Summary Report

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Assessment of promising pasture legumes and grasses

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Executive Summary

The objectives for the research

The principal focus of B.NBP.0766 was the field testing of recently developed pasture grasses and legumes (cultivars or yet to be released lines) to develop sown pasture systems which improve the resilience and profitability of beef breeder and grower systems in key beef production regions of north and central Queensland where current options are limited. The overarching target was to overcome marked seasonal deficits in feed quantity and quality which currently limit enterprise productivity in sub-coastal and inland areas characterised by an extended winter dry season. This in turn limits marketing options (sale of weaners and animal growth rates) and the capacity to manage a climate with a high level of rainfall variability. A subsidiary aim was to promote consideration of the adoption of sown-pasture systems through the establishment of evaluation sites and producer engagement across a range of landtypes.

The specific objectives of the project were to:

1. complete multi-site on-property assessments of a range of promising pasture legumes (14 lines from 7 genera) and pasture grasses (18 lines from 9 genera) for beef breeding and finishing systems in seasonally dry areas of north and central Queensland,
2. measure and report establishment, adaptation, seasonal productivity, and acceptability to livestock, and
3. identify the most promising legumes and grasses for increasing productivity and recommend Research, Development and Extension (RD&E) activities required to ensure their value for industry is captured.

The opportunity to address feed deficits through the use of sown pastures

The key focus area of this project (west of Bowen to the Northern Territory border and north to Cape York) contains approximately 30% of the Queensland beef herd with annual turnoff at the farm-gate in excess of $630 M (based on 27% turn-off and mid-2015 average cattle prices of $600 per head). The area contained approximately 3.9 million head at the onset of the project (MLA 2011) (1.8 million breeders) with a turn-off of approximately 1.05 million head per annum.

Breeder productivity (percentage weaning and death rates) and heavier sale weights are recognised profit drivers for the northern beef industry (McLean et al., 2014). A recent economic assessment of businesses in the northern Gulf of Carpentaria found equity, lack of infrastructure and seasonal variability in the quality and quantity of feed to be key factors influencing business profitability and viability (Rolfe et al., 2016). Most of the cattle herd in north Queensland is grazed on native pastures. In sub-coastal and inland areas average annual liveweight gains on unimproved pastures are typically less than 130 kg/head/annum and average stocking rates approximate 1AE :10ha, although this is strongly dependent on soil type(Partridge and Miller, 1991). Reproductive performance is also limited by the native feed resource and highly variable climate, with branding rates commonly ranging from 40 to 65%. Enterprises on eucalypt woodland on light-textured soils in central and southern Queensland, the other geographical zone investigated in this project, face similar challenges. These areas support approximately 510,000 head of cattle with an annual liveweight gain of 130kg/head.

There is considerable scope to improve the profitability of beef breeding and finishing enterprises in northern Australia through the use of sown pastures to improve animal nutrition. This applies principally to areas with of 600+ mm annual average annual rainfall and soils of moderate to high fertility (plant available $\text{phosphorus}_{\text{Colwell}}$ greater than 5 mg/kg). Historical research in north Queensland has demonstrated sown pastures, principally stylos, can lift annual liveweight gain in the 600-800 mm zone in north Queensland from 50-140 kg/AE at 5-25 ha/AE on native pastures to 130-200 kg/AE at a stocking rate of 4.5-2 ha per AE, depending on input levels (Partridge and Miller, 1991; Anon, 1994a, 1994b). The use of legumes sown into grass pastures is also identified as the key method to reverse substantial declines in grass-pasture productivity affecting key beef grazing areas of Queensland (Peck et al., 2011).

Following a decline in government capacity in sown pasture research and development in the last 20 years, and continued demand for pasture plants to benefit grazing systems, a range of methods were employed by government agencies, private companies and universities to identify potentially useful pasture plants for beef production in northern Australia and progress theses towards commercialisation (Cox, 2014). These potentially useful grasses and legumes had not been comparatively assessed in key landtypes in seasonally dry areas of north and central Queensland and beef producers had little objective information upon which to identify grasses and legumes for pasture development.

B.NBP.0766 (2013-2018) was developed to provide reliable independent information on the performance of newer grass and legume cultivars and promising lines compared to older cultivars, where available. The research targeted the establishment of 'weaner' type paddocks on soils of moderate to high fertility broad arc from the southern Gulf of Carpentaria, through sub-coastal districts of north Queensland and into central Queensland.

