Final report

Management options and species evaluation to increase productivity in dieback affected pastures

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Abstract

Pasture dieback has resulted in the death of large areas of previously productive grazing country in Queensland and, more recently, northern NSW. While several factors are likely to be involved, there is a strong association between dieback and pasture mealybug (*Heliococchus summervillei*).

Legumes are not affected by pasture dieback, and some grass species appear to tolerate its effects. Six field trials in 2018 indicated that combinations of cultivating and re-sowing with a legume or pasture/legume mix greatly improved productivity compared to untreated or burned areas.

This new project has re-examined the previous trials to determine whether effects remain after three years. Results of previous trials so far appear to confirm original observations that cultivation plus re-sowing provides the greatest benefits. Burning or cultivation without re-sowing often had negative effects.

Four new trial sites have been established. Preliminary results indicate that stick raking is a viable option for preparing a seed bed in locations that are not particularly weedy, or do not have large bulk of pre-existing grass. Grass and legume mixes appear to be giving good coverage in dieback sites, however, will require longer term studies to assess the impact of dieback on these treatments.

Variety trials have had varying degrees of germination. Further assessments are required to assess the impact of dieback on these varieties.

Executive summary

Background

Pasture dieback is causing major feed losses in Australia. Because of this there is an urgent need to develop strategies to provide feed for stock while a solution for the disease is being developed. While longer term solutions are ultimately needed, short term management strategies that can reduce the impact of the disease need to be developed and communicated.

Southern central and northern Queensland are currently affected by the disease. Current estimates place 200,000 ha affected by the disease, with AgForce estimating a possible 4.4 million hectares could be impacted by dieback by the end of outbreak. Producers facing dieback now or in the future need management strategies that are easy and economical to reduce the impact of dieback until a longer-term solution can be developed.

The results of the research have been used to produce an agronomists' guide to dieback and ongoing communication of results to producers. The materials produced from this project were intended to help producers reduce the impact of dieback on their properties.

Objectives

The broad aim of this project was to rigorously evaluate altered pasture management in dieback-affected areas and communicate the results to producers.

Specifically, the project aimed to:

- Identify and evaluate economically viable pasture management options that could increase pasture productivity and produce feed for stock in dieback-affected Queensland grazing regions.
- To identify and evaluate pasture species or varieties that are tolerant to pasture dieback and/or mealybugs with required agronomic traits to be productive and economically viable in Queensland's grazing regions.
- Communication of results and recommendations to producers via field days, factsheets, and other communication methods.

Field trials have been established to assess these, with successful preliminary results. Further assessments of the full impact of the treatments over time on pasture dieback are required.

Methodology

- Creation of a project reference group assisted with strategic direction of the project, ensuring the project met the needs of the grazing industry and continued to focus on required outcomes throughout the project.
- Assessment of previous MLA field trial sites, with percentage area of plant coverage and dieback incidence within five 0.5 m^2 quadrats.
- Selection, establishment, and assessment of four new field trial sites. Physical and chemical soil properties were recorded, along with the presence of active ground pearls and mealybugs. Both management and variety trials were established on these new sites.
- Development of an agronomists' guide to pasture dieback

Results/key findings

Assessment of previous MLA field trial sites indicated that treatments using cultivation and resowing with a grass and/or grass and legume mix generally gave the best results in useful plant coverage. Cultivating and allowing for natural regeneration resulted in a higher weed incidence, and more dieback expression.

At four new trial sites, early assessments suggest that grass and legume mixes will give the best results by minimising dieback expression and providing good, useful coverage. Stick raking has resulted in seed beds adequate for legume germination. Grass seed germination in management trials may have been outcompeted by pre-existing grass and weeds in some areas, however further assessments are required to determine effectiveness of this treatment. The weediness of an area may impact the effectiveness of these treatments and needs to be considered when sowing legumes.

Dieback symptoms were evident in pre-existing grass in three of the 4 trial sites, with grass mix and grass and legume mix treatments not showing symptoms in recently germinated plants.

Variety trials have had varying degrees of germination. Low seedling numbers in some varieties are most likely the result of poor-quality seed. Further assessments are required to assess the impact of dieback on these varieties.

Benefits to industry

Take home messages for producers:

- Confirmation that legumes are not susceptible to dieback.
- Cultivation (or stick raking), then re-seeding with a legume or pasture plus legume mix, and fertilising with 150 kg/ha DAP, has provided the best productivity (so far) on dieback affected pastures.
- Urea fertiliser is not helpful. Apply products that include phosphate such as MAP or DAP and use soil test results to guide fertiliser mix and application rates.
- Burning, or cultivating without re-seeding, are likely to have only short-term benefits and can increase dieback and/or weed growth.
- Simple strategies, such as stick raking, can be used for removing the bulk of dieback affected plants followed by resowing areas with improved grasses and legumes.

Future research and recommendations

A list of “best bets” for managing dieback were proposed in the agronomists’ guide. These included:

- Biosecurity
  - Restricting access to dieback affected paddocks
  - Avoiding feed from dieback affected areas
  - Limit movement of cattle from dieback affected areas
  - Limit access of vehicles
  - Planting windbreaks, especially downwind of dieback affected areas
- Insecticide
  - Use of insecticide as an early intervention
- Biological control
  - Encouraging beneficial insects such as *Cryptolaemmus* by increasing pasture diversity

- Agronomy
    - Investigate grazing management to promote pasture productivity

These “best bets” will need to be trialled to confirm if they provide some impact on pasture dieback.

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1. Background

1.1 Why was the project necessary?

Pasture dieback is a condition which causes widespread, episodic death of pastures. The condition initially causes reddening or bronzing of the leaves starting at the tip and progressing down towards the ligule. This spreads to the rest of the plant, after which the grass turns grey, as opposed to the normal straw colour of grass that has undergone senescence. Affected grass in unpalatable to cattle and is avoided (Makiela 2008).

Currently, the causal factors are unclear, although a strong association has been suggested between dieback and pasture mealybug (*Heliococchus summervillei*). However, other factors are also likely to be important. Lack of understanding of the causes has so far limited management options for graziers in Queensland and Northern New South Wales. AHR produced a comprehensive literature review of current research relating to pasture dieback in late 2018, Click here to download the report.

Pasture dieback is a major problem for cattle producers in Qld and northern NSW that appears to be getting worse. In 2017 it had been reported by 120 producers, with the condition affecting areas ranging from one to 35,000 ha (Buck 2017). However, due to the drought at that time and the similar symptoms of dieback being to drought affected grass, the number of producers and land area affected were likely much higher. An estimated 4.4 million hectares could be affected by the end of the outbreak.

Dieback kills a range of pasture species, with a focus on the most productive introduced species, including buffel grass, and reduces the amount of feed available for stock (Buck 2017). Producers need a long-term solution, but they also need solutions now to provide feed for stock.

The project aimed to identify and evaluate economically viable pasture management options that can increase pasture productivity and produce feed for stock in dieback-affected Queensland grazing regions. The project also focused on identifying and evaluating pasture species or varieties that are tolerant to pasture dieback and/or mealybugs and have the required agronomic traits to be productive and economically viable in Queensland's grazing regions.

With its focus on economically viable strategies, as well as working closely with agronomists and graziers during variety selection, this project works towards informing both short-term tactical actions by producers to manage pasture dieback, and further research and adoption actions.

2. Objectives

The broad aim of this project was to rigorously evaluate altered pasture management in dieback-affected areas and communicate the results to producers.

Specifically, the project aims to:

- Identify and evaluate economically viable pasture management options that can increase pasture productivity and produce feed for stock in dieback-affected Queensland grazing regions.

- To identify and evaluate pasture species or varieties that are tolerant to pasture dieback and/or mealybugs and have the required agronomic traits to be productive and economically viable in Queensland's grazing regions.
- Communicate the results and recommendations to producers via field days, factsheets, and other communication methods.

3. Methodology

3.1 Activity 1: Establish a project Reference Group and ensure methodologies are aligned

Establishing a project reference group (PRG) provided expertise to the best-practice trials and ensured the trials were on track to deliver useful results to producers. The group of agronomists and pasture experts reviewed the species list and trial protocol, and provided advice in relation to establishment, crop nutrition and other aspects of the trials. The PRG members were paid for their time at normal commercial rates if they were private consultants or agronomists.

The PRG included a seed supplier, a pasture agronomist, a rangelands scientist, producers (2), a representative from AgForce, and a representative from Queensland Department of Agriculture and Fisheries. Applied Horticultural Research's team of experts included an entomologist, plant pathologist and crop nutrition. The PRG met as required via Zoom or teleconference to review trial plans and generally to provide guidance for the project and make sure it delivered.

The AHR, QDAF and NSW DPI teams worked closely together to ensure there were common approaches to site evaluation core pasture species assessed, assessment protocols, data collection, data storage, and sampling and handling protocols. This group met monthly (via Zoom or similar) to check progress and discuss any issues which arose.

The feedback from the selection committee informed development of a collaborative, rationalised network of experimental and demonstration trial sites linked to similar research activities being developed by QDAF and NSW DPI. The experimental protocols included site characterisation, design and layout, species selection, assessment methods and use of the same experimental processes with centralised soil processing/analysis, and archived DNA library to facilitate information exchange. This allowed transparent and open discussion of results and meta-analyses from across regions.

3.2 Activity 2: Assess previous MLA field trials

The previous MLA funded project established trial sites at:

- Biggenden
- Jambin
- Middlemount
- Gogango
- Wowan
- Yerra

A large range of treatments were implemented at each site, including fertiliser (DAP, MAP and urea), cultivation, burning and re-sowing with grasses, legumes, or mixtures of both. Most treatments were applied in January 2018, with results assessed four and eight months later, with further assessments between 2.5 and 3 years after establishment.

Five of the six sites were visited between 2.5 and 3years for assessment of any remaining treatment effects. The sixth site, at Yerra, was not assessessed because the grazier could not be contacted.

Within each treatment block, five 0.5 m^2 quadrats were randomly selected for intensive assessment. As conditions during October 2020 were still very dry, the percentage of area which was either bare or covered with dieback-affected (grey) grass was recorded. This was compared to the previous 'dieback rating' which had been based on overall dieback symptoms on living grass. Biomass samples were not collected as all areas had been grazed.

New pasture dieback and useful pasture indexes were developed in conjunction with Assoc Prof Caroline Hauxwell from Queensland University of Technology and are now being used to quantify dieback and pasture coverage. AHR staff member Dr Naomi Diplock was trained in the quantitative assessment of pasture mealybugs by the QUT team on two occasions. She has used this methodology to assess mealybug numbers in previous trial sites as well as new locations.

A second assessment was conducted at the Jambin site following rain in late November 2020. In this case the assessment was more detailed, including the percentage of each quadrat that was bare, rock, or covered by debris, thatch, grass, legumes, and non-legume forbs species. Dominant and secondary grass species were noted along with height, coverage, and expression of dieback symptoms. The number, life stage (small, medium large) and position in plant, of Rhodes grass mealybugs (*Antonina graminis*) (no *Heliococcus summervillei* present) was also recorded. A third assessment in December 2020 focused on numbers of Rhodes grass mealybug and dieback symptoms.

A second assessment was conducted at Middlemount in January 2021 after rain over the summer. This used the new pasture dieback rating scale and focused on dieback symptoms as well as determining species coverage in plots.

Data collection and analysis: The trials were assessed by measuring the following variables, using the methods described below using replicated sampling (n=5). The data was analysed using Bayesian analysis methods to give some measure of variability within and between sites. While this was not as good as conventional replication (e.g. a Randomised Complete Block Design, or a Completely Randomised Design) there is no alternative since the trials had already been established. It is more of a hypothesis generating activity, which would then be tested under activity 5.

