or swedes *(Brassica napus)*, can with appropriate grazing survive to become a plantain cover crop.

However the industry was divided as to the benefit, with speculation that the plantain would limit the swede yield and not survive the grazing. We carried out several small plot trials to try to understand this.

The primary focus was identifying if the plantain would survive winter grazing when sown with brassica crops, and what was the impact on swede yield from various sowing rates.

Numerous small plot helicropping simulation trials have been conducted to identify the effect of fertiliser on seedling establishment. The same system was used to evaluate plantain companion planting. No soil was cultivated. The old pasture vegetation was simply sprayed out with glyphosate when at 1800 kg Dry Matter/ha. Springtails (*Bourletiella hortensis)* were controlled with diazinon mixed with the glyphosate. Then seed, slug-bait (15 kg/ha Slugout) and fertiliser (400 kg/ha DAP + Boron) surface broadcast per plot, with 6 or 8 treatment replications in late October/early November 2019 and 2020.

Monitoring of large scale on farm crops was carried out with five 6 m^2 areas of the commercial Helicropped swedes that had been sown with 2.0 kg plantain seed/ha as a companion species. Plant counts and dry matter yields were collected. Results of the 2020 small plot trial are presented in TABLE 4.

Buffer strip - soil loss monitoring and establishment.

Seeking to identify how much soil is lost and how wide a grass buffer strip should be to arrest this loss, 4.0 litre liver pails were set up to capture overland flow after being filtered through various widths of grass buffer strip. The pails were staggered across a consistent face of grass buffer, placed at various distances up to 7m from the uphill grazing front. Animals were excluded by electric fence.

Two crops were evaluated, one established using cultivation, the other using Helicropping, on different farms on the CNI pumice soil near Tihoi during the winter of 2021. The cultivated site was strip grazed by cows and had a slope of 10 degrees. The Helicropped site with a slope of 20 degrees, was multi-day block grazed by cows.

The pails were established just prior to crop grazing. The pails monitoring the cultivated crop were assessed twice due to the amount of soil captured. Those monitoring the helicropping site just the once. Results are presented in TABLE 5.

Results and Discussion

Cover crop establishment

In the first winter trials (sown June/July 2018) the only successful treatment was annual ryegrass at the expensive, high seeding rate of 50 kg bare seed/ha. (PHOTO 1). Empty oat husks were evident in the oat treatment (sown at 80 kg/ha) and less than suitable number of seedlings established. Plantain (5.0 kg/ha) and mustard (10.0 kg/ha) seed grew but at the seeding rates evaluated not enough plants established to give adequate ground cover. Higher seeding rates were judged to be too expensive, and the species were dropped from the mid-winter trials.

Pre-harvest sowing: Good ryegrass establishment was achieved from the early April 2019 sowing over a mature swede crop in the CNI. The (non-bird repellent) seeds were shielded

from bird feeding by the crop leaves. There was also evidence of enhanced survival under dead annual weed canopy.

However, none of the seedlings survived the grazing process, and this in free draining pumice soil. It was an interesting idea the results of which could have been predicted, but until it was done there was no clear evidence. No further work was done with pre-harvest sowing of cover crops.

Post grazing sowing of cover crops:

In the first two years of the project, unless using very high seeding rates, surface broadcasting seed into cold, wet winter conditions after grazing swedes, yielded unacceptable results.

The addition of the blue/green colouring agent was similarly disappointing. There was no obvious variation in bird predation.

Prillcote treated seed looked promising, however soon after rain the lime coat fell off exposing the bare seed to birds. It was less than acceptable as a commercial bird repellent, with perhaps 50% of seeds establishing.

Avipel bird repellent gave the results expected. Small tray feeding studies showed birds rejected all Avipel treated seed (annual & perennial ryegrass, oats, ryecorn, triticale) when it was offered in a dry state. These evaluations also indicated that of the seeds on offer, untreated (bare) oat seed was the most preferred, and bare ryecorn was the least preferred.

The winter broadcast paddock scale trials in 2020 and 2021 demonstrated clearly that Avipel seed treatment on annual ryegrass and ryecorn was a likely solution to preventing bird predation of surface sown seed, in both the CNI and Southland, allowing up to 180 seedlings to establish per m^2 (TABLE 2 & 3). Note the improved establishment in the bare annual ryegrass and bare ryecorn in the Southland trials. This likely was due to either reduced bird feeding due to reduced local populations, or possibly buried seed in wet soil.

