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Biodiverse winter pasture cropping – a cost-effective approach to fill the winter feed gap and build drought resilience in grazing systems in the Tweed Local Government Area

TWEED SHIRE COUNCIL

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Disclaimer: The information provided in this report includes the results of a trial conducted by Tweed Shire Council's Sustainable Agriculture Program. It is not intended to be used as agronomic advice. Readers should seek their own agronomic and financial advice before making farm management and business decisions that could be affected by a change in management practices such as multi-species pasture cropping.

Background

Tweed Shire Council received funding from the Australian Government's Future Drought Fund to deliver a project aimed at building the drought resilience of beef and dairy farms in the Tweed Local Government Area (LGA).

Soils on beef cattle farms in the Tweed LGA are typically highly degraded from decades of set stocking with minimal intervention to maintain pasture biomass or soil health. Soils are often acidic, of low fertility, high in available metals and relatively low in organic carbon and soil biology. Structurally these soils are often compacted and support low numbers of pasture species or are dominated by species with low nutritional value for livestock. For example, the poorer quality soil landscapes in most coastal areas and hill country across the Tweed LGA.

The result is a pasture landscape that does not typically respond well to extreme weather or climatic events like floods and drought. Pastures of the Tweed are dominated by summer growing, subtropical, perennial species that perform poorly through the winter months. This means that if stock numbers are not matched to the carrying capacity of the land there becomes a shortage of fresh feed for livestock during winter. This is referred to as the winter feed gap leading to what local graziers term a 'green drought', where the landscape is green, but feed availability is low, especially during late winter and early spring when soil moisture is also low.

Drought can be defined as a shortage of feed meaning that each winter the Tweed LGA's grazing industries are at risk of drought if stock and pastures are not well managed. One way of overcoming this feed deficit is to provide supplementary feed through pasture cropping, a practice that is common in the dairy industry but less so in the beef sector.

In 2019 the Tweed LGA was officially declared a drought affected area. Annual rainfall at Murwillumbah was 717mm, the lowest on record. The event had significant social, economic and environmental impacts largely because the area is not accustomed to drought or how to deal with drought conditions.

To further exacerbate the challenge, pasture dieback appeared in the Tweed LGA in 2019 severely impacting a range of subtropical perennial pastures, leading to feed shortages and loss of ground cover throughout summer and autumn. The loss of groundcover has increased soil erosion and the proliferation of broad-leaved weeds.

Activity aims

The aim of the project was to improve the drought resilience of beef cattle farms by trialling biological farming methods and multispecies pasture cropping at 2 demonstration sites in the Tweed LGA. Pasture species mixes and yields, and various application methods and additions were investigated throughout the trial to determine the costs and benefits of multi-species pasture cropping as a drought preparedness strategy. The effects of multi-species pasture cropping on soil health were also examined.

Methods

Selection of trial sites

Two 1ha trial plots were established in August 2021 to investigate the potential for multi-species pasture cropping as a method to fill the winter feed gap, increase pasture diversity and drought resilience.

Site 1 (Crystal Creek) was selected as a typical, relatively fertile, alluvial floodplain pasture on the Rous River harbouring a combination of kikuyu, Pensacola and a limited number of other subtropical grasses. Site 1 was mildly acidic (6.09 pH in water) with low aluminium (<5% ECEC). Levels of the major nutrients phosphorous and potassium were good however nitrogen and sulfur levels were low. Current management involved set stocking of livestock with no history of fertiliser additions or pasture cropping (Figure 1).

Figure 1. Site 1 (Crystal Creek) trial area during the Spring of 2021.

Site 2 (Nobby's Creek) represented typical undulating hill slope country with poor soils that had been severely affected by pasture dieback and had become dominated by broad-leaved weeds and bare ground. Site 2 was highly acidic (5.08 pH in water) with high aluminium (58% ECEC) and very low soil fertility with low levels of nitrogen, phosphorous and potassium. Current management involved set stocking of livestock with no history of fertiliser additions or pasture cropping (Figure 2).

Figure 2. Site 2 (Nobbys Creek) trial area affected by pasture dieback, with broad-leaved weeds and limited pasture availability following the winter of 2021.

Trial design

Initially 4 treatment areas were established at each of the 2 trial sites to compare the effects of pasture sowing and soil amendments using a direct drill seeder (T1); pasture sowing and soil amendments using the Soilkee Renovator™ (T2); pasture sowing without amendments using the Soilkee Renovator™ (T3); and current practice i.e. set stocking with no amendments or seed treatments (T4). The T2 and T3 treatments covered the majority of the trial area with a smaller area reserved for the control (T4 – No Soilkee). Figure 3 and 4 show the general layout of the trial at both sites.