- Dieback incidence as per agreed methodology
- Presence/absence and counts of mealybugs and other relevant insects including ground pearls
- Growth vigour ratings
- Weed presence and counts
- Establishments and presence of species (%) for re-sown plots

3.3 Activity 3: Assess and select four trial sites covering southern and northern regions, heavy clay and light soil types

This activity was to select sites for the management interventions and improving pasture palatability trials. The sites needed to have active pasture dieback.

Sites were located on commercial grazing properties, with producers who were willing to allow the sites to be used for extension activities, and who were well respected by other graziers.

The sites were chosen to provide adequate coverage of climatic zones and soil types.

- **Two southern Queensland sites**, both with different types of clay soil.
- **Two central/north Queensland sites**, one with a light sandy soil and one with a heavy clay soil.

Members of the project team visited several potential field sites within Queensland to assess their suitability for field trials. This assessment has included measurement of physical and chemical soil properties at four depths (0-10 cm, 10-30 cm, 30-60 cm and 60-80 cm), ease of access, evidence of active pasture dieback, and evidence of active mealybugs or ground pearls.

Soil samples were collected using standard sampling procedures and analysed in AUSPAC-certified commercial laboratory Incitec-Pivot. The soil samples were collected using a hydraulic coring machine, with 15 cores collected in a transect across each site, then pooled and sent to the laboratory for analysis. Back up soil samples were dried and stored at the AHR laboratory. Access to irrigation water was considered as positive to assist establishment but its absence was not considered limiting as it is generally not available on grazing properties. The full list of site characteristics assessed is in Table 3-1:.

Table 3-1. Site characterisation

Data	Detail	Essential	Optional
Site location, description	Record the following for each site: • Location (GPS/google earth) • Elevation (m) (GPS derived) • Aspect and slope • Distance, direction to nearest major town • Availability of irrigation water if required • Access to trial areas • Tenure over site (leased or owned)	✓	
Site history	Record the following for each site: • Previous and current pasture (species composition) • Management for at least the past 12 months • Incidence/history of PD	✓	
Soil nutrient	For topsoil, collect 30 soil cores (0-10 cm) using a hand auger or soil corer across each 'uniform' site. For subsoil, collect 15 samples from 10-30 cm across each 'uniform' site. Bulk samples into composite samples for each depth. If there is a reason to sample deeper, collect 8 x cores per 'uniform' area from 30-60 cm and bulk. Follow the Nutrient advantage Pasture Soil Sampling procedure (Incitec-Pivot). Submit samples to Incitec-Pivot for analysis. For topsoil (0-10 cm) use Test E63 and for subsoil (1-30, 30-60 cm) use test E67. Note: NSW DPI suggest E39 which is a horticulture suite – confirm which test before proceeding.	✓	
Deep soil nutrients	If required, deeper samples can be collected: 30-60 cm, 60-90 cm, 90-120 cm. Agree on depths required before proceeding.		✓
Climate	Annual average and median rainfall (mm) for each site using the BoM SILO app accessible via https://www.longpaddock.qld.gov.au/silo/api-documentation/guide/	✓	
Pasture dieback	Use AHR protocol	✓	

Mealybug	Use the AHR protocol initially and then use the QUT (Caroline Hauxwell) protocol when available and contribute to validation through use. QDAF use a sampling methodology based on vacuum harvesting.	✓	
Ground pearls	Using a soil corer (~35 mm in diameter), sample to depth of 30 cm. Ideally, collect 10 soil core samples from a representative area. If this isn't feasible in the field, 5 samples should be sufficient. Collect a bulk sub-sample of approximately 500 g and send to UQ for assessment (UQ protocol).	✓	

3.4 Activity 4: Best-practice pasture agronomy trials

The objective of these trials was to find ways for graziers to produce feed from dieback-affected pasture through increased productivity and reduced expression of dieback.

Planning and establishment of trials: Field trials were established in dieback-affected grazing regions to evaluate pasture resistance or tolerance to dieback in the field, agronomic performance, biomass yield and mealybug populations. The trials were established on the four properties selected in activity 3, in the southern region (Biggenden/Gaeta), and the Biloela (Jambin/Theodore) region. The trials were fenced, and stock grazing was controlled.

Producers hosting the trials have been fully engaged in the trial process. This involved discussion of plans before trials were established and consultation on the assessment of species. Any costs associated with setting up and running the trials were met by the project, not the producers.

Site preparation: The minimum plot size was 9 x 9 m but varied from site to site. Larger plots were required for the implementation of management treatments and to also improve the likelihood of dieback being present in each plot. Plot sizes varied at different sites. At Theodore plots were 11 m x 12m, at Jambin plots were 8 m x 15 m, at Gaeta plots were 9 m x 9 m, and at Biggenden plots were 10 m x 10 m. Site preparation varied from site to site, variety trials were sprayed out, fertilised, and cultivated to ensure good seedbeds. Management trials did not receive fertiliser unless the treatment included fertiliser.

Treatments: The management interventions to be evaluated were reviewed by the PRG, taking input from activity 3 (Assessment of previous MLA trials) and the results of QDAF trials at Brian Pastures Research Station. The techniques focused on improving business cost-benefit by improving pasture productivity and expected liveweight gains.

The treatments at the different sites varied slightly. Fertiliser rates for fertiliser treatments are in

Table 3-3. The lists of treatments are as follows: For the Theodore and Jambin sites:

1. **Untreated control**
2. **Stick rake**
3. **Stick rake + buffel**
4. **Stick rake + grass mix**
5. **Stick Rake + legume mix**
6. **Stick rake + grass and legume mix**
7. **Stick rake + grass mix + fertiliser**
8. **Stick rake + legume mix + fertiliser**
9. **Stick rake + grass and legume mix + fertiliser**

For the Biggenden site:

1. **Untreated control**
2. **Stick rake**
3. **Stick rake + Bisset**
4. **Stick rake + grass mix**
5. **Stick Rake + legume mix**
6. **Stick rake + grass and legume mix**
7. **Stick rake + grass mix + fertiliser**
8. **Stick rake + legume mix + fertiliser**
9. **Stick rake + grass and legume mix + fertiliser**

For the Gaeta site:

1. **Untreated control**
2. **Cultivate + scarify**
3. **Cultivate + scarify + grass mix**
4. **Cultivate + scarify + legume mix**
5. **Cultivate + scarify + grass and legume mix**
6. **Cultivate + scarify + grass mix + fertiliser**
7. **Cultivate + scarify + legume mix + fertiliser**
8. **Cultivate + scarify + grass and legume mix + fertiliser**
9. **Scarify + bisset**
10. **Scarify + bisset + fertiliser**

Table 3-2: Grass and Legume mixes and their associated sowing rate used for management trials

Treatment	**Common name**	***Scientific name***	**Sowing rate (kg/ha)**
Buffel mix	Buffel mix (USA, Gayndah)	*Cenchrus ciliaris*	15
Bisset mix	Bisset	*Bothriochloa insculpta*	15
Grass mix	Reclaimer Rhodes	*Chloris gayana*	3
	Callide Rhodes	*Chloris gayana*	3
	Purple pigeon (bare) Or Biloela Buffel	*Setaria incrassate* Or *Chloris gayana*	1.35 Or 4.5
	Gatton panic	*Panicum maximum*	13.5
Legume mix	Lab Lab	*Lablab purpureus*	1.5
	Butterfly pea	*Clitoria ternatea*	3.75
	Desmanthus (Coastal or Progardes)	*Desmanthus spp*	3
	Stylos (caatinga)	*Stylosanthes guianensis*	3.75
	Cowpea (buff)	*Vigna unguiculata*	5.25
Grass and legume mix	Reclaimer Rhodes	*Chloris gayana*	3
	Callide Rhodes	*Chloris gayana*	3
	Purple pigeon (bare) Or Biloela Buffel	*Setaria incrassate* Or *Chloris gayana*	1.35 Or 4.5
	Gatton panic	*Panicum maximum*	13.5
	Lab Lab	*Lablab purpureus*	1.5
	Butterfly pea	*Clitoria ternatea*	3.75
	Desmanthus (Coastal)	*Desmanthus spp*	3
	Stylos (caatinga)	*Stylosanthes guianensis*	3.75
	Cowpea (buff)	*Vigna unguiculata*	5.25

Table 3-3 rates of fertilisers used for variety trial and fertilised plots in the management trial

		Site			
		Theodore	**Jambin**	**Gaeta**	**Biggenden**
Fertiliser (kg/ha)	**DAP**	158	50	158	158
	Sulphate of ammonium	85	195	85	85
	$CuSO_4$	5	5	NA	NA
	$ZnSO_4$	41	15	NA	NA
	Borax	NA	10	NA	NA

Site maintenance: Field plots were maintained in good condition. Spraying along the fence line at Jambin was carried out a week after trial establishment. Mouse bait was distributed through the Jambin site due to large numbers of rodents. Slashing for parthenium management was conducted for the trial at Theodore. Project staff aimed to visit sites at least once per month, however due to the impact of COVID-19 on travel restrictions visits were less frequent. During these visits, fences were inspected to make sure they were intact and any incidence of mealybug or dieback was recorded as outlined.

Statistical design and analysis: The field experiments were set up as Randomised Complete Block Design (RCBD) with four replicates in each trial. Field trials included 9-10 treatments. Individual treatment plot size varied with each site ranging from 81 m^2 to 120 m^2. The individual trial plans were developed for each site in collaboration with the producer and checked by a biometrician.

Following further assessments, a standard two-way analysis of variance was carried out on the data following a test of normality. Data was transformed if required to achieve normality. Least significant differences were used to identify significant differences between means ($P<0.05$).

Assessment of dieback: A 50 x 50 cm quadrat was randomly placed and photographed within a typical dieback area in two locations per experimental plot. The severity of dieback was assessed by rating each quadrat for pasture dieback symptoms, as below. For percentages less than 5, 1% increments were recorded, for percentages over 5, 5% increments were used (Table 3-4).

Table 3-4: Dieback assessment protocol

50x 50cm quadrat /100
% Bare
% Rock
% Debris (exc. thatch)
% Grass including thatch
% Forbs- legume Note species if known
% Forbs – non leguminous Note species if known
Grasses / 100
Dominant sp.
% (dom. species)
Height (cm) (dom. species)
% Purpling
% Yellowing
% Dead (thatch)
% Dead (dry/ golden)
% Dead (grey)
Sec. Sp./new grass
% (sec. species)
Height (cm) (sec. species)
% Purpling
% Yellowing
% Dead (thatch)
% Dead (dry/ golden)
% Dead (grey)
% Other grass (note species)

An overall score of useful coverage was then calculated by using the following formulas. Each grass species is coded as palatable (1) or weedy (0) (eg. Indian couch). This was modified to focus on particular species.

Equations:

Percent dom species cover *= % dom species x grass cover/100*

Percent sec species cover *= % sec species x grass cover/100*

Percent useful coverage *= (% dom species cover – (% dead x % cover dom species/100) x grass code) + (% sec species – (% dead x % cover sec species/100) x grass code) + legume*

Discolouration percentages and presence of mealybug can then be compared to the % useful cover to assess for correlations.

Assessment of mealybugs

These assessments were based on the overall appearance of each plot and on a detailed examination of each treatment. Mealybug assessments were weather dependent, with more focus on counts given during times of mealybug activity. An overall site check (5 random points) was conducted for mealybug at each visit using the QUT method: Dig a shovel width square of grass, carefully lift from ground keeping intact, lay plant and soil on plastic. Carefully and systematically check and count mealybugs from leaves through to soil. Note numbers, location and size of mealybugs found (small/medium/large).

If mealybugs are found, use one of the same 0.25 m^2 sampling quadrats in each plot from pasture dieback assessment. Assess the presence of mealybugs by counting the number of mealybugs found in the leaf and mulch layer in the bottom left quarter of the quadrat (25 cm x 25 cm). Record numbers counted in each plot.

3.5 Activity 5: Field trials to evaluate pasture species/varieties for resistance to dieback

Determine the pasture species to be planted: The objective of this activity was to make sure all potentially resistant pasture species were included in the field trials.