Avipel was not a solution for oats however. The treatment when applied to oats, is applied to the oat husk not the seed. When exposed to moisture the husk appears to soften sufficiently to allow birds to remove the seed from the husk without being affected by Avipel. Triticale, having no husk and good winter vigour, may be a replacement for oats. Triticale has been to establish in November sown trials, however this has not been proven in winter sown trials.

PHOTO 1: LHS no seed sown, RHS untreated annual ryegrass at the very high rate of 50 kg seed/ha. Sown July 2018; Photo October 2018.

TABLE 2: Seedling counts 6-7 weeks after June/July sowing – Tihoi

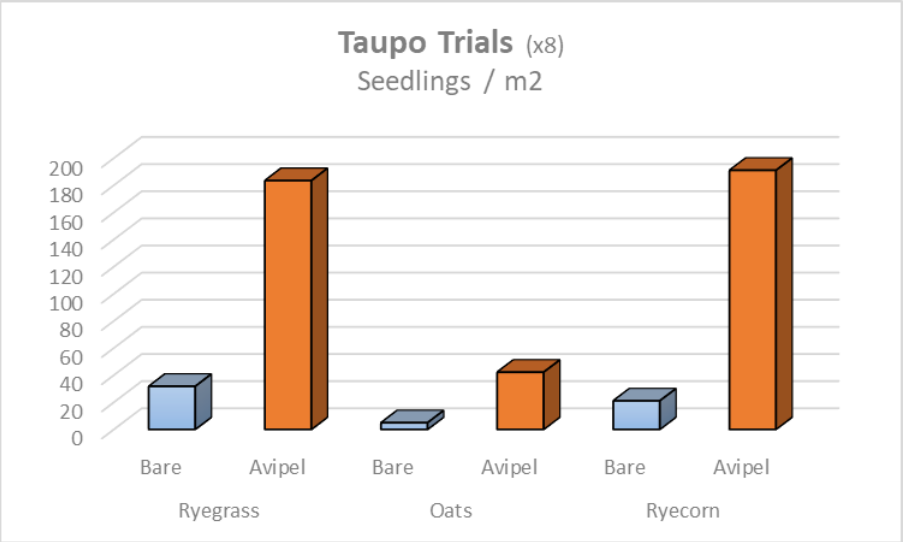
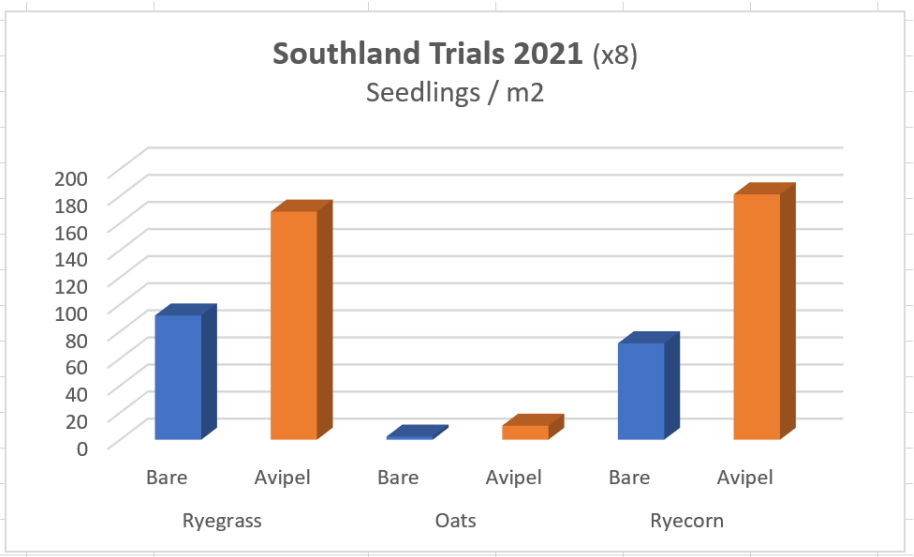