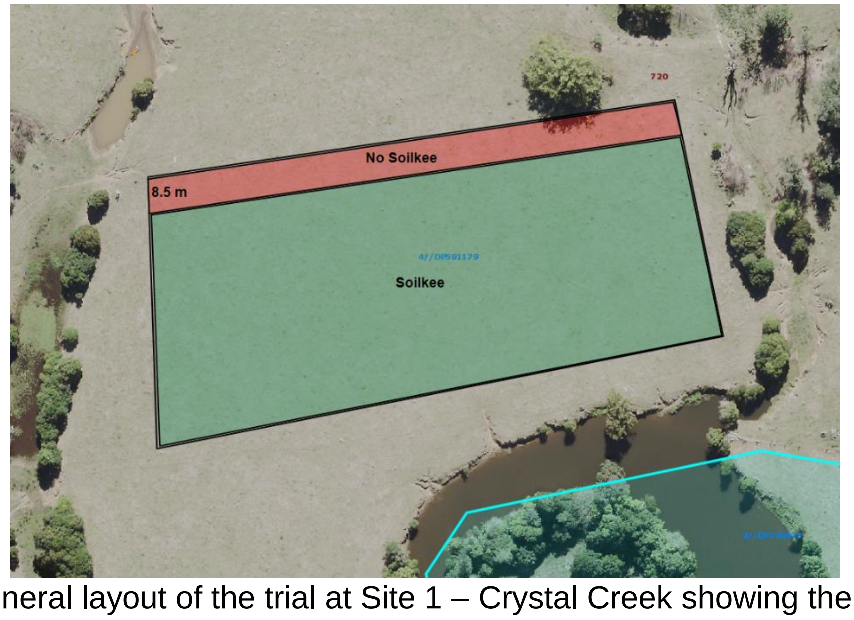

Figure 3. General layout of the trial at Site 1 – Crystal Creek showing the extent of the pasture cropping area (Soilkee) and the uncropped or control area (No Soilkee).

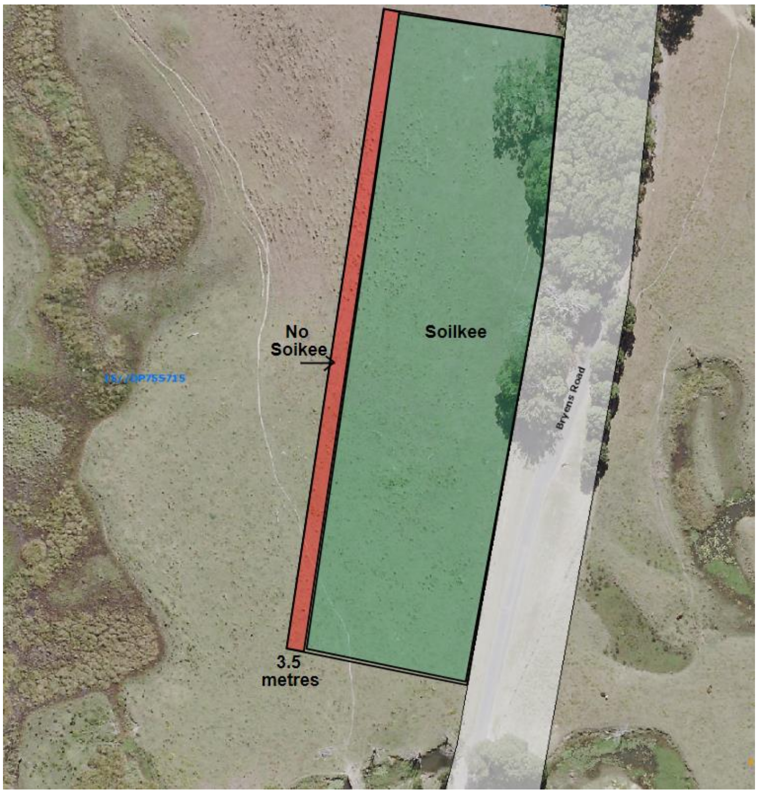

Figure 4. General layout of the trial at Site 2 – Nobbys Creek showing the extent of the pasture cropping area (Soilkee) and the uncropped or control area (No Soilkee).