AHR undertook a preliminary study of pasture species with potential resistance to dieback (Appendix 3: Species summary. This list of species was a starting point for a more comprehensive study aimed at identifying all species with potential resistance to pasture dieback. Current inclusions were checked against reports of susceptibility in the field, and the seed companies (PGG Wrightson, Landmark Biloela, Progressive Seeds and Heritage Seeds) were asked for suggested species. The project reference group was also consulted on species suggestions, and the collaborating producers were asked about species they thought should be evaluated on their properties.

The group working on preliminary (greenhouse) species evaluation at the QUT was contacted about any species available for field evaluation.

Producers hosting the field trials were fully engaged in this activity and were supportive of the list of species being trialled. Plans were discussed before trials were established, and producers were also asked for input into assessment of species. Any costs associated with setting up and running the trials were met by the project, not the producers. Producers were expected to be champions for any species shown to be effective in the trials. To support this outcome, establishment methods, agronomy and other aspects of the trials were confirmed to be commercially available, and able to be adopted by other producers with a minimum of investment in equipment.

Establishment of field trials: Field trials were established in dieback-affected grazing regions. The following activities took place:

- **Mark out and fence the trial area**. Electric fencing was set up around the trial areas to exclude stock after pastures have been sown.
- **Soil preparation and fallow**: In Biggenden and Theodore trial areas were sprayed out with glyphosate andall sites were cultivated to kill weeds and existing pasture. Follow-up cultivation took place immediately before sowing seed. The aim was to achieve sufficient soil moisture and a suitable seedbed for small-seeded grasses to establish reliably.
- **Fertiliser application**: A fertiliser application program providing N, P, S, Cu was developed based on the soil test results. This was used to fertilise the variety trial at the same rate used in fertiliser treatments in the management trial. Fertiliser was spread before the final cultivation of the trial plot.
- **Weed and pest management:** General weed control has been conducted along the fence line at Jambin and for parthenium control at Theodore. In general, pest controls are rarely used on

pastures in Qld. Because they may also confound results with respect to mealybugs or other insects, they were not used.

- **Soil samples**: Soil samples collected during site preparation were used for the development of the nutrition program.
- **Sow pastures:** Trials were established by hand sowing, using a 'feeding the chickens' method.

Preliminary list of pasture species to trial: The strategy had a core of common pasture species that were trialled in all QDAF, NSW DPI and AHR sites, plus other species that were selected based on local climatic and soil suitability and producer preferences (**Error! Reference source not found.**). This was based on the potential pasture species list for trial. (Appendix 3: Species summary The final list was agreed after consultation with the PRG and discussion with producers (Table 3-6).

Statistical design and analysis: The field experiments were set up as Randomised Complete Block Design (RCBD) with 4 replicates in each trial. Field trials included 14-15 varieties depending on site. Individual variety plot size varied with each site from 8.4 to 10.8 m^2. The individual trial plans were developed for each site in collaboration with the producer.

Site maintenance: Field plots were being maintained in good condition. Spraying along the fence line at Jambin was carried out a week after trial establishment. Mouse bait was distributed through the Jambin site due to large numbers of rodents. Spraying for parthenium has been organised for the variety trial at Theodore. Project staff aimed to visit sites at least once per month, however due to the impact of COVID-19 on travel restrictions visits were less frequent. During these visits, fences were inspected to make sure they were intact and any incidence of mealybug or dieback was recorded as outlined.

<u>Assessment of management and species evaluation trials protocols</u>

Harmonisation of methodologies: The data collection protocols formed part of a common set that are used by NSW DPI, QDAF and AHR for the assessment of trial results. Other parties running agronomic and species assessment trials in the MLA-funded program should adopt the same protocols.

Data collection and storage: Data collection was started at trial establishment. Pasture growth assessments were taken 5-6 weeks after sowing, with plans for ongoing assessment. Data collection included: counts of germinated seedlings, agronomic performance, dieback incidence and mealybug occurrence. Data collected was stored on respective secure AHR data storage systems and backed up regularly. The AHR file system is held and backed up on two separate cloud-based systems and backed up at one physical location.

The harmonised assessment protocols are outlined in

Table 3-5**Error! Reference source not found.** and in the associated notes. Not all trials used all assessments, with flexibility to account for regional differences in climate, soil types and commercial standard practice.

Table 3-5 Minimum data set and assessment methodologies

Data	Detail	Timing and frequency	Essential	Optional
Frequency of visits	The trials should be visited at least once every two months or more frequently if needed, and especially in the establishment phase.		✓	
Weather observations	Record actual rainfall on-site (either local landholder records or automatic rain gauge) Collect daily weather data from each site using the point datasets available from the BoM SILO app accessible via https://www.longpaddock.qld.gov.au/silo/api-documentation/guide/	Daily	✓	
Establishment /recruitment	**Option 1: Pasture seedling density score**. Scoring system to be defined.	Every 4-6 weeks following significant post sowing rainfall	✓	
	Option 2: Seedling counts. Measure seedling establishment (plants/m^2) every 4-6 weeks following significant rainfall after sowing as follows: Count the number of seedlings in 5 random quadrats (10 cm x 50 cm) (10 cm mesh) per plot avoiding the outer rows of each plot. **Note**: Pasture seedling counts may need to be conducted several times as the species/cultivars will recruit/regenerate at different rates.	Budgeted 3 assessments per year		✓
Pasture dieback	Refer to the method described below.	At time of establishment, persistence assessments and herbage mass assessments	✓	
Mealybug	Refer to the method described below developed jointly by AHR and the QUT team.	Start and end of growing season	✓	
Ground pearls	Using a soil corer (~35 mm in diameter), sample to depth of 30 cm. Ideally, collect 10 soil core samples from a representative area. If this isn't feasible in the field, 5 samples should be sufficient. Collect a bulk sub-sample of approximately 500 g and send to UQ for assessment (UQ protocol).	Start and end of growing season		✓
Flowering (for species assessment only)	**Phenological development at time of herbage mass assessment**. The proportion of each sown species in the following categories will be recorded at the time of each herbage assessment: vegetative; flowering, seed set. Assessment to be conducted on 3 strata (this method will be reassessed in 12 months).	With herbage mass (3)		✓
Grazing	Whenever possible, experiment should be slashed after each assessment of herbage mass.	Once per season and keep		✓

Data	Detail	Timing and frequency	Essential	Optional
	Mow to 5-8 cm to conduct the assessment. Herbage should be removed from the plot, unless it contains legume seed (legume treatments), then it will need to be mulched on the plot.	consistent with commercial practice		
Monitoring with a drone (optional)	Collect RGB images of the trial area. Convert RBG images to NVDI equivalent and map, or use NVDI and RGB sensors together, and map.	After a specific event		✓

Table 3-6 List of species used in variety trials. Note Buffel mix and Biloela buffel were not included at Biggenden or Gaeta trials. Bisset was not included in Theodore or Jambin trials.

Variety	Species	Sowing rate (kg/ha)
Buffel mix (USA and Gayndah)	*Cenchrus ciliaris*	15
Bisset	*Bothriochloa insculpta*	15
Biloela buffel	*Cenchrus ciliaris*	15
Qld bluegrass	*Dichanthium sericeum*	15
Signal grass (Mekong Briz™antha)	*Brachiaria sp.*	15
Tully grass/Humidicola	*Brachiaria humidicola*	45
Purple pigeon (bare)	*Setaria incrassata*	4.5
Strickland digit grass	*Digiteria milanjiana*	30
Premier digit grass	*Digitaria eriantha*	15
Gatton panic	*Panicum maximum*	45
Swann forest blue grass	*Bothriochloa bladhii ssp. glabra*	15
Floren bluegrass	*Dichanthium aristatum*	45
Dave's choice (G2) panic (bare)	*Panicum maximum*	4.5
Endura Rhodes	*Chloris gayana*	15
Forest bluegrass (bare)	*Bothriochloa bladhii*	13.5
Bambatsii panic	*Panicum coloratum*	30

3.6 Activity 6: Production of agronomist guide

AHR produced the draft to the agronomists' guide (Figure 3-1). All researchers and organisations working on pasture dieback were invited to contribute and comment. With input from most participants, the resulting guide is a successful synthesis of all research on the problem. It is a useful tool to inform advisers and producers about pasture dieback and its management. In addition to the initial draft AHR provided photographs and results. QLD DAF and QUT assisted with editing, comments on the manuscript, photographs and trial results. NSW DPI provided photographs. Agronomists, graziers and the national Landcare program were consulted for comments. QUT provided comments on mealybugs and UQ provided comments on ground pearl.

The guide was printed by MLA and distributed in May at Beef Australia 2021.

The guide was also published online and is available here.

Figure 3-1. The pasture dieback agronomists' guide

Briefly, the guide contained the following sections:

1. Recognising pasture dieback
    - What is pasture dieback?
    - How to recognise pasture dieback
    - Development and long-term signs of dieback
    - Grass species affected
    - Cause of pasture dieback
    - Summary of current information of the cause(s) of pasture dieback
2. Managing Pasture Dieback
    - Biosecurity
    - Insecticides
    - Biological controls
    - Cultural and agronomic management
    - Managing dieback – Best Bets
3. Conclusions

3.7 Activity 7: Communicating results

Field days/farm walks: As soon as results are visible in the trials, field days will be organised, and producers invited to view the trials and talk to the host producer and project staff. There will be a strong commitment to including commercial agronomists and extension staff at these events. AgForce and MLA will be invited to assist with publicity for the events. Updates on the progress of the project will be produced each month for the MLA (Friday feedback) and for AgForce.

Factsheet: Although factsheets had been planned, deliberate focus was on the agronomists' guide to combine results from other projects, providing a central source of information to avoid possible conflicting information from other sources. This agronomists' guide will continue to be updated.

Future work: A future project will start in towards the last quarter of 2021, with further work and assessments on the sites.

4. Results

4.1 Activity 1: Establish a project Reference Group and ensure methodologies are aligned

The PRG was made up of the following industry representatives, plus two members from AHR. The PRG kept in close contact with other project teams, including the QDAF and NSW DPI teams. Membership of the committee is outlined in Table 4-1.

Table 4-1 Project reference group member details

Name	Organisation	Position / Expertise
Will Wilson	Calliope Station	Producer
Don Loch		Pasture species specialist
Neil Sutherland		Agronomist
Greg Palmer	Matrix Professionals	Expertise in Pasture dieback
Graham Pearson		Producer
Jacob O'Brien	P.G. Wrightson Seeds	Agronomist pasture species specialist
Geoff Maynard		Producer
John Baker		Producer
Felice Driver	MLA	Program manager
Gordon Rogers	AHR	Agronomist
Naomi Diplock	AHR	Pathologist with pasture experience

An initial meeting of the PRG was held on 13 November 2020. Discussion points included site preparation (e.g. use of Roundup), treatments (fertiliser type, cultivation vs direct drill vs stick raking), timing of treatments (e.g. burning when female mealybugs are above ground, planting soon after rain) and useful species.

A number of changes were made to the proposed treatments resulting from this discussion, particularly the use of stick rakes instead of full cultivation; cultivation can only be applied to limited sites (possibly 15-20% of affected properties) and is far more expensive than stick raking. The use of burning was discussed and rejected, as was broadcasting mixtures of low-cost pasture species, at least during ongoing dry conditions.

There was significant discussion of pasture species that should be trialled, and as a result the list of potential species has been modified significantly. A master grass, legume and forage species list was updated and sent to pasture species specialist Dr Don Loch for review and improvement. This pasture list was updated throughout the project and has become a valuable resource for collecting and communicating best practice information relating to species tolerance to dieback. The pasture list can be found in Appendix 3: Species summary.

4.2 Activity 2: assess previous MLA field trials

4.2.1 Biggenden

The site was assessed on 12/10/2020. Conditions were extremely dry (Figure 4-1), with no significant rain received since January, and no rain at all for the preceding 18 months. This made it difficult to accurately assess treatment effects. Communication with the grazier has indicated that poor rainfall has resulted in little growth, as such, no further assessments have been made.

