Your Levy at Work

Terms of Reference: Consultancy brief

Investigating options for investment in tropical grass variety development using contemporary biotechnological and breeding approaches

Closing date: November 24, 2017

1. Introduction

Recently the implementation of new approaches to grass breeding, such as large-scale observation of plant performance (called phenomics) and DNA based selection (called genomic selection) has led to transformational improvements in the quality of temperate perennial species. Further contemporary approaches, such as gene-editing, have been piloted in other plant species models (tobacco) with the view of applying this technology to pasture breeding.

In comparison, there has been little recent investment in perennial tropical grass breeding (both domestically or globally), with little or no application of contemporary forage development methodologies. This issue is exacerbated by the lack of focus on breeding on tropical grass quality by conventional methods. Historically, governments have been key investors in tropical grass development programmes both domestically and internationally. Typical investment and timeframes needed to develop new forage varieties utilising emerging breeding technologies are over $10 million AUD with a timeframe of more than seven years.

The paper in Appendix 1 provides an overview of the potential productivity gains that could be made with perennial tropical grasses through the application of gene-editing to down-regulate lignin synthesis. These gains are substantial and present a sound business case for future investment for tropical and subtropical dairy industries internationally.

2. Objectives of the Consultancy

2.1 Broad Objective

It is the primary outcome from this consultancy to scope out viable co-investors, both domestically and internationally, to partner with Subtropical Dairy to breed a perennial tropical grass variety delivering a 15% increase in per cow productivity (achieved through greater intake and/or digestibility) by 2029.

2.2 Specific Objectives

Specifically, the Consultancy is expected to deliver the following:

2.2.1. Undertake a desktop scoping study of strategic and operational plans of current investors in relation to tropical grass breeding programmes specifically targeting dairy production, but also incorporating other ruminant industries. Initial contact is to be made with key decision makers in these organisations regarding their potential interest in participation in a joint project. Details regarding their mode of collaboration should also be sought.

2.2.2. Review non-traditional plant breeding investment sources such as climate change, support/aid for developing countries, or other alternate funding that may contribute to the outcome from this project. This may include private companies and established plant breeding organisations.

2.2.3. Provide Subtropical Dairy with relevant critical success factors needed to attract potential investors.

2.2.4. Provide Subtropical Dairy with a strategic overview of the next steps for engaging with potential investors including key contacts in these organisations. Indicate which potential partners or mix of partners are seen as the most likely to fund the work and why. If appropriate, propose how a potential collaborative project might be structured.

3. Qualifications and Competence of Consultant

The ideal Consultant should possess the following:

- Minimum of a Degree in Agricultural or Biological Sciences with expertise in plant breeding
- At least ten years post-graduate experience
- Track record in accessing project funding
- Experience in leadership of cross organisational teams
- Proven track record of consultancy work in project investment

4. Duration of the Consultancy

Deliverables will be required six weeks from the consultancy implementation date.

5. Budget

The Consultancy is capped at $10,000 ex GST including any operating and travel costs.

6. Expected Outputs

6.1 Minimum of 20-page report.

7. Request for Proposal

Please provide a consultancy proposal, maximum 3 pages, outlining your experience in this area, your proposed approach to the project and how you would add value to the project if offered the brief.

Please email your proposal to Dr Brad Granzin, Executive Officer, Subtropical Dairy (brad@subtropicaldairy.com.au) by 5.00 pm EDST Friday 24 November 2017

If you require any further information, please call Brad Granzin on + 61 431197479.

