Hill country cropping with no land-based equipment

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Abstract

A series of demonstration/proof of concept trials conducted on four sites in northern North Island hill country from 2001 over 3 years, identified practical techniques to establish a high-yielding brassica crop as part of a pasture renewal programme, using a helicopter. Practices similar to no tillage flat-land operations were identified, but they also take into account the risk associated with aerially applying fertiliser, seed and pesticides onto steep hill country.

Keywords: hill country, cropping, aerial application

Key messages

- Crops can be successfully grown on non-tractor hill country using aerial application
- Good planning using proven weed and pest control tools and an appropriate fertiliser program are essential to success
- Young or high value stock, with good farm infrastructure, will yield better returns.

Introduction

Hill country farms often have limited areas that can be cultivated to establish crops and pasture. They may produce well below their potential because of soil loss resulting from cultivation and grazing management difficulties when the topography ranges from rolling (tractor accessible) to steep (tractor inaccessible).

This paper reports the outcomes of a farmer initiated study, in association with the Northern North Island Sheep Council, designed to evaluate methods of pasture renewal using aerial application. The first method used herbicide-induced summer fallow and the second included a summer fodder crop.

Sites were located in the northern North Island at Pikowai (Te Puke), Waitomo, Te Akau (Raglan) and Kaiwaka (Wellsford). The project involved across-industry co-operation with chemical, seed, and fertiliser specialists (Monsanto (NZ) Ltd, PGG Wrightson Seeds and Ballance Agri-Nutrients) working with the farmers.

Trial design included a treated and untreated area of similar size (approximately 5-10 ha), located on similar aspects. Cost and comparisons of metabolisable energy (ME) at all sites were measured as well as stock weight gains at one site.

This study aimed to act as a catalyst to stimulate discussion on practical methods to improve the productivity of hill country farms and identify the elements of effective hill country cropping and pasture renewal.

Methods

Each of the four sites were chosen based on topography (moderately to steep), summer conditions (whether summer wet or dry) and dominant pasture species.

1. Pikowai – Steep topography (slope range 10 to 60 degrees, 10% accessible to tractor) with a predominantly south-east aspect overlain with sandy loam. Summer dry conditions with pastures dominated by kikuyu (*Pennisetum clandestinum*) and ratstail (*Sporobolus africanus*).
2. Kaiwaka – Moderately steep topography (slope range 10 to 40 degrees, 70% accessible to tractor). Clay soils with a predominantly easterly aspect. Summer dry climate with unimproved pastures mainly perennial ryegrass (*Lolium perenne*), white clover (*Trifolium repens*) and kikuyu.
3. Waitomo – Steep topography (slope range 15 to 70 degrees, 5% accessible to tractor) predominantly northeast facing with Mairoa ash-based soils. Summer wet (rainfall>2000 mm/year well distributed annually) with browntop (*Agrostis capillaris*), Yorkshire fog (*Holcus lanatus*) and cocksfoot (*Dactylis glomerata*) dominated pasture with sparse clover.
4. Te Akau – Moderately steep topography (slope range 15 to 50 degrees, 20% accessible to tractor) predominantly north facing with heavy clay soils on a limestone base. Summer dry climate with pastures perennial ryegrass, browntop and Yorkshire fog dominant.

At Pikowai and Kaiwaka, the role in soil moisture retention of herbicide induced ‘summer fallow’ was evaluated, followed by a grass crop to suppress weed ingress (and enhance returns) and improve subsequent permanent pasture renewal.

At Pikowai, glyphosate herbicide with a penetrant was applied at 2.0 kg a.i./ha in January. Following a March summer fallow, glyphosate (1.5 kg a.i./ha) was again applied and a short rotation diploid ryegrass was broadcast (25 kg/ha) with superphosphate and urea

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fertilisers (total 250 kg/ha). Glyphosate was applied again in December and in the following March, after a further glyphosate treatment, a pasture mixture was sown that comprised perennial ryegrass, cocksfoot and white clover. Di-ammonium phosphate fertiliser (DAP, 275 kg/ha) was spread with the coated seed.

At Kaiwaka, glyphosate herbicide with a penetrant was applied at 2.0 kg a.i./ha in January. After the ensuing summer fallow, glyphosate was re-applied in March along with coated tetraploid Italian ryegrass seed (25 kg/ha) and fertiliser (urea, 100 kg/ha).

A summer forage crop was established at Waitomo and Te Akau. These locations being summer wet and summer dry, respectively.