Figure 4-1: Trial site at Biggenden, showing weedy, dry conditions and bare ground.

Treatment effects were generally inconsistent. For example, although ‘cultivate + legume mix’ had one of the lowest dieback scores, ‘cultivate + legume mix + 150 DAP’ had the highest dieback score. However, it was noted that treatments that had been burnt generally had higher dieback scores than those that were not burnt. Also, although the ‘control’ had a moderate dieback score, these quadrats were mainly populated with angular grass and couch. In general, cultivated areas sown with pasture or pasture + legume had the best coverage.

A full report on this assessment, with photographic records of treatments, is included in Appendix 1: Summary reports old sites

4.2.2 Jambin

The Jambin site has been visited three times: 9/10/2020, 20/11/2020 and 12/12/2020.

At the October assessment, conditions were extremely dry, with no significant rain since February and heavy grazing.

The grazier commented that following rain earlier in the year, there was good growth, particularly of sabi grass, however dieback was quick to take over. Remnants of sabi grass could be found throughout the trial site. Pastures surrounding the trial site appeared thicker and less impacted by dieback, dominated by green panic and Biloela buffel.

All treatments with the addition of 150DAP exhibited a higher dieback rating than the equal treatment without. Burnt treatments did not have significant active dieback present, however, were high in weeds and Biloela buffel. Cultivated treatments were heavily infested with weeds (thistle, cotton bush, creeping lantana), with poor pasture growth and prominent dieback.

The site received 70 ml of rain in late October, so although the ground had dried by the second assessment, more green material was evident (Figure 4-2). Much stronger treatment effects could now be discerned.

Figure 4-2. Trial site at Jambin on 9/10/2020 (left) and 20/11/2020 (right). Weeds are most prevalent in areas which have been cultivated.

Treatments that were cultivated and sown with a pasture and/or legume mix generally displayed good recovery and few symptoms of dieback. In contrast, those that were cultivated then allowed to regenerate naturally had higher dieback ratings. All treatments that included burning had less useful coverage or were similar to the untreated controls.

While no pasture mealybugs were found, significant numbers of Rhodes grass mealybugs were observed, mostly on sabi grass. However, numbers of mealybugs did not appear to correlate with observed dieback symptoms; for example, 'cultivate + buffel + 150 DAP' averaged 7.4% leaf reddening but only 0.4 mealybugs/quadrat (Figure 4-3).

Excitingly, the treatments that were looking most promising after eight months still provided the best ground cover at the assessment three years after the trials were set up. Replanting with legumes or with Rhodes/Buffel grass + legumes + added fertilizer were essentially the best treatments, while burning and cultivation were the least effective.

It will be interesting to see if this pattern is repeated at other trial sites over time, and if this is the case, it will increase the value of data collected in the earlier assessments as a predictor of long-term effects on productivity.

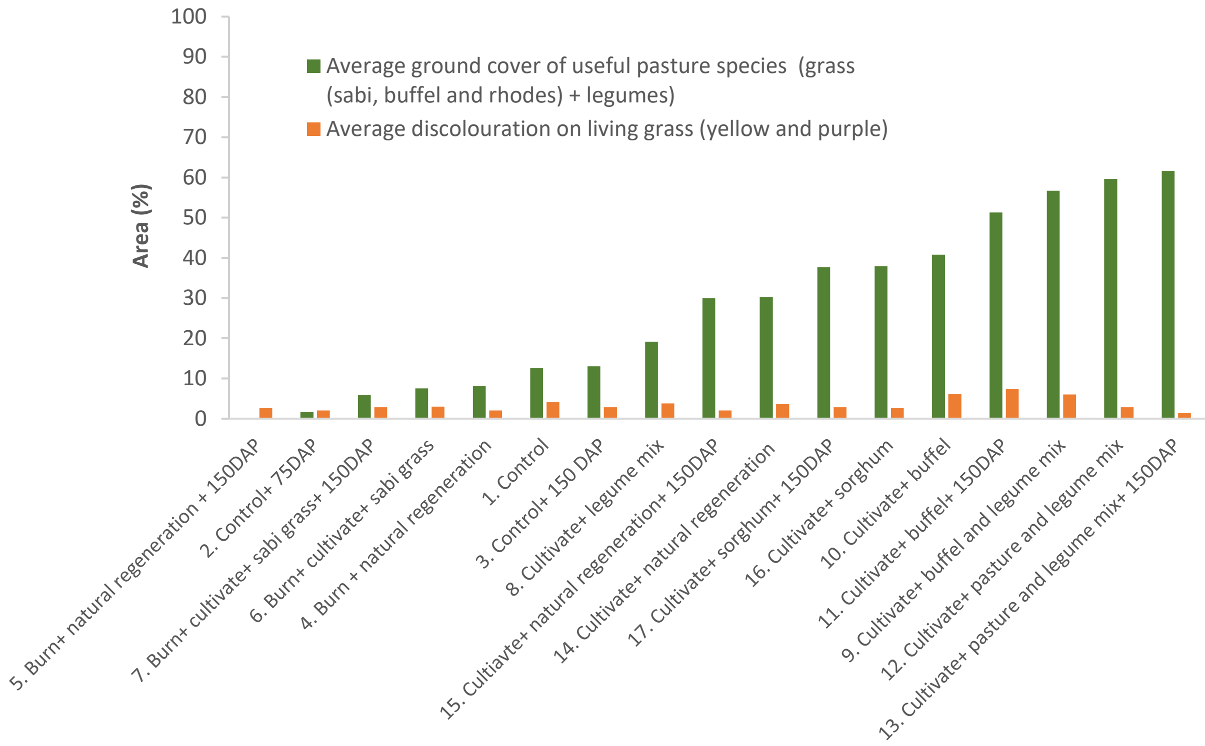

Figure 4-3. Useful pasture coverage and dieback incidence three years after treatment

The assessment on 12 December focussed on mealybugs and dieback rather than treatment. Again, no pasture mealybugs were found on dieback affected grasses, but up to 100 Rhodes grass mealybugs were observed on clumps of sabi grass and black spear grass. Small numbers (2 per clump) were found in USA Buffel grass.

A full report on this assessment, with photographic records of treatments, is included in Appendix 1: Summary reports old sites

4.2.3 Middlemount

An assessment of the Middlemount trial site was conducted on 8/10/2020 and again on 17/01/2021. During the first assessment the property was in drought, and cattle had been grazing what little vegetation was present. As found previously, cultivation combined with pasture or pasture and legumes provided the best results, whereas cultivation without re-sowing resulted in increased dieback. However, at this site no treatments were significantly better than the untreated controls. This result may be due to the dry conditions; all grass was dead and dry, but differences were assessed on the basis of golden compared to grey colour.

The second assessment in January was following rainfall with significant growth since the last visit. Ground coverage was high across all treatments, with Indian couch commonly invading areas that had been killed off by dieback (Figure 4-4).

The cultivate + pasture and legume mix gave the highest useful species coverage score, with good ground coverage. The treatment that appeared to be most significantly impacted by dieback was 'cultivate + fertilise + natural regeneration.' This also appeared to be impacted most prominently across other trial sites.

As observed in the previous assessment, clumps of floren bluegrass did not appear to be impacted by dieback, however ground was covered in thatch/Indian couch between these clumps. Communications with the grazier two weeks after that assessment indicated that floren bluegrass had begun to show dieback symptoms.

Assessment of dieback symptoms showed American buffel grass to be displaying significant discolouring (Figure 4-5). Other useful species appeared to be generally free from any significant yellowing/purpling.

Control treatment 1 did not appear to be as significantly impacted by discoloration as other treatments, however application of fertiliser in treatments 2 and 3 appeared to increase dieback incidence. During the previous assessment a large circle of dieback was noted in the control + 75DAP treatment with smaller scattered patches in the control + 150DAP. This circle was now colonised by a good cover of butterfly pea, among weeds. While not intentionally planted here, this is neighbouring the legume treatment. and may have self-seeded. This would suggest that an established legume crop may be a viable option in dieback impacted pastures.

Treatments 9-10 were fenced off separately, as they were more heavily grazed areas surrounding a watering point. These showed good coverage of Biloela buffel, with a small amount of yellowing. Sabi grass was also scattered throughout these treatments, showing little sign of dieback.

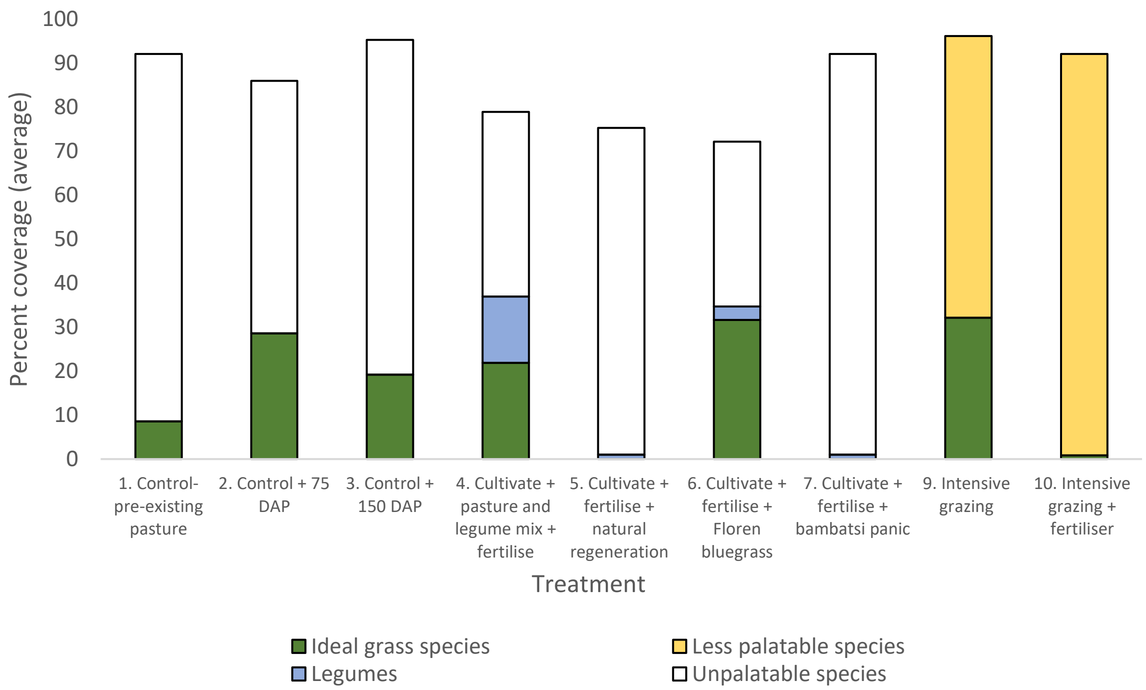

Figure 4-4. Impact of treatment type on presence of discoloration (when rated as % of grass discoloured in quadrat). n=5. Note: In this assessment ideal grass species = American buffel, Gayndah buffel, Floren bluegrass, Bambatsii panic; Less palatable = Biloela buffel; Unpalatable = Indian couch.

