Leucaena: Highlighting the value of good agronomy for establishing pasture systems.

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Abstract
In northern Australia, pasture establishment methods are often rushed by graziers trying to minimise lost grazing time, with minimal attention given to ground preparation, weed control or soil-moisture storage. Pasture seeds are often broadcast from an aeroplane, blade plough or spreader, a practice that results in more failures than successes, lost production for extended periods, and disillusionment with sowing pastures in the harsh and variable climates of northern farming systems. However, those growers who work with scientists to use better agronomy for Leucaena establishment, have achieved impressive results. As a consequence, establishment of Leucaena is no longer perceived to be as risky or troublesome as it once was.

Leucaena is a perennial forage legume, and when sown with a productive grass it can more than double annual cattle weight gain compared to grass-only pastures. A key to the improvement in establishment has been the mindset of treating a pasture like a crop, where good agronomic techniques of adequate ground preparation, weed control, soil-moisture storage and planting quality seed at the right depth are strictly adhered to. These lessons can be applied to other sown pasture systems, potentially improving establishment 10-fold. While graziers need not be cutting-edge farmers, following several key agronomy principles will significantly improve the reliability of establishment and hence profitability of pastures in northern farming systems.

Key Words
Leucaena, pasture establishment.

Introduction
Sown pastures cover approximately 12 M ha of northern Australia (Peck *et al.* 2011), contribute millions of dollars into the communities of Queensland and hence are critically important for the economic sustainability of northern farming systems. When sown on suitable soils, sown pastures provide high cattle growth and stocking rates (Middleton 2001). However, they require on-going soil fertility and grazing management for long-term persistence and production. A wide range of sowing methods are used for the establishment of sown pastures but too often preparation is rushed with minimal ground preparation, weed control or soil-moisture storage. Soil moisture is paramount for establishment success, with variable rainfall and competition from existing plants being two factors that dictate the germination and subsequent speed of establishment (Cook *et al* 1993a; Clem *et al.* 1993).

The selected sowing option(s) are generally based on practicality (access across paddocks), agronomic desirability (maximise establishment opportunities) and cost minimisation (Cook *et al.* 1993a). Low cost and easy methods of broadcasting seed are typically used, especially when large areas are sown in remote and rough situations. Too often these same low cost techniques are employed in situations with adequate paddock access on productive soil types. In these situations better preparation, albeit at higher cost, can significantly improve success with faster establishment and earlier grazing time.

Leucaena is a tropical perennial legume used in northern grazing systems and when sown with a productive grass, significantly improves cattle growth and stocking rates over grass-only pastures (Middleton 2001). Early experiences with Leucaena indicated establishment was more 'miss than hit' with 65% of planted areas failing (Lesleighter and Shelton 1986). These experiences were a significant hurdle to adoption (Chamberlain 1998; Shelton and Dalzell 2007), and so staff from agencies including Qld Department of Primary Industries and University of Qld combined with the desire and commitment of over 400 graziers were harnessed to overcome a range of establishment issues (Mullen *et al.* 2005). Using the best available

knowledge, skills and application, graziers still experience failures caused by climatic vagaries such as heat waves or heavy rainfall soon after planting, but improvements in seedbed preparation, soil moisture management, seed quality and planting equipment have been the main determining factors for success. While these principles are not revolutionary or new, the fact that these points have been strongly espoused by extension staff and meticulously followed by graziers, is the point of difference.

Keys to success

The agronomic factors for reliable Leucaena establishment have been widely extended to producers through activities of the grower organisation The Leucaena Network, and in recent publications (Dalzell *et al*. 2006). The key factors for ensuring reliable establishment of Leucaena-grass pastures are also effective for successful establishment other sown pastures (Table 1).

Table 1. Key factors for reliable establishment

Factor	Critical comments
Seedbed preparation	Fine seedbed ensures seed-soil contact for rapid germination and establishment
Soil moisture management	Weeds controlled during fallow and early in-crop to maximise seedling growth
Seed quality	Plump seed with high germination ensures vigorous seedlings
Planting equipment	Accurate seed depth control and placement; presswheels improve germination

Seedbed preparation

Leucaena is a highly productive perennial plant and to maximise production should be sown on deep, fertile and well drained soils (Cooksley *et al.* 1988). Arable landscapes are therefore typically chosen where paddock access is generally unconstrained by ground undulations or other impediments. Seedbed preparation facilitates sowing of seed into moisture with accurate depth control, allows press-wheels to assist seed / soil contact, and provides an environment for effective weed control.

Whole paddock preparation is conducted when converting existing forage or grain production paddocks to Leucaena-grass pastures. However in existing grass-pastures, graziers have two options for seedbed preparation; whole paddock, or strips (Jones *et al.* 1982). Existing grass-pasture paddocks are increasingly being sown to Leucaena, to incorporate a perennial legume to complement the existing grass sward (Radrizzani *et al*. 2010). Whole paddock preparation entails either cultivating or spraying the entire paddock, providing the best opportunity for Leucaena to access important soil resources of moisture and nutrients. However preparation cost is higher, there's no opportunity for grazing during the fallow period and grass needs to be re-sown. On the other hand, strip preparation entails either cultivating or spraying in designated zones or strips, usually 4-5m wide and spaced to obtain the selected row spacing. This technique can halve the cost of seedbed preparation, enables opportunistic grazing during the fallow period minimising lost grazing time, and allows ready-made seed production from the remaining grass, important in heavy clay soils where successful re-seeding of grass is unreliable. However, roots of vigorous perennial grasses, especially buffel, can grow into the prepared strip robbing valuable soil moisture and potentially reducing Leucaena establishment (Dalzell *et al.* 2006). This can therefore be a riskier option in drier seasons where fallow rainfall is below average, or when follow-up rain occurs sometime after sowing.