Appendix 1

Potential benefits to dairy industry productivity through breeding more digestible tropical grasses utilizing contemporary approaches

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Abstract

There is increasing demand for dairy products in many tropical countries with emerging economies, such as Indonesia and Brazil. Tropical forages, such as perennial tropical grasses, are key to many of these country's dairy industries. Their high yield and input efficiency makes them a low cost feedstuff. However, their productivity in terms of milk production per cow is low in comparison to temperate forages due to their high concentration of lignified structural carbohydrates. There has been significant genetic improvement in tropical grass agronomic qualities over the last fifty years, but limited progress towards reducing their lignified structure and improving digestibility. More recently there has been a renewed interest in utilising high yielding grasses as potential biofuel feedstocks and overcoming their low fermentability. This paper reports on recent advances using transgenics that have reduced tropical grass lignin content by 1.0 to 1.4 acid detergent lignin % dry matter (16 to 23% of unmodified plants). It also models potential benefits to cow productivity of feeding low lignin tropical grasses and describes potential economic benefits to dairying industries such as northern Australia. This paper also describes other non-transgenic plant breeding techniques that may have potential application and greater consumer acceptance.

Keywords: tropical grasses, plant breeding, lignin, cow productivity.

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Introduction

Between the latitudes of 30 N and 30 S, there are approximately 120 countries producing 37% of the world's milk supply. Dairy cows are the dominant dairy species (66%) in this region (FAO, 2013). Approximately 100 of these countries would be classed as tropical and subtropical non-arid climates with perennial tropical grasses the basis for milking herd diets (FAO, 2014).

Due to various biological efficiencies, well managed tropical grasses are capable of over twice the dry matter (DM) yield of temperate grasses with in excess of 80 t DM/ha.yr recorded (Garcia et al., 2014). Tropical grasses are often a cheap feed source (Garcia et al., 2014).

Under best management, milk yield from unsupplemented, grazing Holstein cows is limited to 16 L/cow.day (Garcia et al., 2014). This is well below yields observed in systems based on temperate forages (Hills et al., 2015). The nutritional limitations of tropical grasses in lactating cow diets are due primarily to their high concentrations of cell-wall components. Lignified structural carbohydrates have two main effects on the lactation performance of dairy cows; intake is limited due to rumen fill, and forage digestibility is relatively low. Both of these factors in combination often means that energy intake is the primary factor limiting milk production per cow (Hills et al., 2015).

Improving cow productivity by reducing forage lignification: Brown midrib (BMR) corn and sorghum

A recent meta-analysis by Ferraretto and Shaver (2015) of BMR corn hybrids [avg. 34% DM intake (DMI)] versus non-BMR varieties showed a 4 % improvement in both intake and milk production (0.9 kg DMI/cow.day and 1.5 L/cow.day, respectively). BMR varieties had lower lignin concentrations (2.0 vs 2.7 % DM) and higher neutral detergent fibre (NDF) digestibility [(NDFD) 58.1% vs 46.7%].

BMR forage sorghum varieties have also outperformed non-BMR varieties when fed (avg. 49% DMI) to lactating dairy cows (Grant et al., 1995, Aydin et al., 1999, Oliver et al., 2004, and Astigarraga et al., 2014). On average, BMR varieties had lower concentrations of NDF (53.9 % vs. 56.9 % DM) and lignin (4.4 vs 5.4 % DM), while NDFD (44.1 vs 51.2%), DMI (24.3 vs 22.4 kg DM/cow.day) and milk yield (28.8 vs 26.1 kg/cow.day) were all increased.

Applying contemporary biotechnology to develop low lignin tropical grasses

Development of low lignin tropical grasses using transgenics.

Downregulation of lignin synthesising genes through interventions with genetic material from other plants (transgenics) has led to the development of tropical grasses with lower lignin concentrations under laboratory conditions. Giordano et al., (2014) developed variants of *Paspalum dilatatum* with significantly lower lignin concentrations than unmodified plants (12.3 vs. 15.1 % cell wall). Muguerza et al., (2014) observed a reduced lignin concentration in eight transgenic lines of *Paspalum notatum* versus unmodified plants (4.7 vs. 5.6 % DM). Preliminary *in vitro* dry matter digestibility (IVDMD) measurements by Muguerza et al., (2014) showed improvements of four transgenic lines recording with an average increase in IVDMD of 13% (61 vs 54 % IVDMD).

