

Oversowing arrowleaf clover on North Island East Coast dryland hill country – results from two farm case studies

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Abstract

Low clover content of grass-based pastures is often a challenge on summer-dry hill country. This study measured the performance of oversowing arrowleaf clover (*Trifolium versiculosum*) on two East Coast properties (Wairakaia in Gisborne and Tourere in Central Hawke's Bay) following a herbicide/oversowing programme on steep uncultivable hill country. Arrowleaf clover is a hard-seeded aerial flowering plant and the intention was for light grazing in Year 1 to achieve maximum seed set and develop a long-term seed bank to increase pasture clover content. In Year 1, dry matter production was 11.7 tonnes/ha at Wairakaia and 10.5 tonnes/ha at Tourere. Seed set was 425 and 1380 kg/ha, respectively. Because arrowleaf is hard seeded, little germination was expected in Year 2 and both paddocks were oversown in a cover crop of plantain (*Plantago lanceolata*) at Wairakaia and arrowleaf at Tourere. Over 3 years, the areas which had been oversown produced substantially more dry matter than adjacent resident pastures, with significantly higher herbage accumulation rates in the first two years. However, the high residual cover ('trash') that resulted from seed set was difficult to clean up. Moreover, subsequent germinations suffered from heavy slug infestations. Whilst oversowing with arrowleaf clover was successful in the first year, the challenges in managing arrowleaf clover in subsequent years means that arrowleaf clover is unlikely to have a role in improving clover content under a permanent pasture situation.

Keywords: germination, oversowing, plantain, seed set, *Trifolium vesiculosum*

Introduction

In dryland environments, drought conditions affect the persistence of traditional perennial clovers such as white (*Trifolium repens*) and red clover (*Trifolium pratense*), meaning subterranean clover (*Trifolium subterraneum*) is often the dominant legume on dryland hill country. A resilient annual, subterranean clover survives by producing hard seed that remains dormant until conditions are suitable for germination. However,

in many farming situations the opportunities for clover re-seeding are limited by traditional set stocking with ewes and lambs (Ates et al. 2006).

As a result, much of dryland hill country has a low clover/legume content. Legumes are a key driver of production as increasing clover content lifts ewe milk production and provides a higher ME feed for suckling lambs (Nicol and Edwards 2011). Increasing lamb weaning weight in a dryland region results in more lambs finished prime off their mothers (POM) and an increase in farm profit (Thompson et al. 2016). Early drafting of lambs also provides a safety valve to de-stock before the onset of dry conditions.

Erect annual clovers hold promise in summer dry areas as they grow vigorously during spring, are aerial seeders and, with the exception of Persian clover, produce significant amounts of hard seed (Macfarlane et al. 2015). A combination of plantain and erect annual clovers produced a significant improvement in yield and animal performance on cultivatable land on the East Coast of the North Island, NZ (Macfarlane et al. 2014). Moreover, modelling showed that this would result in significantly improved financial returns and could be a game-changer for North Island dryland areas (Muir et al. 2019).

Arrowleaf is a very high yielding annual clover (Evans and Mills 2008; Muir et al. 2020) and in Canterbury, arrowleaf clover grew at 153 kg DM/ha/day in spring (Evans and Mills 2008). Arrowleaf clover has a long tap root (Thompson 2005) with the potential to access moisture at greater depths than other resident dryland pasture species. Preliminary studies with arrowleaf clover on steep hill country at Castlepoint Station in the Wairarapa resulted in the re-seeding and successful re-establishment of arrowleaf plants (P. Muir, unpublished data).

This work examined the potential role for arrowleaf clover to improve the long-term clover content of grass-based pastures on uncultivable hill country by establishing an arrowleaf crop on moderate-steep slopes through oversowing. As the grazing of top-flowering annuals such as arrowleaf reduces seed set (Macfarlane et al. 2015) the plants from the initial arrowleaf sowing were allowed to set seed to provide a reservoir of hard

seed in subsequent years. This work was undertaken on two hill country farms in Gisborne and Hawkes Bay as part of Beef and Lamb NZ's Innovation Farm Programme.

Wairakaia Station – Rob and Sandra Faulkner

Farm description. Wairakaia is located in the Muriwai district near Gisborne (38.46°S, 177.54°E) with an average rainfall of around 1000 mm and is regarded as summer-dry. The farm comprises 600 ha including around 140 ha cultivatable land (includes 10 ha citrus), an additional 50 ha of leased cropping land and around 260 ha of medium to steep hill country. The current sheep policy is 1850 breeding ewes with a lambing percentage of 160% plus 640 hoggets with a lambing percentage of 80-90%. Winter lambs are purchased in autumn and killed in early spring at 21 kg carcass. The cattle policy is to mate 130 breeding cows and 30 R2 heifers each year. Around 70 R1 heifers and 70 R1 bulls are purchased each year with additional heifers/steers purchased if required. The livestock cropping policy involves 32 ha of chicory/plantain/clover mixtures, 10 ha of brassica and 75 ha of Winterstar annual ryegrass planted after squash and seed maize.