TABLE 3: Seedling counts 6-7 weeks after June/July sowing – Southland



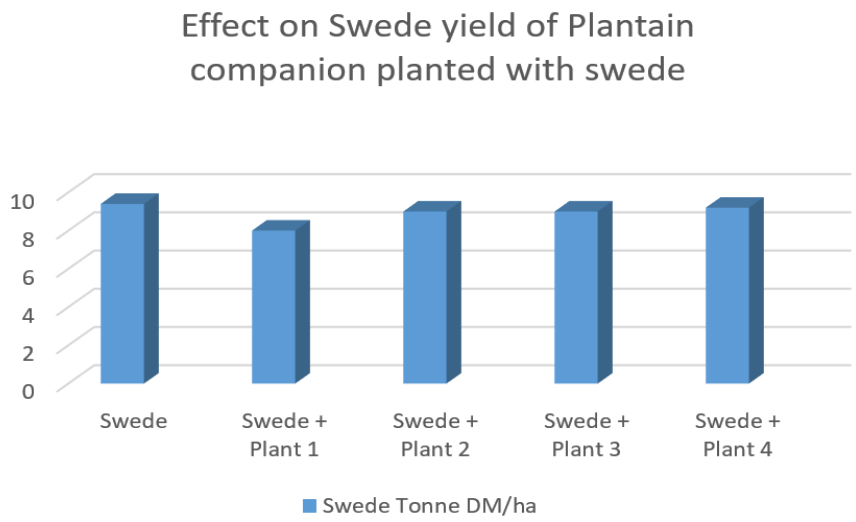
Companion cropping swedes with plantain

Plantain survived and grew well under farmer grown rape crops that had been grazed at least once in mid-summer. The plantain even flowered and set seed under the rape. Under swedes it survived, filling in gaps in the canopy, and similarly even flowered and set seed. However plantain did not survive under full season kale presumably due to lack of light. Kale can grow to more than two metres high.

Of the two small plot trials laid to evaluate plantain companion planting effect on swede crop yield, one was lost due to inappropriate herbicide use. The seedling plantain was killed off by clopyralid. In 2020 a second small plot trial showed clearly that at the recommended seeding

rate of 2.0 kg plantain seed/ha (4.0 kg prillcote plantain/ha) swede yield was not affected. (TABLE 4)

TABLE 4: Effect of various plantain companion crop seeding rates on swede crop yield.



With appropriate grazing management, farmers have shown that plantain sown as a companion crop with swedes, not only survived and set seed over the summer months, but also survived the grazing to form the basis of firstly a cover crop, and secondly (after set seeds germinate in September/October) a summer lamb finishing crop.

With poor grazing management, the plantain was destroyed. (PHOTO 2). As a companion species with swedes, plantain may become a useful indicator of grazing management to prevent soil damage.

PHOTO 2: LHS Plantain cover crop after good Helicropped swede grazing management. RHS Plantain lost due to pugging by cattle.

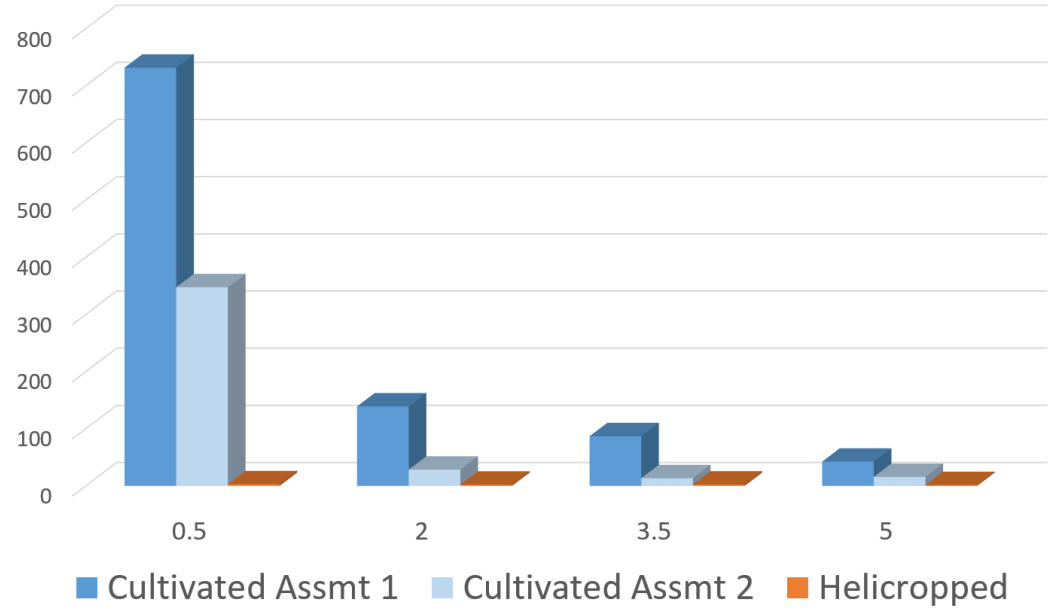
Buffer strip width and soil catchment

The two buffer strip trials presented here tell a compelling story.