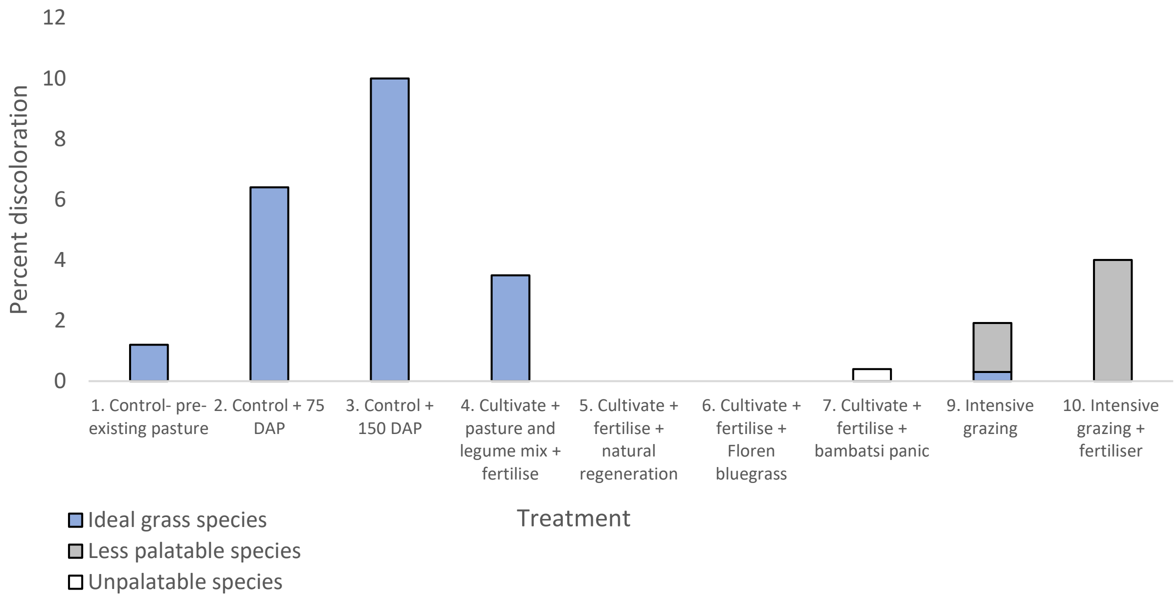

Figure 4-5: Impact of treatment type on presence of discoloration (when rated as % of grass discoloured in quadrat). n=5. Note: In this assessment ideal grass species = American buffel, Gayndah buffel, Floren bluegrass, Bambatsii panic; Less palatable = Biloela buffel; Unpalatable = Indian couch.

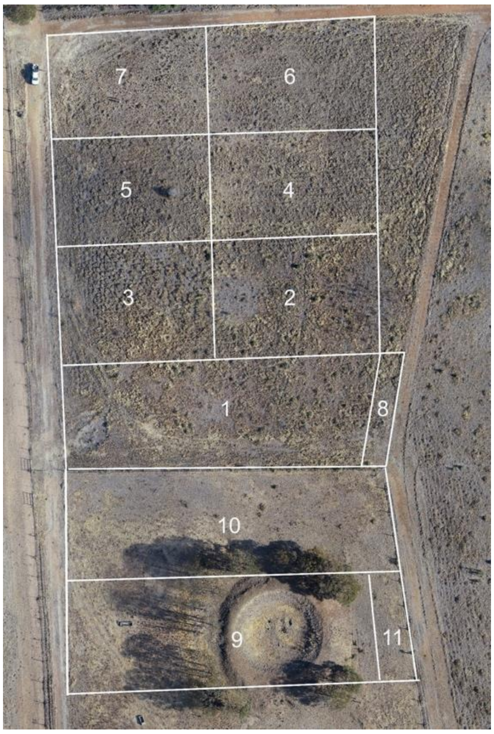

Figure 4-6: Orthomosaic map of the Middlemount trial site (8/10/20) as captured by the drone with overlay of trial layout. Note fence line separating treatments 9-11 from the rest of the trial, this area was heavily grazed. Treatment 8 and 11 may be incorrectly located.

A full report on this assessment, with photographic records of treatments, is included in Appendix 1: Summary reports old sites

4.2.4 Gogango

The Gogango site was assessed on 7/10/2020. Conditions were dry (Figure 4-7) and cattle had been grazing the area.

Large numbers of parthenium seedlings were found throughout the trial site: the grazier commented that these were usually outcompeted by pasture growth, but dieback has made this a problem. Although control sites often had greater ground coverage, these were frequently weedy. While significant bare areas were found in areas which had been cultivated and resown, this may have been due to cattle grazing. Results were generally inconsistent, with few significant differences among the treatments. No further assessments could be made at this site due to the property being sold.

Figure 4-7. Treatment site at Gogango.

A full report on this assessment, with photographic records of treatments, is included in Appendix 1: Summary reports old sites

4.2.5 Wowan

The site at Wowan was visited but not assessed. Some of the trial blocks had been sprayed with insecticide, potentially influencing the results. Moreover, conditions were extremely dry (Figure 4-8), preventing any expression of treatment differences.

Figure 4-8. Trial site at Wowan, showing the extremely dry conditions still present in November 2020.

4.3 Activity 3: Assess and select four trial sites covering southern and northern regions, heavy clay and light soil types

4.3.1 Theodore

Dieback symptoms where first noticed on the property in 2016. Symptoms at the trial site were initially found in 2019.

The site at Theodore was selected and marked out on December 11th, 2021. The site is grey cracking clay with a pH of 7.5 – 8. This site was chosen due to the presence of widespread dieback on the site. Severe dieback and presence of pasture mealybug (*Heliococcus summervillei*) were observed at the site. Pasture mealybugs and ground pearl have been found during site selection, trial establishment and first assessment.

4.3.2 Jambin

Dieback was first noted on the Jambin property in March 2017 following a visit to another dieback affected property. Dieback may have been present on the Jambin property earlier than this, however, was only identified upon return from being shown dieback affected pastures. No *H. summervillei* have been found on the Jambin property. Although the grazier noticed white specks on the roots and assumed these to be mealybug, this was uncertain. *Antonina graminis* have been identified at several locations on his property in areas displaying typical dieback symptoms. Dieback was first noticed in the trial paddock in late 2017, with large stands of grass dying unexpectedly. The site was burnt in a wildfire in early November 2020 with fresh growth showing typical dieback symptoms.

The site at Jambin was selected on 19 November 2020 and marked out on 15 January 2021. This site was chosen due to widespread active dieback in buffel grass. The site has a brown sandy loam, with a pH of 6.0. No pasture mealybugs (*Heliococcus summervillei*) have been identified at this site, however Rhodes grass mealybug (*Antonina graminis*) have been found on both buffel grass and sabi grass (*Urochloa mosambicensis*) at this site as well as on black spear grass (*Heteropogon contortus*) in an adjacent paddock. It is possible that *H. summervillei* are present and have not been found due to being deep in the soil, as they have been known at two metres below ground.

4.3.3 Gaeta

Dieback was first observed on this property in January 2016 as a large dead patch that appeared in a short amount of time. The trial site first showed dieback symptoms from October 2017 to March 2018.

The site at Gaeta was selected and marked out on 17 February 2021. This site was chosen due to widespread active dieback in bisset bluegrass (*Bothriochloa insculpta)*. Severe dieback with grey 'dusty' grass was present at the site. Large numbers of pasture mealybug were observed at the site. Pasture mealybugs and ground pearl have been detected during every subsequent visit to the site.

4.3.4 Biggenden

Dieback was first observed by the grazier at on his property in 2017. This started as a single patch in one paddock, and a small patch by the house. The dieback at the trial site was first observed on 4 February 2021 during a scout for an appropriate site.

The site at Biggenden was selected and marked out on 20 February 2021. This site was chosen due to widespread active dieback in bisset bluegrass (*Bothriochloa insculpta*). Severe dieback and large numbers of pasture mealybug (*Heliococcus summervillei*) were observed at the site, with a thick white powder coating shoes and clothes on the initial visit. The site at Biggenden was chosen as the most coastal site, with a brown-yellow clay soil and pH of 6.2.

4.4 Activity 4: Best-practice Pasture agronomy trials

4.4.1 Theodore

A 50 cm^2 quadrat was representatively randomly placed in each plot. Two quadrat assessments were taken in each plot, giving a total of eight assessments per treatment.

While a larger number of parameters were recorded, this report will focus on plant type coverage for the best overview of what was seen in the field.

It was difficult to detect new germination in the management trial. While few seeds were found to have germinated, these were not counted due to the inaccuracies of counting in long grass and weeds. The most notable weed at this site is parthenium. The allelopathic nature of parthenium is possibly influencing germination of seeds; as well as potentially hiding germinating plants. As shown in Figure 4-9 and Figure 4-10, parthenium and buffel grasses are present in large proportions in each management type. It should be noted that in the incidences where legumes have been added, relatively high levels of germination and establishment have occurred (Figure 4-10). Further assessments over time are required to determine the impact of these treatments in dieback affected areas.

For further detail and photos see Appendix 2: Summary reports new sites

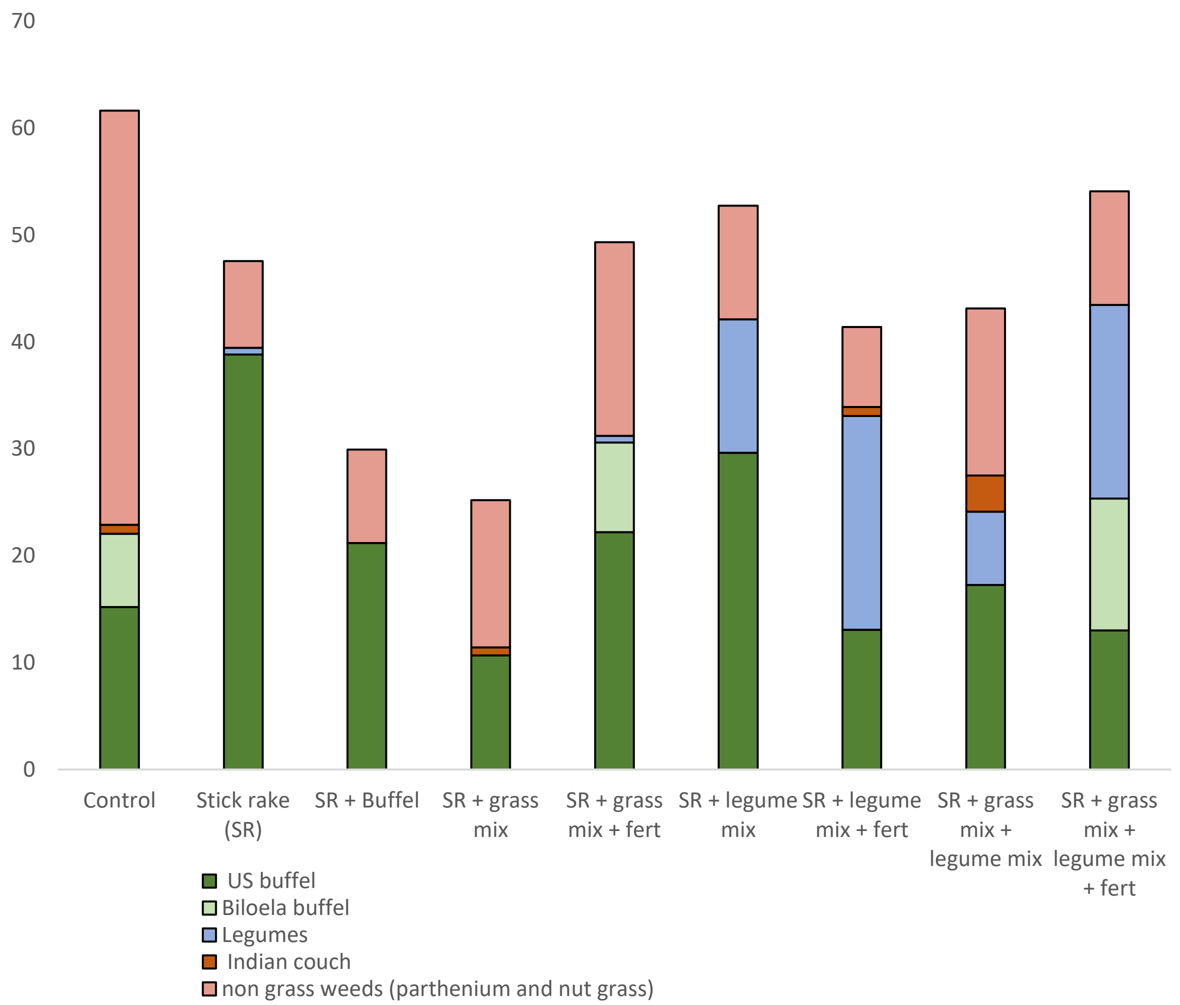

Figure 4-9: Average plant type coverage in the Theodore management trial using 50 cm x 50 cm quadrat. n=8