In 2014, lamb weaning live weights at Wairakaia averaged 28 kg. Since then, twin bearing cull ewes have been rotationally grazed at 12 ewes/ha on plantain/clover pastures on cultivatable land, from lambing to weaning. These cull ewes are typically killed at carcass weights of 37 kg and around 80% of their lambs are drafted at weaning at carcass weights of 19 kg in early November. These benefits have flowed across the farm and resulted in an overall increase in lamb weaning liveweights across the farm from 28 kg to 32 kg. This has resulted in a farm system better suited to the summer-dry environment. The success of plantain and annual clovers on cultivatable land has led to the possibility that erect annual clovers could be used to improve the productivity on the steeper uncultivable parts of the property as well.

Establishment. An oversowing programme was undertaken on 4 ha of uncultivable easterly facing hill country at an altitude of 50 m above sea level and a slope of approximately 25°. The soil type was a light silt loam. The paddock was previously ryegrass dominant with very little clover present. Soil tests in March 2016 indicated a pH of 5.9 and Olsen P levels of 51 mg/L. All spray and seed applications were carried out by helicopter. The area was double sprayed with 5 litres/ha of Polaris 450 (ai 450 g/l glyphosate) on the 1st Dec 2015 and the 10th Mar 2016. On the 20th March, Aglime was applied at 3 t/ha and DAP at 140 kg/ha. On 7th April, 'Arrotas' arrowleaf clover seed inoculated and pelleted with lime was oversown at 12 kg/ha.

Immediately after sowing, 1200 ewes were moved around the paddock for 24 hours to facilitate treading and seed/soil contact. On 19th May, the area was sprayed for broadleaf weeds with 4 l/ha Tropotox (ai 25 g/l MCPA and 375 g/l MCPB) and 1 l/ha Headstart (ai 50 g/l flumetsulam). Between 9th and 25th September, the oversown paddock was lightly stocked with 72 ewes and 126 lambs and grazed to a pasture residual of 10 cm. From the 26th September 2016, the paddock was left ungrazed to maximise seed set. After seed set, breeding cows were used to clean up the large amount of trash and achieve a degree of treading of the seed.

As arrowleaf is very hard seeded, little or no germination was expected for 12 months and 7 kg/ha of 'Tonic' plantain was oversown by helicopter as a cover crop in April 2017. However, in spite of hard grazing with cattle after seed set, a large amount of dead material remained. This created cover for slugs and made plantain establishment difficult. Nevertheless, a plantain crop was successfully established.

Measurements. Arrowleaf seedling counts were made in 10 quadrats (0.5 m²) on the 12th August 2016. Three pasture exclusion cages were each placed in the oversown paddock and in an adjacent permanent pasture that had a botanical composition similar to the sown paddock prior to it being sown. The exclusion cages were cut at approximately 8 weekly intervals and at a high residual (10 cm) in the oversown paddock and at a lower residual (6 cm) in the permanent pasture. Pasture was weighed fresh and a 200 g subsample was dried at 80°C for 48 hours to enable dry matter (DM) yields to be calculated. On the 25th November 2016, botanical composition was determined from herbage subsampled and dissected by hand into grass, legume, weed and dead and the subsamples dried at 80°C for 48 hours. On the 11th January and the 14th February, total flower heads were counted in 10 quadrats (0.5 m²). In February, thirty flower heads were collected and the seeds rubbed out using soft rubber pads and weighed to estimate seed weight per hectare. Two years after sowing, counts of germinating arrowleaf seedlings were made in 10 quadrats (0.5 m²) on 31st May 2018.

Mean and standard error values for the seedling count, herbage accumulation and seed yield data were calculated in MSExcel.

Results. Seedling counts on the 12th August indicated 59±11 (sem) arrowleaf seedlings/m². Initial herbage accumulation rates were slow, at 7 kg DM/ha/day from sowing through to 25th July (Fig. 1). Herbage accumulation rates were 25 kg DM/ha/day from 26th July to 14th September, 70 kg DM/ha/day from 15th September to 16th October and 110 kg DM/ha/day from 17th October to 25th November. Total DM production

in Year 1 was 11 700 kg DM/ha. In November 2016, botanical dissections showed that the arrowleaf paddock comprised 94% legume and 4% grass compared to 1% legume and 94% grass in the adjacent resident pasture. Seed set was measured at 425 kg/ha in February 2017. By May 2018, newly germinating arrowleaf seedlings within the plantain sward numbered 275 ± 89 plants/m² with highest numbers in the sunny areas. However, these seedling numbers did not translate into high DM yields as slugs proved difficult to control, in spite of an aerial application of slug bait (Metarex ai 50g/kg) at 5 kg/ha in winter 2018.