What economic benefit would a significant reduction in lignification of tropical grasses means for tropical and subtropical dairy industries?

No experiments could be found by the author where specifically developed low lignin tropical grasses have been fed to lactating cows to examine their efficacy. Given the scale of reduction in lignin content in transgenic tropical grasses as discussed above (16 to 19% reduction) is comparable to BMR corn and sorghum variants (31% and 16%, respectively), it could be hypothesized that comparable improvement in NDFD and lactating cow productivity may be achieved when low lignin tropical grasses are fed.

Reviews of NDFD have indicated an increase in milk yield of 0.25 L/cow.day and DMI of 0.17 kg/cow.day per % unit increase in forage NDFD (Oba and Allen, 1999). Table 1 models the indicative impact of adoption of low lignin tropical grasses on the productivity of three different tropical and subtropical dairy industries assuming a conservative improvement in NDFD of 10%. These assumptions do not consider a number of factors such as cow genotype and environmental factors which may impact on these productivity improvements.

The development of low lignin tropical grasses with greater intake and digestibility characteristics would also lead to reductions in greenhouse emissions (Knapp et al., 2014).

Based on Table 1 and using mitigation assumptions by Gerber et al., (2011), CO_2 equivalents per litre would be reduced approximately by 10%, 20% and 30% for northern Australian, Indonesian and Brazilian industries, respectively.

Table 1. Potential indicative benefits to northern Australian (N. Aust.), Indonesian and Brazilian dairy industries from adopting low lignin tropical grasses on-farm.

Simulation factors	**N. Aust.**	**Indonesia**	**Brazil**
Number of farms	600	90,000	1,350,000
Average milking herd size (no. of cows)	200	5	17
Milk production/cow.yr (litres)[1]	5,300	3,000	1,300
Tropical grass contribution to milk production (%)	50	60	70
Increase in milk production/cow.yr from LLTG[2] (litres)[3]	375	450	525
Milk price USD (cents per litre)	42	38	40
Increase in milk revenue/cow.yr (USD)	$158	$171	$210
Additional pasture intake/cow.yr (USD)[4]	$13	$15	$18
Increase gross margin/cow.yr (USD)	$145	$156	$192
Benefit to industry annually USD (millions per year)	$17	$70	$4,475

[1]Assumes one 300 day lactation per year. [2]Low lignin tropical grasses. [3]Assumes an increase in milk yield of 2.5 litres for a 10% NDFD increase of a 100% tropical grass diet. [4]Assumes an intake of 1.7 kg DMI for a 10% NDFD increase in a 100% tropical grass diets. Costed at $50 USD per tonne DM.

Alternative biotechnology options to transgenics

The commercialisation of transgenic plant in some countries is not easy, with both government policy and commercial signals often being inhibitory. Targeted mutagenesis however may be an alternative (Cai et al., 2015). This approach is based on the fundamentals of mutagenesis (which has been widely practiced by plant breeders over the last 50 years) utilising gene downregulation through elimination. Other options include genomic selection and improved field-based phenotyping technology as described by Barrett et al., (2015).

Conclusions

In comparison to temperate forage development, there is only limited investment globally in breeding tropical grasses. Despite the work of organisations such as CIAT and EMBRAPA, the quantum of government investment has significantly reduced since the 1980s, with limited commercial models replacing this investment. Unless this is corrected, subtropical and tropical dairy farms will become less competitive in comparison to temperate farms over time.

An analysis of average forecast growth in Gross Domestic Product 2015 to 2020 (IMF, 2015) shows that 26 out of 40 of the world's fast growing economies are located within non-arid subtropical and tropical countries with dairy industries. Given the link between increasing animal protein consumption and developing economies (Vorster and Bourne, 2016), these dairy industries will have growing domestic markets to service in the future.

Recent developments in plant breeding techniques and emerging domestic markets makes a strong business case for subtropical and tropical dairy industries at various stages of development to collaborate and co-invest internationally in low lignin tropical grass development.

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