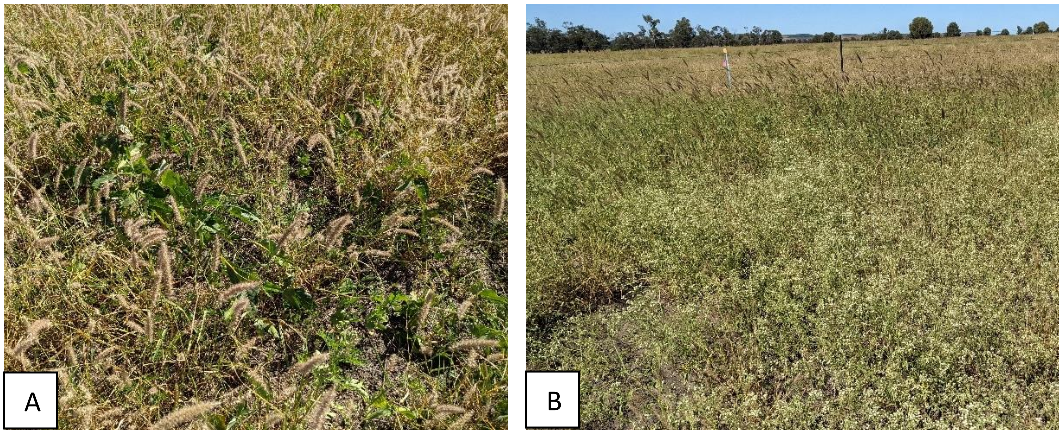

Figure 4-10: Legumes growing among yellowing buffel. Theodore Management trial 19 April 2021 (A); Severe infestation of parthenium in management trial (B), Theodore, 19 April 2021

4.4.2 Jambin

A 50 cm^2 quadrat was representatively randomly placed in each plot. Two quadrat assessments were taken in each plot, giving a total of eight assessments per treatment.

While a larger number of parameters were recorded, this report will focus on percentage coverage for the best overview of what was seen in the field.

The highest number of germinated seeds were seen where legumes had been sown. It was too early to assess the impact of fertiliser application on these treatments.

This site is dominated by pre-existing grass. Where pasture mix has been sown there has been some growth of new grass, however assessments were difficult in areas of dense pre-existing grass. Legumes demonstrated relatively good establishment. Where grass seed has been sown, recently germinated grass has recorded less coverage than the control due to growth being at an early stage. (Figure 4-11).

These figures may be misleading as it was difficult to assess new germination in plots with high percentages of pre-existing grass (Figure 4-12). Freshly germinated grass only covered a small percentage of the plot due to plants being small, so further assessments over time are required for a clearer result.

All grass appears to have recovered well from previously noted dieback symptoms.

For further detail and photos see Appendix 2: Summary reports new sites.

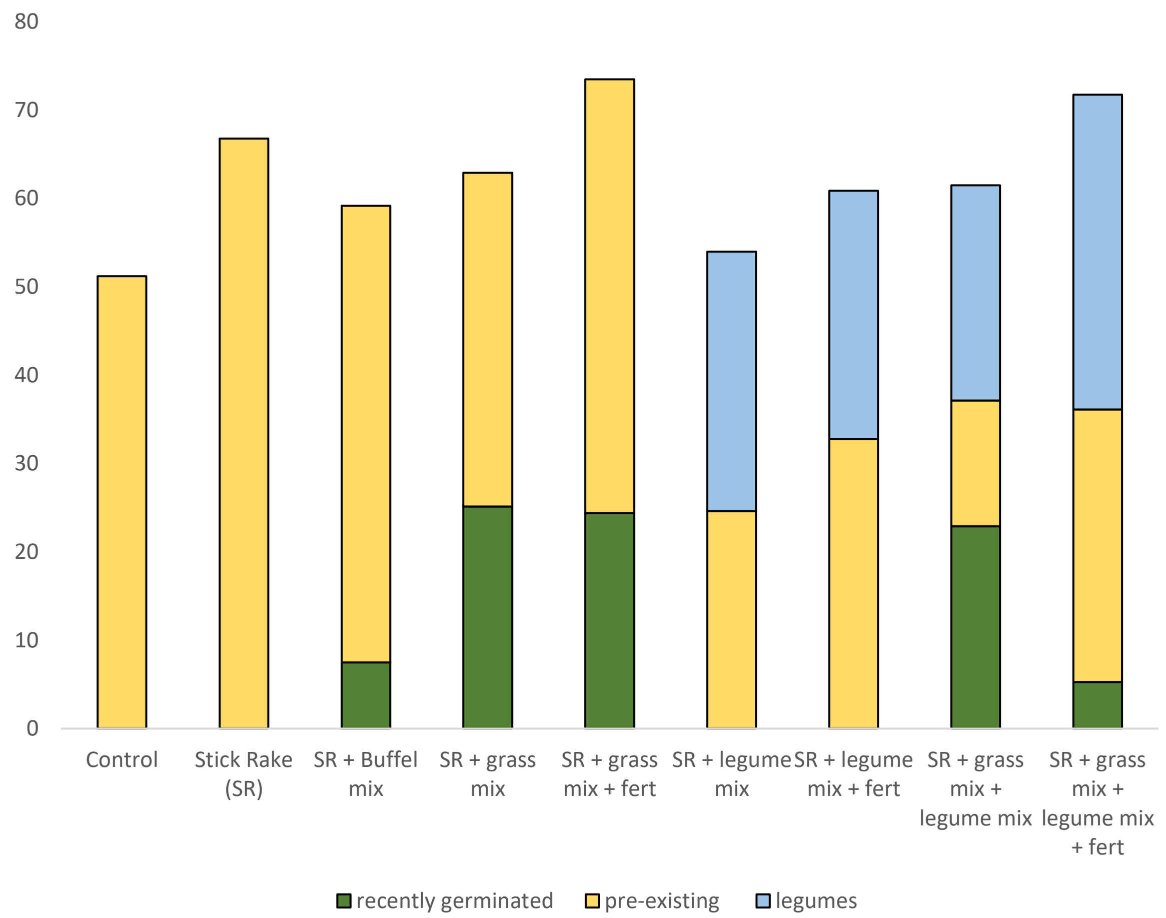

Figure 4-11: Seedling count in Jambin management trial using 50cm x 50cm quadrat 20 April 2021. n=8

Figure 4-12: Management trial at Jambin, note trial is predominantly covered by buffel grass (A) and good growth of legumes growing under buffel (B)

4.4.3 Gaeta

A 50 cm^2 quadrat was representatively randomly placed in each plot. Two quadrat assessments were taken in each plot, giving a total of 8 assessments per treatment.

While a larger number of parameters were recorded, this report will focus on percentage coverage because the grass was too big to count effectively, making percentage cover the best overview of what was seen in the field.

The best coverage was seen in the grass and legume mixes. It is too early to assess the impact of fertiliser application on these treatments (Figure 4-13).

Good growth has occurred in recently germinated grass in plots where cultivation has been conducted (Figure 4-15). Good legume growth has been observed where it has been sown. While good coverage is present on the control, cultivate +scarify, scarify + bisset (+/- fert) there is also significant discolouration in the grass (Figure 4-14). Varying numbers of mealybugs were found in these plots. Contrasting this, plots where grass (excluding bisset) and legume mixes have been sown there is noticeably less discolouration in the grass, only one mealybug was found in one quadrat across all grass (excluding bisset) and legume mix treatments (Figure 4-14).

For further detail and photos see Appendix 2: Summary reports new sites.

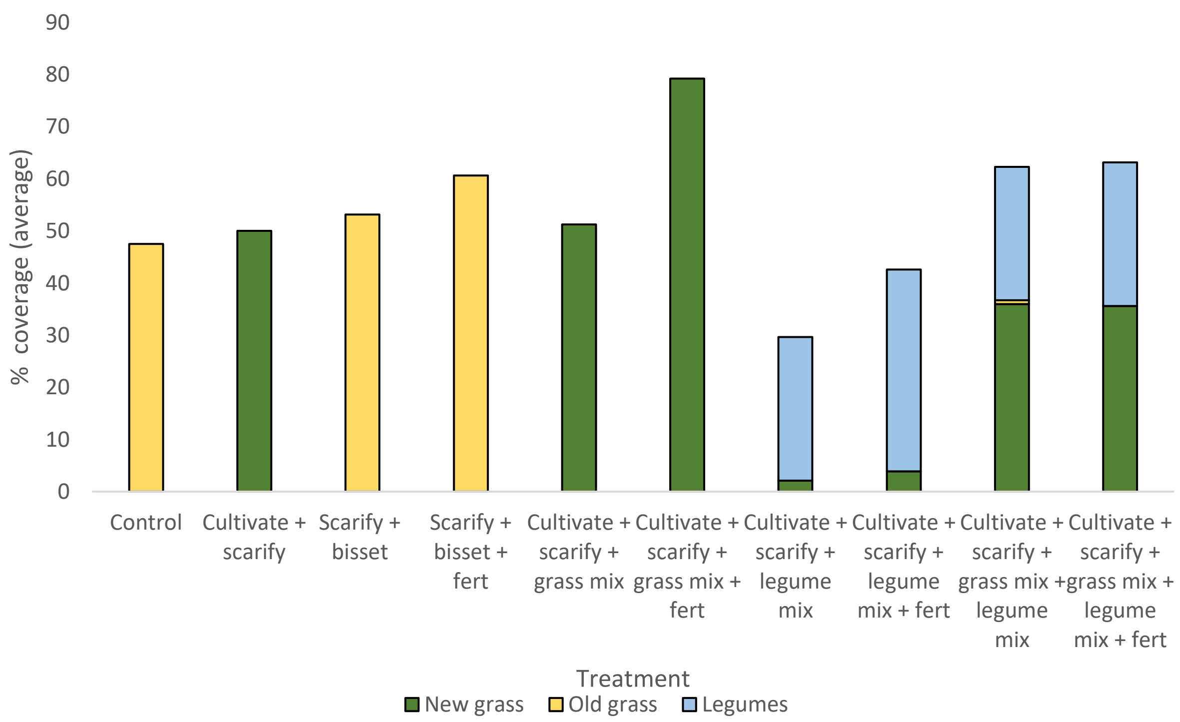

Figure 4-13 Percentage plant coverage in management trial using 50 cm x 50 cm quadrat in Gaeta trial April 2021. n=8