From three to four years after the initial arrowleaf establishment, herbage accumulation rates from the oversown arrowleaf/plantain paddock were the same as the adjacent resident pasture (Fig. 1). However, over the full four years of measurement, arrowleaf/plantain produced 30% more DM yield than the resident pasture (44.0 vs 33.7 tonne), with much of this extra feed occurring in October and November (Fig. 1).

Tourere – Pete Swinburn and Suzanne Hoyt

Farm description. Tourere is a partnership between the Swinburn and Isles families. The farm is located in Central Hawkes Bay (40.07°S, 176.25°E) and comprises 1250 ha with 56% cultivatable and the remainder medium to steep hill country. Average rainfall is 1000 mm and the property is considered summer dry. Soils range from heavy clay flats through to papa/sandstone hill country. The sheep policy is 2500 breeding ewes and 750 hoggets mated. Average lamb weaning weights are 26–27 kg, with around 20% of lambs drafted prime off their mothers (POM). Winter lambs are purchased in autumn and killed in early spring. The cattle policy is to have around 500 weaners and 200–400 R2 cattle with

flexible sale and slaughter decisions based on season and feed availability. An annual cropping programme involves 450 ha sown annually with 100 ha of summer or winter brassica, 200 ha of ‘Tonic’ plantain and 150 ha of annual ryegrass (cv. Moata) or perennial ryegrass (cv. One50).

Establishment. A steep 3.3 ha north dryland block (Right Triangle) with a slope of approximately 30° and covered in mostly browntop (*Agrostis capillaris*) was sprayed out with 3 l/ha glyphosate 360 in October 2016 and oversown in an early maturing rape crop. Soil tests indicated a pH of 5.9 and an Olsen P of 49. All spray and seed applications were carried out by helicopter. The paddock was again sprayed with glyphosate 360 on 8th April 2017 and oversown with inoculated arrowleaf seed (cv. Zulu 11) at 12 kg/ha (plus slug bait) on 12th April in a mix with 200 kg/ha DAP. The area was then grazed with a mob of ewes for 48 hours to assist seed-soil contact. Arrowleaf was lightly grazed through winter with hoggets and in spring with ewes and lambs leaving a high residual (> 2000 kg DM/ha). Thirty two ewes (59 kg) and sixty twin lambs (11.9 kg) were weighed onto Right Triangle and set stocked at 10 ewes/ha from the 20th August to the 30th September. On the 1st October 2017, the paddock was shut up to allow seed set. Breeding cows were grazed in late February 2018 to reduce the amount of material left behind after seed set.

Because of Arrowleaf clover’s hard-seeded reputation, little germination was expected from the 2017 sowing and on the 31st March 2018 the area was re-sprayed with 750 ml/ha glyphosate 360 and oversown again with arrowleaf clover (cv. Zulu 11) as a grazing proposition. However, dry conditions in autumn

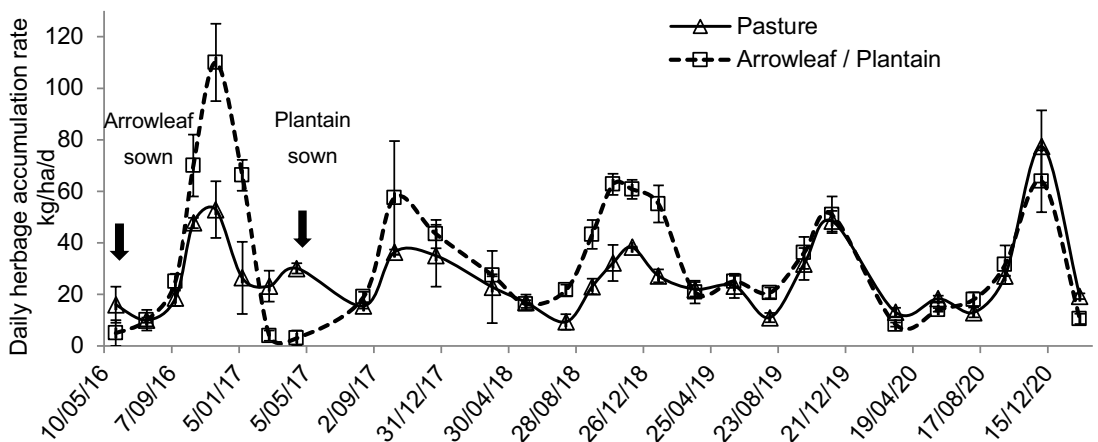


Figure 1 Daily herbage accumulation rates (kg DM/ha/d) of arrowleaf clover sown in March 2016 and followed by plantain sown in April 2017, compared with an adjacent resident pasture, at Warakaia Station.

combined with the residual trash from the previous year resulted in a slow germination. The residual trash provided a haven for slugs, with slug bait having to be applied twice during the winter of 2018.