Following inconsistent results in the direct drill treatment areas in year 1 it was decided to simply focus on a comparison between the Soilkee Renovator™ and control area in the second year of the trial. This was the most practical approach and reflects the common practice of minimal intervention to pastures, especially during the winter months.

Site preparation and soil amendments

The 2 trial sites were heavily mulched prior to seeding in August 2021 and again in April 2022 to ensure good seed germination and minimal competition with existing pasture species. This approach was preferred over the conventional method of broadacre herbicide application that is typically used prior to pasture cropping.

The following amendments were applied by belt spreader once to the Soilkee and direct drills areas after mulching in August 2021 but not to the control (No Soilkee area):

- 1t/ha lime dust
- 2t/ha basalt dust
- 250kg/ha rock phosphate (Natramin – prill form)

Test strips (5m) of fertiliser were also applied perpendicular to the treatment areas by hand spreader at both sites in September 2021. Fertiliser consisted of 20:10:20:10 NPKS.

Pasture mixes

Pasture mixes were developed with assistance from local pasture agronomist Michael Gout, and biological farming practitioner Dave Forrest. Due to the timing of the initial sowing event (August 2021, being late winter) a combination of winter and summer grasses and herbaceous plants were selected. After mulching and spreading of amendments the seed mix was applied either directly through the Soilkee Renovator™ or a direct drill seeder depending on the treatment area.

The pasture mix was adjusted for the April 2022 planting to suit the seasonal conditions and also respond to findings from the August 2021 sowing. For the April 2022 planting only the Soilkee Renovator™ was used. The species planted and sowing rates are shown in Table 1 and Table 2.

Table 1. Pasture species and sowing rates for Crystal Creek trial site (Site 1).

10 August 2021 Species	**Sowing rate**	**18 April 2022 species**	**Sowing rate**
Ryegrass (Speedyl)	20kg/ha	Ryegrass (Sultan)	12kg/ha
Oats (Dynasty)	20kg/ha	Oats (Dynasty)	20kg/ha
Woolly vetch (Namoi)	6kg/ha	Vetch (Common)	4kg/ha
Rape (Greenland)	2kg/ha	Peas (Morgan)	8kg/ha
Chicory (Punter)	2kg/ha	Chicory (Punter)	1.5kg/ha
		Red clover (Rossi FFP coated)	2kg/ha
		Leafy turnip (Pacer)	1kg/ha
		White clover (Quest FFP coated)	0.5kg/ha
		White clover (Rampart Ladino FFP coated)	0.5kg/ha
		Tillage radish	0.5kg/ha

Table 2. Pasture species and sowing rates for Nobby’s Creek trial site (Site 2).

10 August 2021 Species	**Sowing rate**	**18 April 2022 species**	**Sowing rate**
Oats (Dynasty)	20kg/ha	Ryegrass (Sultan)	12kg/ha
Cocksfoot (Lazuly soft)	12kg/ha	Oats (Dynasty)	20kg/ha
Prairie grass (Jeronimo)	5kg/ha	Vetch (Common)	4kg/ha
Woolly vetch (Namoi)	5kg/ha	Peas (Morgan)	8kg/ha
Crimson clover	2.5kg/ha	Chicory (Punter)	1.5kg/ha
Red clover (USA)	2kg/ha	Red clover (Rossi FFP coated)	2kg/ha
White clover (Haifa)	1kg/ha	Leafy turnip (Pacer)	1kg/ha
Chicory (Punter)	1kg/ha	White clover (Quest FFP coated)	0.5kg/ha
Rape (Greenland)	1kg/ha	White clover (Rampart Ladino FFP coated)	0.5kg/ha
Tillage radish	0.5kg/ha	Tillage radish	0.5kg/ha

The pasture mix in year 1 was slightly different between sites and then the same seed mix was used at both sites in year 2. The initial seed mix for site 2 included cocksfoot, a summer active temperate perennial grass that is tolerant of acid soils with high aluminium and low fertility. It does however thrive in higher fertility environments and produce all year round.

Management of trial areas

Cattle were excluded from trial sites by using electric fencing until pastures were ready to graze. The intention was to rotationally graze the trial areas with a mob of livestock, introduce nutrients via cattle dung and urine, followed by a rest period to allow the pasture to regenerate. The idea being to introduce nutrients naturally via the livestock rather than application of topdressings of fertilisers. This proved difficult to implement in practice but was conducted on at least two occasions (Figure 8).