Although a rather primitive and low cost means of evaluating soil loss from the two very differently managed sites, it clearly demonstrated that one system lost vastly more soil than the other. (TABLE 5)

The swede and kale crop grown in fully cultivated pumice soil, on a 10 degree slope, grazed by cows behind a daily shift electric fence lost many times as much soil than the steeper (20 degrees) Helicropped site. In the Helicropping site the soil was left undisturbed at crop establishment and the crop was harvested using the "multi-day block grazing" technique. Multi-day block grazing allows cows to settle down and move less, diluting hoof pressure instead of concentrating hoof pressure near the hot wire. Also a grass cover crop established soon after grazing.

TABLE 5: Width of grass buffer strip, slope and soil disturbance on soil capture/loss
Vertical axis is grams soil captured per pail; Horizontal axis is width of grass buffer in metres)



The soil captured in the pails show clearly that a grass buffer strip at around 5m wide is sufficient to arrest the majority of soil movement, depending on slope, rainfall intensity, previous soil manipulation, and stocking pressure. It would not stop the overland flow where water is concentrated into gullies.

Avipel treated ryecorn and triticale surface sown in strips within swede crops in early November, has been shown to establish and compete through the summer. This suggests that surface sown buffer strips can be sown as and where required on the day the swedes are sown. Another use for Avipel treated seed. Seed rate applied would likely be 70-80 kg ryecorn plus 20-30 kg triticale in the strip. The triticale grows erect making the strip easy to see, while the ryecorn grows rather prostrate, creating a very good buffer strip. It appears also that only 10-15% of the ryecorn flowered and set seed over the first summer. Assuming they survive the winter crop grazing, the non-flowering ryecorn tillers would likely flower in the second spring.

Conclusions

Soil loss from winter grazed forage crops is not just a function of slope, soil type and climate. The type and size of animal grazing, how the animals are controlled during grazing, location and width of buffer strips all play a part.

This project has highlighted a number of options to reduce soil loss with winter forage cropping. Whether the crop is established using cultivation or no-tillage/Helicropping techniques has a major effect. Leaving the soil undisturbed during no-tillage/Helicropping, with structure intact, water infiltration unaffected, soil life functioning as expected, results in vastly less soil loss during the cropping and harvesting process.

It has been shown that cover crops can be established with Avipel (bird repellent) treated seeds, surface sown following grazing of winter forage crops, in mid-winter, in both Southland and on the central North Island plateau.

Avipel (anthraquinone) has demonstrated sufficient protection from birds to allow mid-winter surface sown cover crop seeds to establish. Avipel is safe to birds, causing only mild digestive distress. Some crop seeds are more suited than others. Surface broadcast annual ryegrass and ryecorn were particularly successful. The oat treatment failed as the treatment is applied to the oat husk, not the seed..

No benefit was observed from the application of 200 kg/ha DAP with the seed. However, depending on cover crop plans, a case could be made for late season (post drainage) nitrogen application to enhance yield.

Sowing plantain as a companion species with swede is another opportunity for establishing a cover crop. Mature plantain under swedes survives the impact of sheep and well managed cattle when grazed. However with poorly managed cattle grazing, the plantain is killed. It is likely that plantain could be used as an indicator species to ensure appropriate grazing management.

Plantain sown at a mere 2.0 kg seed/ha, enables 10-20 plants to establish/m^2, filling gaps between swede plants (with more roots to hold the soil), they flower and set seed under the swede canopy. The wild seed produced germinates around September/October complimenting the surviving plantain cover crop, to establish a dense plantain crop, protecting the soil, and useful for lamb finishing. At 2.0 kg seed/ha the plantain did not affect the swede yield in the one small plot trial. Likely prillcote seed would be used at 4.0 kg/ha, as the doubling of seed weight improves seed ballistics.