In April 2019, plantain (cv. Agritonic) was oversown at 12 kg/ha after the paddock was sprayed off with glyphosate 360 at 750 ml/ha in May. Plantain was used as it encourages clover growth and would be expected to provide a better environment for the expected germination from the arrowleaf seed set from the 2017 sowing.

Measurements Arrowleaf seedling counts (2nd June 2017) and amount of seed set (7th December 2017) were measured using the same methods as described for Wairakaia Station. Arrowleaf seedling counts were again measured on 30th May 2018 after arrowleaf had been re-sown. On 18th May 2019 arrowleaf seedlings were again measured to determine the number of seedlings present from previously set seed.

Arrowleaf herbage accumulation rates in Right Triangle were measured using 3 randomly placed exclusion cages with measurements every 4-6 weeks from 16th June 2017 to 28th September 2020. The cages were cut to 10 cm and then placed on another pre-trimmed area. From Year 2, pasture herbage accumulation rates were also measured in a resident pasture of similar aspect, contour and botanical composition (Bottom Triangle) with cages cut to 6 cm. Botanical composition was measured on 8th November 2018 on both Right Triangle and Bottom Triangle using the same method as at Wairakaia.

Mean and standard error values for the seedling

count, herbage accumulation and seed yield data were calculated in MSEXcel.

Results Arrowleaf seedling counts averaged 130/m²±42 in June 2017. Herbage accumulation rates averaged 19 kg DM/ha/day from sowing to 31st July, 78 kg DM/ha/day from 1st August to 13th September and 99 kg DM/ha/day from 14th September to 10th October (Fig. 2). Whilst Right Triangle produced 10.5 tonnes of high-quality dry matter in Year 1, much of this was unutilised as the paddock was shut up from 17th October and allowed to set seed. Seed set was 1380 kg seed/ha.



Plate 1 Arrowleaf clover in flower in December 2017 after sowing in April 2017 at Tourere (Right Triangle paddock)

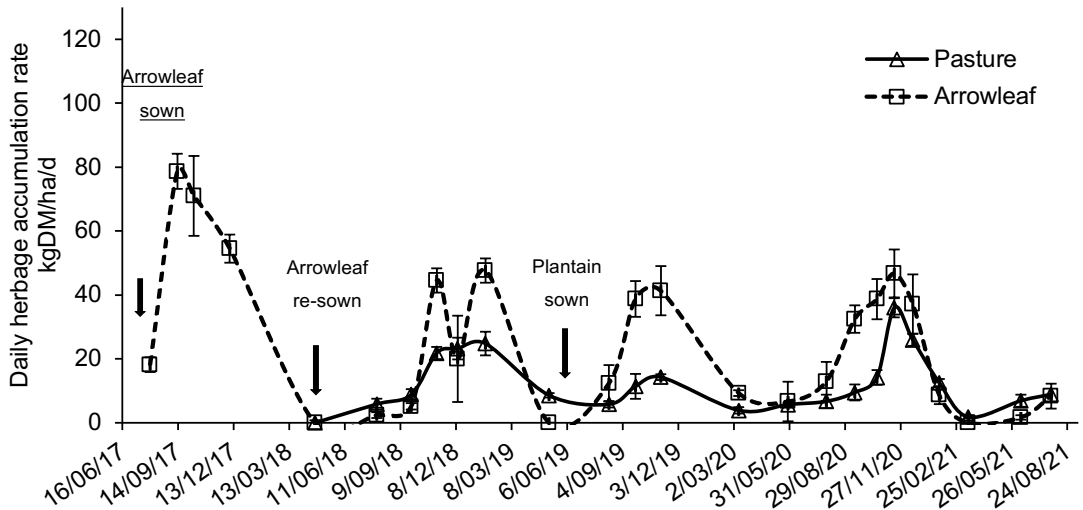


Figure 2 Daily herbage accumulation rates (kg DM/ha/d) of successive plantings of arrowleaf sown in April 2017 and March 2018, followed by plantain sown in April 2019 (Right Triangle block) compared with an adjacent resident pasture (Bottom Triangle block) at Tourere.