At Waitomo, coincident with a November spraying with glyphosate (2.0 kg a.i./ha) a hybrid forage turnip (*Brassica* sp.) (5 kg/ha), chicory (*Cichorium* sp.) (2 kg/ha) and white clover (2 kg/ha) were sown with superphosphate (1 tonne/ha) and lime (2.5 tonnes/ha). In the following March glyphosate (1.5 kg a.i./ha) was applied along with a short rotation diploid ryegrass (25 kg/ha). Slug bait containing thiocarb was applied in December when a slug (*Deroceras reticulatum*) problem was noted. In November, glyphosate was applied and forage brassica (4 kg/ha), chicory (4 kg/ha) and white clover (4 kg/ha) broadcast along with slug bait (10 kg/ha) and 200 kg/ha DAP. In the following April, glyphosate was applied before a pasture mixture was sown that contained perennial ryegrass, cocksfoot, white clover and chicory, with 200 kg/ha DAP.

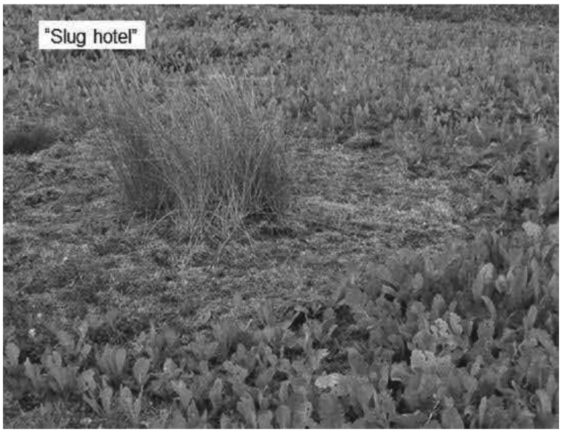

Figure 1 Rushes (Juncus sp.) providing a 'slug hotel' with access to nutritious food on the Te Akau site.

A similar pasture renewal process was followed at Te Akau but fertiliser was applied in March (200 kg/ha, DAP) and thiocarb grain bait for slug control was applied with the initial summer crop.

Table 1 Comparison of treatment costs per ha ($NZ, 2005) using a helicopter compared to renewal costs using ground-based equipment.

	Pikowai	Kaiwaka	Waitomo	Te Akau	Ground-based equipment
Fertiliser	648	578	631	491	740
Flights	1913	891	754	1058	862*
Chemical	258	239	343	356	434
Seed	408	719	877	877	519
Total $	3227	2427	2605	2782	2555

*Contractor costs for cultivation (x2), drilling (x4) and herbicide application (x4) based on costs at the Bay of Plenty Monitor Farm in 2005.

Results

Table 1 summarises the component costs per ha for the four trial sites and a land-based operation for comparison. The costs are in 2005 dollars but the primary objective is to compare costs rather than indicate today's (2015) costs. It was estimated that the helicopter cost $50/ha, (based on a minimum land areas of 100 ha). This estimate excluded ferrying costs and took into account that the helicopter is charged by time not area (ha). The major difference between sites for helicopter time was the ferrying cost. At Waitomo some of the helicopter costs were defrayed by using a fixed wing aircraft for some operations. Additional chemical costs at Waitomo and Te Akau were incurred for slug control. An additional sowing of a chicory crop contributed to the higher seed costs for pasture renovation at Kaiwaka.

The presence of plant residue or in the case of the Te Akau site, dead but intact rushes (Figure 1) creates

Table 2 Metabolisable energy (ME) expressed as MJ ME/kg DM for the pasture/crop on the treated (Trd) and untreated (Untrd) areas at each site (NA= not applicable).

	Pikowai		Kaiwaka		Waitomo		Te Akau	
	Trd	Untrd	Trt	Untrd	Trt	Untrd	Trt	Untrd
Start	12.1	10.9	12.5	11.5	11.4	9.8	10.5	9.8
Crop 1	10.7	10.6	9.8	8.7	11.6	8.6	12.3	11.4
Crop 2	NA	NA	NA	NA	11.5	11.2	11.6	11.4
Final	8.9	8.1	11.5	9.3	11.6	8.9	11.2	11.6

Figure 2 Soil moisture retention under dead/dying pasture cover.

a refuge for slugs and snails. Anticipating the potential impact of pests and diseases is an important part of the planning exercise.

ME offers a comparison for the quality (based on digestibility) of forage. Using either a ‘summer fallow’ or summer forage crop (annual ryegrass or brassica/chicory) during pasture quality (Table 2). At Waitomo, there was a three-fold increase in stocking rate and a 44% increase in stock weight gain when comparing renewed to un-renewed areas. Because of the small area treated these data are an indication only of the potential livestock productivity gains from increasing forage quality.

A chemical summer fallow (Figure 2), whereby dying and dead vegetation is left to reduce soil moisture losses that would otherwise occur through plant transpiration.

Discussion

As a proof of principle the trials were successful. Crop and pasture species can be established by aerial oversowing. Costs per ha are similar to land-based machinery alternatives and could further be reduced through judicious use of helicopter time. However, some operations are critical and should not be eliminated just to reduce the time. If a key activity is overlooked, for example, pest control, it is no small matter to rectify the problem. Fertiliser application is also important as there is a high risk of failure if species with high nutrient requirements are sown in a low fertility environment.