Strip grazing is practiced to ensure optimum utilization of a finite winter forage crop. However strip grazing concentrates hooves leading to soil damage. Some farmers have naturally moved to “multiday block grazing” when grazing swedes, due to scarcity of labour. These farmers prioritize reduced soil damage by offering four or more days grazing as a block, allowing no access to the previously grazed area. They move them a day early during inclement weather. Interestingly the cattle settle down, bullying reduces and movement is minimized. Initially there is likely to be increased crop wastage. It is important to begin multi-day the block grazing during the transition period. A mobile trough can be used to ensure water is available.

It is widely accepted that a grass buffer strip will slow down overland surface water flow, allowing larger soil particles to be captured, reducing soil loss. The question we had with Helicropping was how wide does this grass strip have to be to be effective? Two trials conducted during the 2021 winter grazing period indicate that the majority of the large soil particles are arrested with a mature 5 metre wide grass buffer strip.

The trial established via cultivation, with a 10 degree catchment slope lost a vast amount of soil. The front row of pails were full of soil on two occasions over two months, with significantly less soil in the pails 5m further away through the grass strip, proving that the monitoring system, although primitive, worked. This cultivated crop was grazed by cows with daily shifts behind an electric fence.

The trial established in the Helicropped paddock, with a 20 degree slope, grazed using "multi-day block" grazing, lost almost no soil. The comparison was very stark, challenging the recently imposed 10 degree maximum slope for grazing stock on winter crops. It is not only the slope that determines soil loss.

The novel attempt to establish a cereal buffer strip in November 2021 using Avipel treated ryecorn seed was successful. In future a five metre wide ryecorn buffer strip could be broadcast wherever required soon after sowing the forage crop. These buffers could be sown in swales, or adjacent to streams and other sensitive areas, or to simply put buffer strips across long sloping paddocks.

Acknowledgments

Thank you to the numerous farmers involved in both the Central North Island (special mention to Colin & Dale Armer, Geoff & Joanna Fitzgerald, Matt O'Neil, and Mark Grace) and in Southland. Without their willingness to allow access to their farms, this work would have been difficult to achieve.

Thank you also to the financial funders of this work: MPI via the Sustainable Farming Fund, Beef+Lamb, Ballance Agri-Nutrients, PGGWrightson Seeds, Agricom Seeds and Nufarm, plus their in-kind contribution and also the in-kind contribution from BOP Regional Council.

Thanks also to the management of Ballance Agri-Nutrients for support and enabling the project to proceed.

References

Carey, P.L.; Cameron, K.C.; Di, H.J.; Edwards, G.R.; Chapman, D.F. 2016. Sowing a winter catch crop can reduce nitrate leaching losses from winter-applied urine under simulated forage grazing: a lysimeter study. *Soil Use and Management 32*: 329-337.

Carey, P.L.; Cameron, K.C.; Di, H.J.; Edwards, G.R. 2018. Does sowing an oats catch crop reduce nitrate leaching from urine deposition following simulated winter forage grazing? - A growth chamber experiment. *Plant and Soil* https://doi.org/10.1007/s11104-018-3742-2.

Clapperton, B, Morgan D, Day T, Oates K, Beath A, Cox N, Matthews L. 51- 56 Margaret Ave, Havelock North 4130, New Zealand. Efficacy of bird repellents at deterring North Island robins (Petroica australis longipes) and tomtits (P. macrocephala toitoi) from baits. 2013 https://newzealandecology.org/nzje/journalsearch1/anthraquinone

Malcolm B.; Teixeira, E.; Johnstone, P.; Maley, S.; de Ruiter, J.; Chakwizira, E. 2017. Establishment methods of oat catch crops after winter forage grazing. *Agronomy New Zealand 47*: 65-77.

Malcolm, B.; Teixeira, E.; Johnstone, P.; Maley, S.; de Ruiter, J.; Chakwizira, E. 2016. Catch crops after winter grazing for production and environmental benefits. *Agronomy New Zealand 46*: 99-108.

Malcolm B.; Carey E.; Teixeirai P.; Johnstone P.; Maley S.; De Ruiter J.; Potential of catch crops to reduce nitrogen leaching in New Zealand winter grazing systems *Journal of New Zealand Grasslands 80: 207-214 (2018)* Brendon.Malcolm@plantandfood.co.nz

Mastrota FN, Mench JA. 1994. Avoidance of dyed food by the northern bobwhite. Applied Animal Behaviour Science; Volume 42, Issue 2: 109-119 1994, Pages 109-119; https://www.sciencedirect.com/science/article/abs/pii/0168159194901511?via%3Dihub

Roundup Topping Spray-topping pastures | Agriculture and Food