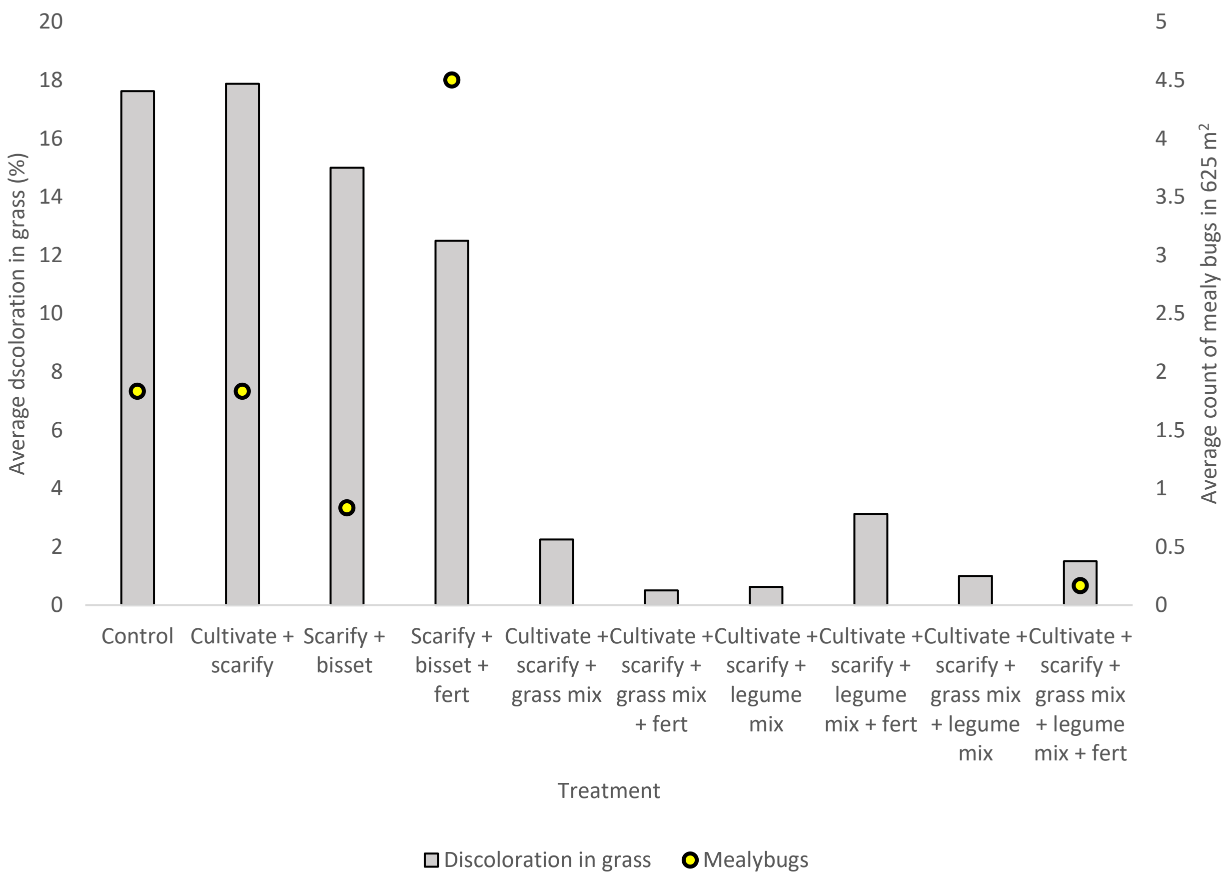

Figure 4-14 Discoloration percent and numbers of mealybugs observed in grass in Gaeta trial April 2021. n=8

Figure 4-15: Management trial at Gaeta, April 2021. Note good grass and legume growth

4.4.4 Biggenden

A 50 cm^2 quadrat was representatively randomly placed in each plot. Two quadrat assessments were taken in each plot, giving a total of eight assessments per treatment.

While a larger number of parameters were recorded, this report will focus germination counts of recently germinated grass for the best overview of what was seen in the field.

Control plots displayed poor grass growth, with only small numbers of pre-existing bisset remaining (Figure 4-16). While plant coverage was higher in control plots this was due to significant coverage by Wyn cassia which had become persistent in dieback affected areas on this property (Figure 4-17). The highest numbers of germinated seeds were seen in the grass and legume mixes. It was too early to assess the impact of fertiliser application on these treatments (Figure 4-16)

While seedling counts in many of the treatments show promise of good coverage, poor growth has been observed. This may be attributed to insufficient rainfall following planting. Further assessment of the trial should be undertaken to assess the longer-term impacts of these treatments.

For further detail and photos see Appendix 2: Summary reports new sites.

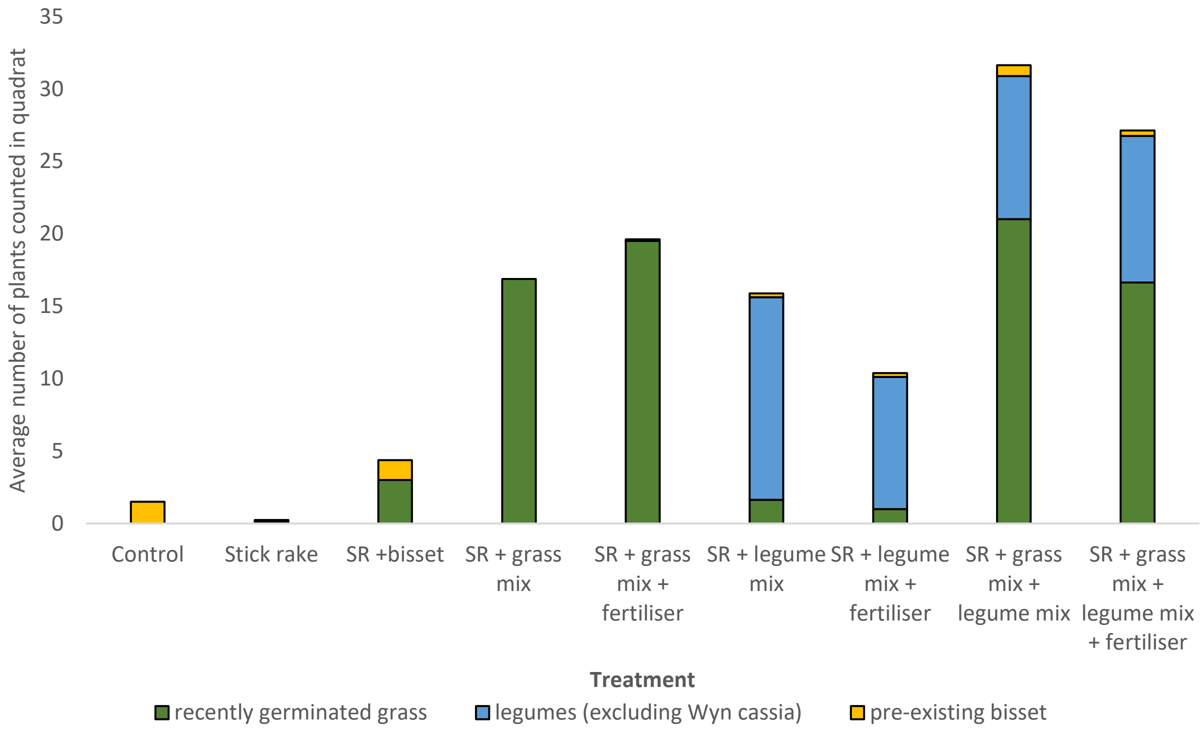

Figure 4-16 Plant count in management trial using 50cm x 50cm quadrat at Biggenden. n=8

Figure 4-17: Management trial at Biggenden. Note Wynn cassia dominating many of the plots

4.5 Activity 5: Field Trials to evaluate pasture species/Varieties for resistance to dieback

4.5.1 Theodore

Numbers of seedlings were counted in the variety trial plots, with varying degrees of germination observed (Figure 4-18). Efforts were made to exclude counts of seedlings that could be identified to most likely be buffel (except for buffel specific treatment). Plots were weedy with a significant infestation of parthenium (Figure 4-19). One quadrat in each plot was counted for freshly germinated seed (four quadrats per variety). Good germination was observed in Strickland digit grass compared to other treatments. Poor results in some varieties may be a result of poor-quality seed, as well as allelopathic impacts of parthenium. Arrangements have been made with the grazier to spray this plot to minimize further impacts of weeds. Follow up assessments are required over time to assess the impact of dieback on these varieties.

For further detail and photos see Appendix 2: Summary reports new sites

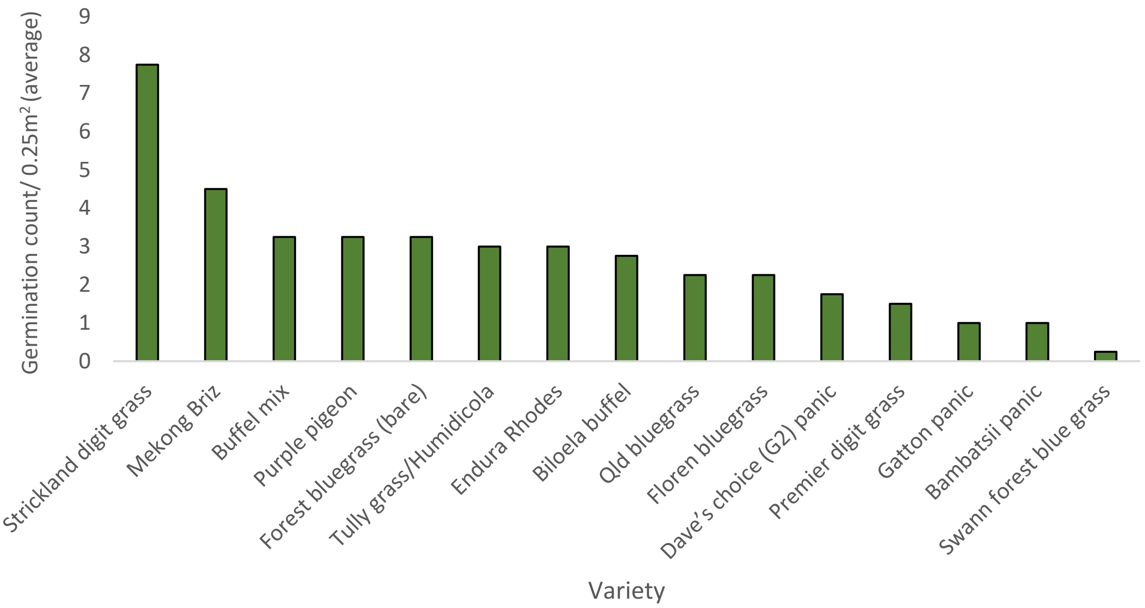

Figure 4-18 Germination counts in the Theodore variety trial (50 x 50 cm quadrat). n=4

Figure 4-19: Purple pigeon grass germination in Theodore variety trial (50 x 50 cm square quadrat) 19 April 2021. Note severe infestation of parthenium

4.5.2 Jambin

Number of seedlings were counted in the variety trial plots, with varying degrees of germination observed (Figure 4-20). Efforts were made to exclude counts of seedlings that could be identified to most likely be buffel (except for buffel specific treatment). Plots were not weedy and good growth was observed in many varieties (Figure 4-21). One quadrat in each plot was counted for freshly germinated seed (four quadrats per variety). Poor results in some varieties may be a result of poor-quality seed. Strickland digit, purple pigeon, premier digit and Bambatsii panic each had germination rates exceeding 15 plants/0.25 m2. Follow up assessments are required over time to assess the impact of dieback on these varieties.

For further detail and photos see Appendix 2: Summary reports new sites

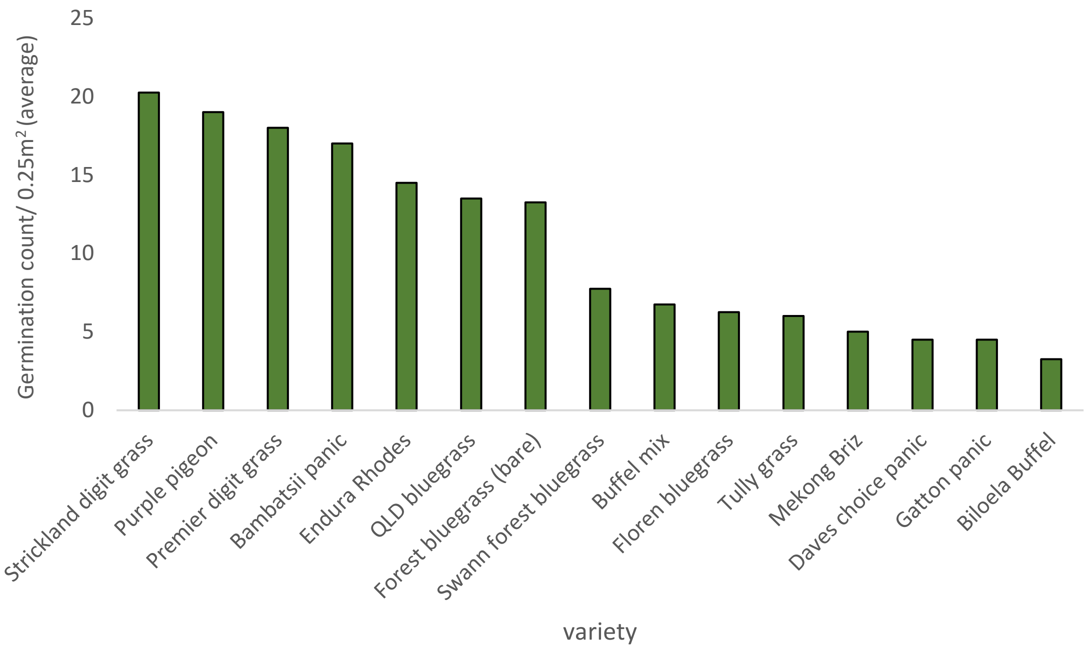

Figure 4-20 Germination counts in variety trial at the Jambin site (50 x 50cm quadrat). n= 4

Figure 4-21: Variety trial, Jambin, 20 April 2021. Note good growth in many plots (A); good germination and growth in purple pigeon (B).