Trial monitoring

The focus of the trial was to investigate the differences in pasture yield between treatments by conducting pasture cuts at different stages in the crop cycle. Cuts from each treatment area were dried and weighed to determine a feed dry weight per hectare equivalent. One pasture cut was taken to represent the year 1 crop and 3 pasture cuts were taken following sowing of the pasture crop in year 2.

The Northern Rivers Soil Health Card was used as a method to monitor soil physical and biological characteristics before and after the trial. The test investigates physical and biological properties of the soil that are not evident through chemical soil tests. An initial soil chemical test was conducted at each trial site however a follow-up test was not conducted. The monitoring methodology was developed in collaboration with the CSIRO and is detailed on the Soilcare Pty Ltd website:
https://www.soilcare.org/soil-health-card.html

Results

Pasture assessments

At Site 1 there was no significant difference in pasture yield between the pasture cropped area and the control in the first year. However, fertility patches (or areas where livestock had deposited dung or urine during the previous grazing event) in the pasture cropped area produced 4 times the feed or 2,436kg DM/ha more than the control at Site 1 (see Table 3).

Table 3. Forage yield at known points in time at Site 1 – Crystal Creek (kg DM/ha).

Treatment	**27/10/21**	**22/6/22**	**15/9/22**	**31/10/22**
Soilkee + amendment + fertility patch	3,242	-	-	-
Soilkee + amendment	913	196	759	1,533
Soilkee + amendment + urea	-	-	1,537	1,539
Soilkee only	909	196	759	613
Soilkee no seed	674	-	-	-
Direct drill + amendment	954	-	-	-
Control + Urea	-	324	332	571
Control mulched	806	324	132	641

In the first year of the trial both sites produced 56 – 81% more biomass than the control at Site 2 which equated to an additional 675 – 975kg DM/ha. Again, areas of high or adequate nutrition (i.e. pasture growing on a former dung pat, or 'fertility patch' and fertilised areas) produced 186% or 2,231 kg DM/ha more than the control area at Site 2 and an additional 1,266kg DM/ha more than the Soilkee without fertiliser (see Table 4). The effect of fertility patches on pasture growth is shown at Figure 5. Whilst these areas produced an equivalent amount of feed as areas where synthetic fertiliser was applied, they were sparsely distributed through the trial area (Figure 6).

Table 4. Forage yield at known points in time at Site 2 – Nobbys Creek (kg DM/ha)

Treatment	**19/11/21**	**22/6/22**	**8/9/22**	**18/10/22**
Soilkee + amendment + Urea	3,446	-	-	-
Soilkee + amendment	2,180	924	1,965	1,220
Direct drill + amendment	1,880	-	-	-
Control mulched	1,205	368	297	306

Test strips of fertiliser were applied perpendicular to the treatment areas to determine the effect of synthetic fertiliser interventions. The addition of fertiliser increased the number of plants and their growth rate. However, this was an immediate and temporary response with the sustained effects on pasture growth and soil health largely unknown.

By March 2023 there was high diversity of sown species with clovers and other legumes being more prevalent than they had been at any other time of the trial. These species continued to persist and grow all year round.

Figure 5. Prolific growth of sown pastures on nutrient rich ground in association with a previous grazing event at Site 1 (Crystal Creek). These fertility patches produced the equivalent amount of feed as areas where synthetic fertiliser was applied.

Figure 6. Fertility patches were sparsely distributed across Site 1, highlighting the significant impact of poor soil nutrition on growth of sown pastures. This area received lime, rock phosphate and basalt dust prior to seeding with the Soilkee Renovator.

Economic analysis

An economic analysis of the costs and benefits of winter pasture cropping was conducted as part of the trial. Table 5 summarises the results of this assessment which incorporates results from trial sites 1 and 2 as well as a number of other sites where pasture cropping was concurrently taking place in the Tweed LGA using the Soilkee Renovator and other techniques. The results show that the addition of fertiliser to the existing, predominantly subtropical pasture assemblage in winter resulted in a net loss of profit (-$18/ha). In contrast, all winter pasture cropped areas demonstrated the potential to generate a profit, irrespective of the cropping method. The results also indicate that relying on the existing subtropical pasture as the principal feed source throughout winter does not result in any profit, and risks depleting the resource at no benefit to the producer. Whilst the Soilkee with fertiliser or direct drill with fertiliser were the most expensive approaches to establish a winter pasture crop ($580/ha and $573/ha respectively), they also had the potential to generate the most profit for the producer ($1,752/ha and $2,135/ha respectively).