The research approach and broad methodology

Comparative assessments were completed at 12 research sites representing soils of moderate to high fertility (basalt, duplex, red earth, clay and alluvial soils). These sites represented key vegetation communities used for beef grazing in Queensland including blackspear (*Heteropogon*), midgrass (*Aristida-Chrysopogon*) and bluegrass-browntop (*Dichanthium fecundum*) communities of north Queensland and midgrass (*Bothriochloa-Chloris-Aristida*) community of central Queensland (Tothill and Gillies, 1992). The project was estimated to cover ~ 160 000 km^2 when the sites were matched with soil-type and within 10% of long-term mean annual rainfall and ~ 320 000 km^2 at +/- 40% long-term rainfall. Small (0.8-3.6 ha) sites were prepared in areas considered representative of the local landtype (some cleared, some open woodland). Each site was fenced to restrict cattle and wallaby access and the sites prepared for planting using simple cultivation (discs or tines) to prepare a rough, but weed-free seedbed. Fertiliser phosphorus or sulphur was applied to overcome soil deficiencies.

Up to 29 legumes (*Centrosema* (2 species), *Clitoria* (1), *Desmanthus* (3), *Macrotyloma* (1), *Macroptilium* (3), *Stylosanthes* (4)) and 30 grasses (*Bothriochloa* (3), *Brachiaria* (3), *Dichanthium* (2), *Digitaria* (2), *Panicum* (3), *Urochloa* (1)) were sown into replicated small plots with the selection of lines based on soil type and historical knowledge of the species. The assessed lines included lines representing older cultivars (Seca *Stylosanthes scabra*, Gayndah *Cenchrus ciliaris*) or key native grasses (*Heteropogon contortus*) used as standard industry comparators. Seeds were sourced from either the DAF seed bank at Walkamin Research Facility, Mareeba or commercial companies, and tested to determine sowing rates to achieve suitable populations for comparisons. Appropriate *Bradyrhizobium* legume seed inoculum was sourced and applied prior to sowing.

Once established, the evaluation sites were grazed (if sufficient biomass) or cut at the end of the key growing period and cut again, if required, prior to the onset of the following growing season. Each line was assessed for changes in plant cover, whole-of-season above-ground biomass, plant nutrient content, growth into the dry season, the capacity to produce seeds and acceptance by cattle.

The research was conducted over a period of initially low, followed by out-of-season, rainfall during negative or neutral phases of the Southern Oscillation Index. Establishment (germination and survival through the following dry season) was mostly successful when seeds were planted by hand in rows and covered, despite often low or delayed rainfall after sowing. However, extremely low rainfall resulted in repeated establishment failure on clay soil sites in north-west Queensland for all but a few legumes.

Key results

After four seasons of monitoring (after the establishment year), persistent grasses and legumes were identified for basalt, red duplex and red earth landtypes in north Queensland. Grasses which were persistent across a range of sites included mostly newer lines from *Brachiaria, Bothriochloa, Digitaria* and *Panicum,* along with the standard comparator species *Heteropogon contortus*. The most persistent legumes across sites were *Desmanthus* and *Stylosanthes* (particularly *S. seabrana* and *S. scabra*), whereas *Clitoria* and *Macroptilium* only persisted under more benign growing conditions (higher rainfall and lower grazing pressures). Delays in establishment meant that assessments on alluvial soils were less advanced by the end of the project. Results to date suggest a relatively wide range of grasses and legumes can be sown on these relatively fertile soils and competition from weeds may require careful management. Repeated poor first year survival after germination meant that comparative assessments of grasses and legumes could not be conducted at heavy clay sites in north-west Queensland. Only *Desmanthus* survived after establishment.

The grasses and legumes were also assessed over three years after establishment at brown clay, alluvial and brown duplex soil sites in central Queensland. Many of the same lines of grasses and legumes performed well in north and central Queensland, but there were differences within some genera, particularly *Brachiaria* and *Macroptilium*. A relatively wide range of grasses persisted well, overall. Newer legumes, *Desmanthus* spp. and *Stylosanthes seabrana*, persisted particularly well in central Queensland.

High grass and legume biomass yields were measured at the end of the growing season. This is the period when key classes of livestock (weaners, heifers) require high-quality feed (dry-season or winter feed gap). The more persistent (well-adapted) grasses and legumes mostly produced similar or higher biomass yields to the local comparators but were usually of higher feed value (crude protein and metabolisable energy): *Heteropogon contortus* and Seca *Stylosanthes scabra* were of notably poor quality having high proportions of stem compared to leaf.

Differences between grasses and legumes in flowering times and the capacity to stay green as the dry season progressed were generally consistent across years. The more productive and persistent legumes and grasses mostly grew well into the dry season. Some legumes (*Desmanthus, Macroptilium*) dropped their leaves when conditions became extremely dry in north Queensland, but showed a strong capacity to rapidly produce new growth after rainfall. Leaf drop was less prevalent in central Queensland, and was attributed to a shorter dry season component for rainfall. Early and late flowering grasses and legumes were identified, with the early flowering types usually producing seed over the wet and early dry season and later flowering types mid-dry season. These differences in seeding times have implications for the timing of grazing in order to accumulate seed in soil for the future recruitment of plants.