4.5.3 Gaeta

Number of seedlings were counted in the variety trial plots, with varying degrees of germination observed. Efforts were made to exclude counts of seedlings that could be identified to most likely be bisset (except for bisset specific treatment) (Figure 4-22). Germination counts varied between treatments, with good growth observed in those with good germination. Plots varied in number of weeds, with those with poor grass germination having much higher numbers of weeds. One quadrat in each plot was counted for freshly germinated seed (4 quadrats per variety). Purple pigeon grass (Figure 4-23) and Forest bluegrass exhibited good germination, with the control grass (bisset) performing poorly in comparison (Figure 4-22). Poor results in some varieties may be a result of poor-quality seed. Follow up assessments are required over time to assess the impact of dieback on these varieties.

For further detail and photos see Appendix 2: Summary reports new sites

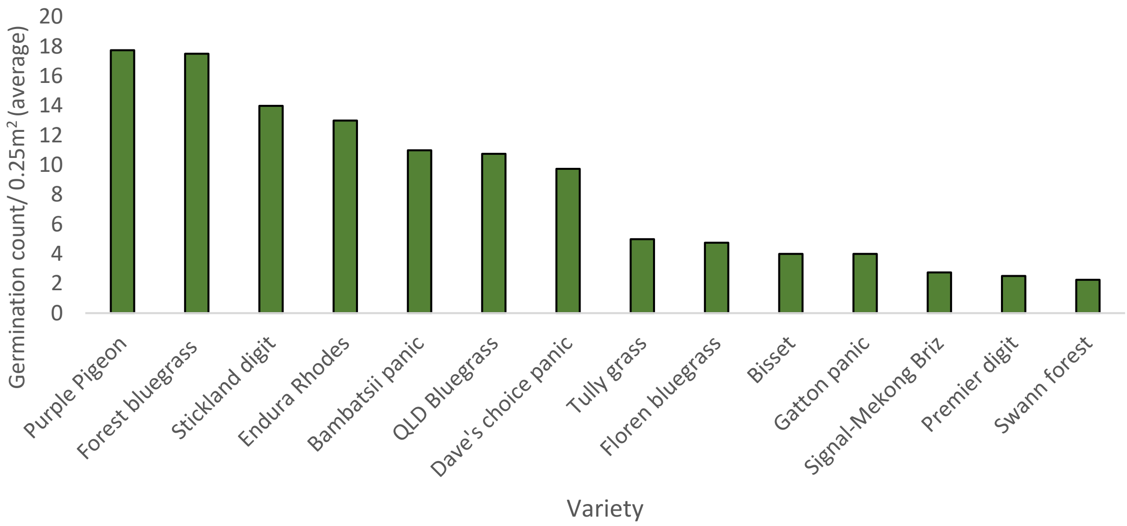

Figure 4-22 Germination counts in variety trial at Gaeta (50 x 50 cm quadrat). n=4

Figure 4-23: 50 x 50cm quadrat of purple pigeon grass in Gaeta variety trial, 26 April 2021 (A); Variety trial at Gaeta. 26 April 2021. Note varying degrees of germination, growth and weediness between plots (B)

4.5.4 Biggenden

Seedling numbers were counted in the variety trial plots, with varying degrees of germination observed. Efforts were made to exclude counts of seedlings that could be identified to most likely be bisset (except for bisset specific treatment) (Figure 4-24). Plots were not weedy and remained relatively bare, with freshly germinated seeds just emerging (Figure 4-25). One quadrat in each plot was counted for freshly germinated seed (4 quadrats per variety).

Strickland digit grass gave the highest germination rates with an average of 48 plants per 0.25 m^2 while the control grass (bisset) gave very poor germination rates (0.75 plants/0.25 m^2). Poor results in some varieties may be a result of poor-quality seed. Follow up assessments are required over time to assess the impact of dieback on these varieties.

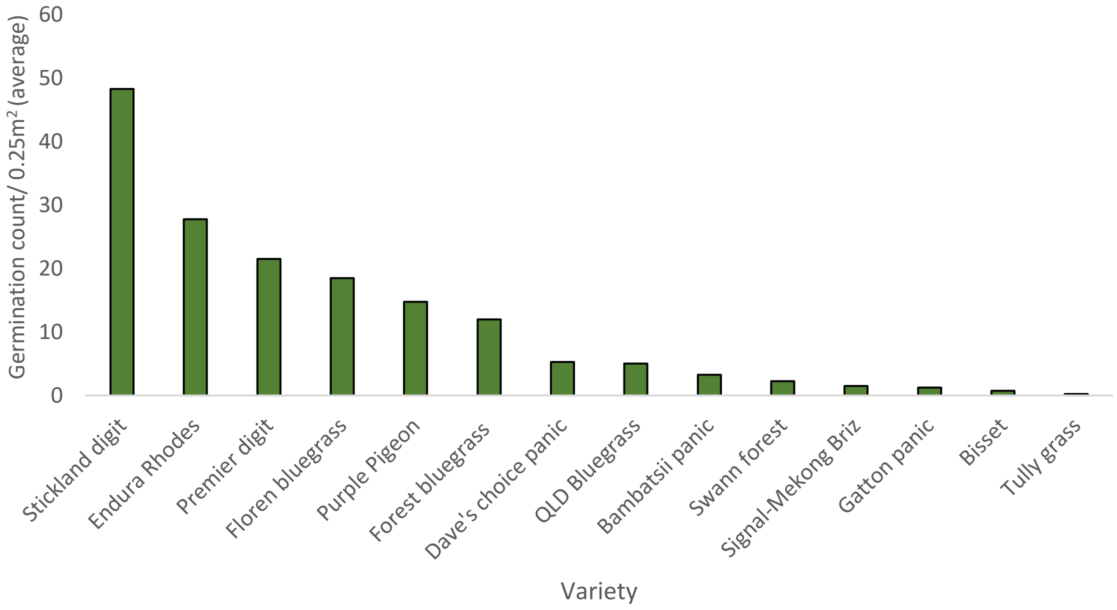

Figure 4-24 Germination counts in variety trial at Biggenden (50 x 50cm quadrat). n=4

Figure 4-25: Purple pigeon grass germination in variety trial (50x50cm square quadrat). 27 April 2021

4.6 Activity 6: Production of agronomists' guide

An agronomists' guide was produced. It was printed and distributed by MLA at Beef Week in 2021. The guide was also published online on MLA's website and can be found here.

Feedback at Beef Week was positive. Online distribution can be assessed by looking at MLA's website traffic to the report.

4.7 Activity 7: Communicating results

During May 2021 Beef Week, a range of presentations were made on pasture dieback. AHR conducted one to a sold out audience of 225 people. Feedback from the audience at AHR's presentation was strongly positive. David Beatty (MLA) said: "Consistent messaging and a clear plan to tackle this complex and debilitating condition has been appreciated by producers".

5. Conclusion

The project is progressing as planned, despite some impediments. The previous trial sites are yielding valuable information regarding the long-term effects of interventions including burning, cultivation, resowing with various grasses and/or legumes and application of fertiliser, as well as combinations of these.

New trial sites are underway. Recent rain allowed new pastures and legumes to establish at these sites following sowing, according to the treatment schedule. A range of native and introduced species have been selected for testing for tolerance of pasture dieback. Further assessments over time are required to assess the impact of dieback on these treatments.

Finally, the agronomists' guide has been completed and was released by MLA during Beef 2021, both online and as a printed resource. While the guide contains the best management advice now available, it will be reviewed and updated as the project progresses. Updated information will further increase its value to agronomists and graziers.

5.1 Key findings

- Assessment of previous MLA field trial sites indicated that treatments combining cultivation and resowing with a grass and/or grass and legume mix generally gave the best results in useful plant coverage. Cultivating and allowing for natural regeneration resulted in a higher weed incidence, and more dieback expression.
- In the four new trial sites, early assessments suggest that grass and legume mixes will give the best results in terms of minimising dieback expression and providing good, useful coverage. Stick raking has resulted in creating a seed bed adequate for legume germination. Grass seed germination in management trials may have been outcompeted by pre-existing grass and weeds in some areas however further assessments are required to determine effectiveness of this treatment. The weediness of an area may impact the effectiveness of these treatments and needs to be considered when sowing legumes.
- Dieback symptoms were evident in pre-existing grass in three of the four trial sites, with grass mix and grass and legume mix treatments not showing symptoms in recently germinated plants.

- Variety trials have had varying degrees of germination. Low seedling numbers in some varieties are most likely a result of poor-quality seed. Further assessments are required to assess the impact of dieback on these varieties.

5.2 Benefits to industry

The project delivers the following important findings:

It confirms that legumes are not susceptible to dieback.

Cultivation (or stick raking), then re-seeding with a legume or pasture plus legume mix, and fertilising with 150kg/ha DAP, has provided the best productivity (so far) on dieback affected pastures.

Urea is not useful. Instead, apply products that include phosphate such as MAP or DAP, and use soil test results to guide fertiliser mix and application rates.

Burning, or cultivating without re-seeding, are likely to have only short-term benefits and can increase dieback and/or weed growth.

Simple strategies, such as stick raking can be used for removing the bulk of dieback affected plants and resowing areas with improved grasses and legumes.

6. Future research and recommendations

Long term observations of field trials should be carried out to assess the effectiveness of these treatments over time.

A list of “best bets” for managing dieback were proposed in the agronomist guide. These included:

- Biosecurity
    - Restricting access to dieback affected paddocks
    - Avoiding feed from dieback affected areas
    - Limiting movement of cattle from dieback affected areas
    - Limiting access of vehicles
    - Planting windbreaks, especially downwind of dieback affected areas
- Insecticide
    - Using insecticide as an early intervention
- Biological control
    - Encourage beneficial insects such as *Cryptolaemmus* by increasing pasture diversity
- Agronomy
    - Look at grazing management strategies to promote pasture productivity

These “best bets” will need to be trialled to confirm if they provide some impact on pasture dieback.

7. References

Buck, S., 2017. Pasture dieback: Past activities and current situation across Queensland (2017).

Makiela, S., 2008. Studies on dieback of buffel grass (*Cenchrus ciliaris*) in Central Queensland (Doctoral dissertation, PhD thesis, Central Queensland University, QLD, Australia).

8. Appendix

8.1 Appendix 1: Summary reports old sites

8.1.1 Biggenden

8.1.2 Jambin

8.1.3 Middlemount

8.1.4 Gogango

8.2 Appendix 2: Summary reports new sites

8.2.1 Theodore 19th April 2021

8.2.2 Jambin 20th April 2021

8.2.3 Gaeta 26th April 2021

8.2.4 Biggenden 27th April 2021

8.3 Appendix 3: Species summary