Table 5. Cost benefit analysis of various winter pasture cropping techniques.

Ave. 300kg steer	Unit	Tropical + fert	Tropical	Direct drill	Soilkee	Broadcast	Broadcast + fert	Soilkee + fert	Direct drill + fert
Days		*182*	*182*	*182*	*182*	*182*	*182*	*182*	*182*
Yield	*kg DM/ha*	3,027	1,333	2,314	2,456	2,912	6,569	6,774	7,784
Utilisation	*%*	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Utilised feed	*kg DM/ha*	1968	866	1,504	1,596	1,893	4270	4,403	5060
NDF%	*%*	58.1	58.1	46.4	46.4	46.4	46.4	46.4	46.4
ME	*MJ/kg DM*	9.3	9.3	11.4	11.4	11.4	11.4	11.4	11.4
Feed Intake	*kg /hd/day*	6.2	6.2	7.8	7.8	7.8	7.8	7.8	7.8
Feed Intake	*MJ ME/day*	57.6	57.6	88.4	88.4	88.4	88.4	88.4	88.4
ME for lwg		13.6	13.6	44.4	44.4	44.4	44.4	44.4	44.4
Grazing days	*days*	318	140	194	206	244	550	568	652
Ave daily gain	*kg/hd/day*	0.303	0.303	0.988	0.988	0.988	0.988	0.988	0.988
Lwt gain	*kg lwg/ha*	96	42	191	203	241	544	561	644
Price	*$/hd lwg*	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50
Gross Income	***$/ha***	$433	$191	$862	$915	$1,084	$2,446	$2,522	$2,899
FCE	*Utilised*	20.5	20.5	7.9	7.9	7.9	7.9	7.9	7.9
	Grown	31.5	31.5	12.1	12.1	12.1	12.1	12.1	12.1
Costs									
seed	*$/ha*	$0	$0	$200	$200	$200	$200	$200	$200
estabmnt	*$/ha*	$0	$0	$113	$120	$63	$63	$120	$113
fert+ appl.	*$/ha*	$260	$0	$0	$0	$0	$260	$260	$260
Total costs	***$/ha***	**$260**	**$0**	**$313**	**$320**	**$263**	**$523**	**$580**	**$573**
Gross Margins	**$/ha**	**$173**	**$191**	**$549**	**$595**	**$821**	**$1,923**	**$1,942**	**$2,326**
Extra profit	***$/ha***	**-$18**	**$0**	**$358**	**$404**	**$631**	**$1,733**	**$1,752**	**$2,135**

Soil health

The Northern Rivers Soil Health Card assessment was used to investigate the effects of pasture cropping on soil physical and biological characteristics at trial sites 1 and 2. The results are shown in Table 6.

Table 6. Soil Health Card monitoring results before and after the pasture cropping trials at Site 1 and Site 2.

	Site 1 – Crystal Creek		**Site 2 – Nobbys Creek**	
Soil characteristic	**Before trial**	**After trial**	**Before trial**	**After trial**
Ground cover	9	9	3	7
Diversity of soil life	5	5	2	5
Penetrometer (surface)	2	3	2	4
Penetrometer (20cm depth)	2	2	1	3
Infiltration (surface)	1	2	1	2
Infiltration (20cm depth)	1	1	1	2
Root development	4	5	4	5
Soil structure (10cm depth)	4	5	2	5
Soil structure (20cm depth)	1	1	2	4
Aggregate stability	4	4	3	4
Earthworms	2	3	2	2
pH (10cm depth)	4	5	4	5
pH (20cm depth)	3	4	3	4
Plant species diversity	6	8	5	7

Note: Each soil characteristic is given a score between 1-3 (poor), 4-6 (fair) or 7-9 (good). The results represent 5 replicates at each site.

The Soil Health Card assessment suggests that the Soilkee Renovator improved groundcover and pasture species diversity, improved soil structure (with corresponding improvements in soil penetration and infiltration) as well as a reduction in soil acidity compared to the control area. These results were evident at both sites but more pronounced at Site 2 where the soils were originally of a poorer quality and less groundcover was present following the impacts of pasture dieback.

Figure 7 shows the noticeable improvement in soil structure in the area where the Soilkee Renovator was used and winter active species were grown.

Figure 7. Changes in soil structure as a result of pasture cropping using the Soilkee Renovator (top) compared with the control area (bottom) where no pasture cropping took place.