Helicopters are more limited by weather conditions than is ground-based equipment. Flexibility must be factored into timing the precursors to key events such a grazing before herbicide use to maximise the effectiveness of the herbicide. Broad acre use of herbicides must be accompanied by consideration for non-target effects. Drift under helicopter rotor wash may be exacerbated by downslope air currents. Low drift spray nozzles can help alleviate this problem. There were also indications from this work that pelleted seed had better aerodynamics than un-pelleted seed when distributed by helicopter. Economies with respect to helicopter use may be improved by combining operations. For example, vegetation and springtail spraying, slug and snail baiting plus seed, and fertiliser application can be carried out with three separate passes on the one visit by the helicopter.

Planning was a key feature of this exercise and the farmers involved had the advantage of access to expert advice in the fields of fertiliser, agronomy and agricultural chemicals. In the subsequent decade, advances such as in understanding the role of plant growth regulators and managing nitrogen fertiliser application (Ghani *et al.* 2014), and the economic impacts of changing catchment management on land use (Dodd *et al.* 2014), have placed more onus on the role of expert advice.

Practical implementation of technology in programmes such as Pastoral 21 are important. With an objective to optimise and utilise forage growth on hill country farms to improve the profitability of finishing lambs and young beef animals, incorporating the establishment of new plant genetics in uncultivatable hill country the Pastoral 21 programme, should provide the leadership towards sustainable management of hill country.

Helicopter time represented a high cost (averaging 41% of total costs). Much of this was ferrying time (i.e. getting to the sites) in remote locations. To defray this cost farmers could combine activities to narrow windows of opportunity but this has inherent difficulties due to timing and type of activity, such as co-ordinating a summer fallow. A summer fallow conserves soil moisture and relies on good pasture kill and an initial pasture cover that ensures soil protection. A failure would compromise the subsequent activities. The question of costs to rectify an individual failure in a co-operative exercise may jeopardise the outcome.

Fertiliser application was identified as critical for successful pasture and crop establishment. Identifying the correct fertiliser type and amount should be based on soil tests and crop demands. Requirements will differ from property to property depending on soil type,

Figure 3 An example of a 40 ha hill country kale crop established in 2014 using the methods outlined above.

aspect and farm fertiliser history (Figure 3). Optimising helicopter time by coincidental timing of herbicide and fertiliser applications makes good economic sense. However, arriving at a consensus as to timing applications across a number of farms may present difficulties.

The timing and amount of rainfall was different at each site and affected forage establishment and growth rates. Rainfall will also affect the efficacy of nitrogenous fertilisers. The potential for soil loss was not measured but it may be inferred that keeping vegetation cover intact will reduce risk of soil loss. Tozer *et al.* (2006) reported that seasonal conditions relating to rainfall and seed mixture were the biggest contributors to successful establishment of hand-sown grasses and legumes on steep hill country.

Selection of the appropriate crop for the site, particularly as it relates to slope and timing of crop harvest is important. Depending on grazing demand, a summer-grazed turnip crop may be more suitable than a winter-grazed swede crop. Bearing in mind the costs of a reactive treatment for pests and/or diseases in these crops the value of a prophylactic use of pesticides cannot be over emphasised, particularly while the crop is establishing.

As a result of cultivation, the mosaic of rank and establishing pasture due to redistribution of topsoil and subsoil, and steep inaccessible areas, complicates grazing management. Aerial re-grassing addresses this problem as whole paddocks can be renewed, with minimal soil disturbance.

As this project progressed some ideas were initially considered then rejected. Some may still have a role depending on individual situations. An example was an initial belief that a lot of “hoof and tooth” would be required to get seed/soil contact. After observing the effect on both the stock and the dogs, and considering the general lack of stock suitable for the job in spring, hoof and tooth was abandoned with little apparent effect on subsequent plant establishment.

Experience from this project has resulted in slow permeation of knowledge and adoption of hill country no-till pasture renewal and cropping over recent years. The authors hope this paper will act as an added stimulant to encourage both farmers and the aviation industry to test the concept and apply their own ideas.

Conclusions

Hill country cropping and pasture renewal is both economically and practically viable using no land-based equipment. A recipe has not been outlined here for aerial pasture/crop establishment in steep hill country, but principles for success have been identified. These include the need to address existing pasture/weed species, along with pests relevant to the crop being grown, and address fertility deficits. Slug/snail bait was seen to be as essential as the seed. Optimisation of soil moisture should be considered with every operation. Summer fallow practice is a useful tool to this end. Proximity of helicopters services will determine not only the economics but also the opportunities for in-crop weed and pest control and the potential for nitrogen side-dressing.

While recognising there are challenges associated with aerial pasture/crop establishment in steep hill country, they are not insurmountable and the technologies outlined here offer an opportunity to increase productivity from our hill country farms.

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