Re-sowing of Right Triangle with arrowleaf in 2018 resulted in a very good germination, with an average of 287 ± 42 plants/m² recorded in May. By May 2019, 85 ± 23 arrowleaf seedlings/m² were recorded, presumably these were seedlings that resulted from the original 2017 sowing. However, the results were highly variable across the paddock, partly because of the areas of trash that resulted from the previous year's crop and had proved difficult to clean up with cows. This trash also proved an ideal haven for slugs and the paddock had to have Metarex slug bait (ai 50 g/kg metaldehyde) applied twice at 5 kg/ha during the winter of 2018. The high level of slug damage meant that the arrowleaf sown in 2018 only grew at 8 kg/ha/day through winter and produced a total of 5500 kg DM/ha for the year. Set stocking of ewes and lambs for six weeks in spring 2018 resulted in ewe and lamb growth rates of 100 ± 32 g/d and 318 ± 43 g/d, respectively.

The oversowing of Right Triangle with plantain in 2019 proved successful, producing average yields of 7600 kg DM/ha in the establishment year. In contrast, the resident pasture in the adjacent steep north facing paddock (Bottom Triangle) produced an average of 3600 kg DM/ha over the same period. Pasture dissections using exclusion cages showed that pasture species in Bottom Triangle were largely ratstail (*Sporobolus africanus*), browntop and hair grasses (*Vulpia spp.*). No clover species were seen over the 3 years of the study.

Discussion

Both properties were previously using high quality forages (plantain and annual clovers) for lamb finishing on the easier contoured parts of their farms. This work aimed to increase the finishing ability of the steeper, less productive country.

Compared to the number of seeds sown, early seedling establishment was modest (59 and 130 seedlings/m² at Wairakaia and Tourere, respectively). Based on a 1000 seed weight of ~1.7 g (Muir et al. 2020) a sowing rate of 12 kg/ha translates to around 800 seeds/m². Herbage accumulation rates were thus very slow through the first winter. These growth rates meant that arrowleaf seedlings were susceptible to broadleaf weed competition through the winter. But in spring, with growth rates of up to 110 kg/day, the ungrazed arrowleaf was able to out-compete the weed and grass species present and produced a crop up to 0.8 m in height (Plate 1).

Ultimately, the oversowing programme resulted in a very successful crop of arrowleaf, with forage yields of >10 tonne/ha recorded in an un-grazed situation during the first year at both sites. Leaving such a high yielding crop un-grazed is undoubtedly a waste of high-quality feed but the over-arching intent of the programme was to maximise the seed yield for future

herbage yield. Since arrowleaf is an aerial seeder (flowers are at the top of the stems) leaving the crop un-grazed seemed the best option to maximise seed set. As arrowleaf produces a very high percentage of hard seed (MacFarlane et al. 2015) good numbers of arrowleaf seedlings were expected in subsequent years. A good yield of arrowleaf clover seed was produced at Wairakaia, with 425 kg seed/ha in line with the 569 kg of seed/ha reported for arrowleaf with a closing date of 20th September (Macfarlane et al. 2015). More than twice that amount of seed was produced at Tourere. To produce these high seed yields, arrowleaf was left largely ungrazed and this resulted in a significant trash problem as even beef cows found the hard stems of arrowleaf unpalatable. This trash meant that the ability to get good seed-soil contact and seed germination was variable and resulted in a number of bare patches. The trash also provided cover for slugs and in Year 2 there were highly desirable crops for the slugs: plantain at Wairakaia and arrowleaf at Tourere. This necessitated further expensive applications of slug bait.

Even though large quantities of arrowleaf seed were set in Year 1, germination in subsequent years was poor. Other authors have noted that arrowleaf is very hard seeded and thus re-establishing arrowleaf and other aerial seeding annuals from natural seed set is difficult (Olykan et al. 2021; Taylor et al. 2021). We aimed to overcome these difficulties by maximising seed set in Year 1 but this proved difficult and the scarified commercial seed originally sown at 12 kg/ha produced more dry matter than the 425 – 1380 kg/ha of natural seed set.

Practical implications

The oversowing programme undertaken was very successful in terms of achieving a one-off high-quality crop of arrowleaf clover with high herbage yield relative to resident hill country pastures and good seed yields. Whilst arrowleaf clover is clearly a prolific seeder, the residual trash associated with first-year seed production and the challenges in managing arrowleaf (slugs and poor strike of naturally hard seed) mean that it is unlikely to have a role in improving clover content under a permanent pasture situation.

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