Discussion

The trial demonstrated the benefits of multi-species pasture cropping as a strategy to fill the winter feed gap, improve soil health and drought resilience in the Tweed LGA. A significant increase in pasture biomass was recorded in the pasture-cropped trial areas, particularly where soil fertility was high. Based on the results of this trial the approach may be an economically viable method for maintaining carrying capacity through winter whilst ensuring that pastures are not overgrazed. Set stocked, overgrazed pastures, particularly in winter, lead to poor pasture recovery and carrying capacity going into the hot but dry spring conditions of the northern rivers of New South Wales.

The cost benefit analysis indicated that the costs associated with establishing winter pasture crops could be easily recouped through live weight gains in cattle but only when there was adequate soil fertility to achieve levels of production over 2t/DM/ha. This is also affected by cattle prices which were high at the time of this trial along with the cost of utilising contractors who have the implements required to crop pastures. As cattle prices decline there would be the requirement to achieve greater yields to break even.

Soil fertility was a key limitation to the success of pasture crop establishment and growth. This was exemplified at Site 1 where fertility patches appeared in areas where cattle had previously deposited waste products prior to seeding.

These results highlight the importance of a healthy soil for pasture crop production. It also suggests that the nutrition left behind from the previous livestock grazing event is just as effective at producing biomass as a fertiliser application, albeit over sporadic areas. In situations where topdressing of fertiliser is not preferred, producers could consider harrowing manure 2-3 days after cattle have left the paddock to help distribute nutrients. Care should be given to ensure dung beetle activity is not adversely impacted by this strategy.

The results also showed that fertilising a tropical pasture in winter was not a cost-effective option. Furthermore, synthetic fertilisers high in nitrogen are known to suppress legume growth, limiting pasture diversity and the legumes' ability to draw down nitrogen from the atmosphere and provide a natural source of this macronutrient.

The intention of the trial was to use high numbers of livestock to periodically mob graze the trial areas and introduce additional nutrition via cattle dung and urine rather than topdressing with a synthetic fertiliser. However, this proved difficult to implement with flooding damaging fencing at Site 1 on at least two occasions and periods of time where cattle were able to access the trial site because of fence failures. The opposite occurred at Site 2 where a long period of time elapsed in year 1 where the site had no livestock present due to feed availability issues from pasture dieback. However, in year 2 several timed, mob grazing events were achieved at Site 2 as feed availability increased in the trial area (Figure 8).

Figure 8. Timed, mob grazing of trial site 2 for optimal feed utilisation and deposition of nutrients from cattle waste products.

Even without additional fertility, the trials produced significant increases in winter feed availability. This was a cost-effective option meaning the cost involved in establishing the winter pasture crop was easily covered by the cost of materials.

The Soilkee Renovator was the primary method of pasture crop establishment during this trial. Whilst the implement was successful and proved cost-effective at establishing a multi-species winter pasture under the right soil moisture and fertility conditions, other methods such as direct drill or even broadcasting of seed could generate similar pasture yields under suitable conditions. As the current Soilkee unit is over 3m in width and can weigh over 2t when loaded with seed, it typically requires at least 120hp of machinery to operate. This is not an option for most graziers unless such an implement was available via a contractor or cooperative arrangement with other producers.

Despite the potential yield increase from multi-species pasture cropping, this can only be achieved with appropriate grazing management where livestock are controlled to ensure adequate residual and rest periods following grazing events. On other sites where the Soilkee had been used, grazing occurred too early after pasture crop establishment inhibiting regrowth and delaying the time before the area could be grazed again.

The trial successfully demonstrated the potential to fill the winter feed gap and permanently increase pasture diversity into the summer months with important species such as legumes and broad-leaved pasture species. Winter pasture cropping is suitable in the Tweed LGA because the dominant subtropical pastures stop growing through the cooler months and provide minimal competition for sown pastures. The short duration of the trial does limit our ability to understand the full potential of pasture cropping as a means of improving soil health and as a strategy to increase soil carbon over a longer period of time. Soil carbon is critical for increasing drought resilience with a commonly quoted figure that every 1% increase in soil organic carbon increases the soils water holding capacity by 144,000 litres/hectare.

Future work should consider the long-term effects of pasture cropping, rotational grazing and the effects of different fertilisers on soil health and the drought resilience of grazing systems. Consideration could also be given to summer planting, particularly in pasture dieback affected areas where groundcover is poor and there is minimal competition from the summer-growing subtropical species.

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