Plant nutrient analyses were conducted on ungrazed samples collected at the end of the key growing period (early dry season) when most grasses had flowered and shrub legumes had mostly matured and declined in feed quality. The grasses had low values of crude protein (<4%) and metabolisable energy (< 6 MJ/kg) at this advanced growth stage whereas the legumes had values useful for animal production: legume leaf was of particularly high quality (10-18% crude protein and 7.5-10.1 MJ/kg metabolisable energy). The grasses selected for future development were of higher nutritive value than the local standard *Heteropogon contortus*. The herbaceous legumes (*Clitoria, Macroptilium*) tended to have higher feed quality than the shrub legumes and maintained this longer into the dry season. *Desmanthus* tended to have higher metabolisable energy values and *Stylosanthes* higher crude protein.

Grazing assessments were conducted at selected sites in north and central Queensland during the early- to mid- dry season using weaners or non-lactating cows. The grasses and legumes were all grazed by cattle, but there were differences in preference particularly under low grazing intensities. The grasses and legumes showing good persistence at the grazed sites had similar or higher acceptance levels to the key comparators *Heteropogon contortus* and *Stylosanthes scabra*.

Implications of the research for the beef industry and recommendations to support adoption
The key criteria for nominating higher-performing grasses and legumes were persistence for three years under grazing (or cutting) during the early-mid dry season (typical weaning period) and biomass production in the top 25% of lines over the growing season. Grasses and legumes needed to be well-accepted by cattle to be recommended. Feed quality (particularly crude protein and metabolisable energy) was also considered and related to growth stage (seeding) or the capacity to retain green leaf into the dry season.

Grasses and legumes were identified which are persistent, palatable and productive and show considerable promise for developing weaner-type paddocks in north and central Queensland: these may have application to other seasonally dry areas of northern Australia. These performed well compared to historically grown cultivars or native vegetation. The plant biomass and feed quality values achieved, particularly of the legumes in the dry-season, indicate these lines should contribute substantially to animal nutrition in seasonally dry areas and reduce the need for supplementation.

The grasses and legumes were tested in individual plots and grazed or cut at advanced stages of growth: grazing would normally be more frequent. Whilst this approach is considered to have been effective at estimating adaptation to particular landtypes (soil and rainfall) and to group plants by productivity, it has not necessarily described how plants will perform as a grass-legume sward under grazing as would normally occur in northern weaner operations. It is recommended to assess the persistence and productivity of the superior grasses and legumes as mixtures targeting the same landtypes assessed in B.NBP.0766 but using management (establishment and grazing frequency) more similar to commercial practices. These larger research sites would be used as a regional focus for promotion to beef producers.

The higher-performing lines include a combination of relatively recently commercialised grasses (*Brachiaria brizantha* and hybrids) and legumes (*Desmanthus, Stylosanthes seabrana*) plus grasses (*Panicum, Urochloa*) and legumes (other *Desmanthus, Macroptilium*) yet to be released commercially. Seed increase should be undertaken in north Queensland to ensure a supply of seed for plant evaluation as described above and to support the transition to commercial seed production. This will also enable appraisal of seed yields and seed production characteristics of the grasses and legumes under commercial conditions.

Although not all of the higher performing lines are commercially available, previously successful development of weaner paddocks in north Queensland indicates the development of weaner paddocks using the commercially available types has merit. The development of commercial scale demonstration sites across regions to complement other research sites would enable the collection of data suitable for calculating the economic performance of sown pastures, such as seasonal variation in animal liveweight gain, which cannot be measured on replicated small-plot experiments. The grass-legume systems could also be compared (on suitable soils) with tree-legume systems (*Leucaena*, including the newer hybrids) currently being tested in north Queensland. Such sites would act as key extension resources for use in field days, producer training and the development of remotely viewed platforms. They would also provide an opportunity to refine pasture management methods and complete sampling for strategically significant issues including opportunities to reduce livestock methane emissions and soil carbon accumulation through the adoption of sown pastures.

The research has highlighted the potential utility of certain grass and legume taxa, including new sub-species and hybrids particularly within *Desmanthus, Stylosanthes* and *Macroptilium* for legumes and *Brachiaria/Urochloa* and *Panicum* for grasses. Some have proven to be persistent under a series of dry seasons in hot north Queensland environments. These include some legume taxa identified as having significant potential for cultivar development in a recent review of plant evaluation data across northern Australia (Bell et al., 2016). The tropical forages component of the Australian Pastures Genebank, the principal resource for tropical pasture cultivar development in Australia, contains a wide range of these taxa groups. There may be considerable merit assessing this material to develop future sown pastures cultivars for hotter environments with more variable rainfall