While Leucaena is a success in arable landscapes, there are a range of options to supplement existing pastures with legumes in paddocks with limited machinery access due to ground undulations, standing or lying timber or other physical impediments. The common option in extensive pasture sowings is to broadcast seed out of an aircraft and while practical for paddock access, seeds are required to find a niche in a landscape with established plants and limited seedbed. This hinders germination and establishment, commonly resulting in complete failure or dramatically lengthening the time to obtain a benefit (Cook *et al.* 1993a). The most promising option is to prepare strips in the paddock wherever machinery can operate. This might mean a hap-hazard arrangement throughout the paddock but allows some seedbed preparation to improve establishment success. Strips can either be sprayed with herbicide or cultivated to reduce competition from existing grasses, then after a rainfall event (or two) these strips can be sown with an appropriate planter. If the sown species establish and are managed to set seed every year, spread will occur over time into un-sown areas.

While Leucaena is seen as an expensive 'crop' to establish, where the time and effort is made to ensure a reliable establishment and highly productive life, the same should be espoused and undertaken for other

legumes. The cost of seed for alternative perennial legumes such as Desmanthus and Caatinga stylo is in the same range as Leucaena, and when sown at the same rate (2kg/ha) equates to similar cost per hectare. The productive life and forage yield of these alternatives has shown to be similar to Leucaena (Peck *et al* 2012; Clem and Jones 1996), so why isn't the same effort put in to ensure establishment the first time?

Soil moisture management

The success of any pasture development in northern grazing systems is dependant on receiving favourable climate conditions, particularly rainfall. While the climatic vagaries cannot be influenced, there are a number of management practices grazier's can use to maximise the efficiencies of what rain does fall. With an extensive and deep root system, Leucaena is suited to deep soils with high water holding capacity. While this root architecture provides moisture foraging ability once established, Leucaena is susceptible to water-hungry weeds and grasses at planting and during establishment (Dalzell *et al.* 2006). Leucaena sowing can occur anytime there is sufficient soil moisture but cool soil temperatures limit the earliest sowing to September, and latest sowing occurs February-March depending on timing of earliest frosts. Initial paddock preparation should start early enough with the aim to achieve >60cm of soil moisture at planting, which could take 3-9mths depending on rainfall. It's imperative that the fallow be kept clean of weeds, or grasses in existing pasture situations. Then effective weed control is required at planting and for 3-6 months post-planting to ensure a vigorous bush capable of being productive for more than 30 years. As Leucaena is sown in rows (either single or twin rows 1m apart) every 6-10m, inter-row cultivation for in-crop weed control is feasible. The availability of residual herbicides containing imazethapyr revolutionised weed control and hence establishment success in Leucaena (Mullen *et al*. 2005). This herbicide is widely recommended and used, either as a pre or post planting application for the control of grass and broadleaf weeds. The difficulty to control weeds now occurs post establishment, where no knockdown herbicides for broadleaf weeds are registered.

The high water holding capacity of soils suitable for pastoral improvement in northern farming systems provide the opportunity to fallow and store moisture for use once the pasture is sown. Preventing water use by existing pasture plants, either by cultivation or herbicides prior to a summer fallow provides the opportunity to store moisture during the wettest period of the year. Weed control at planting is critical to ensure the valuable stored moisture is only accessed by the freshly sown pasture. These moisture management techniques have the ability to improve pasture establishment 10 fold, compared to sowing seed without stored soil-moisture or the suppression or removal of existing pasture or weeds (Cook *et al* 1993b).

Seed quality

An adequate supply of quality seed has enabled the continual expansion of Leucaena through northern Australia. Farmer innovation driving harvesting technology improvements has delivered increasing amounts of good quality farmer grown seed of public cultivars marketed at competitive prices. Market competition has further driven seed quality improvements, where most seed producers are providing a germination test and grading and bagging of seed prior to sale. As seed is sown into a prepared seedbed with adequate soil moisture, it's imperative that immediate and consistent germination occurs. The advent of mechanical scarification to break seed dormancy significantly improved the reliability of germination and establishment, as the previous method of hot water immersion was fraught with inconsistencies of temperature and duration (Larsen 1998). Consistent germination also provides benefits of effective in-crop weed control strategies and easier grazing management. Soil insect control is another important aspect of ensuring reliable establishment. Primary strategies include baiting with cracked grain, and or coating the seed with insecticides. However, the effect of specific herbicides on rhizobium viability is unknown. As with other introduced legumes, native rhizobium strains are relatively ineffective resulting in poor nodulation. Commonly inoculation occurs by coating the seed with a peat culture but innovative graziers are now trialling liquid injection, similar to that used for pulse crops, as a method of delivering rhizobium to the seed for improved nodulation.

Planting equipment

Leucaena has a relatively large seed which can easily been sown by a range of planting equipment. Improvements in planting equipment for row crops such as sorghum, corn and cotton has provided the availability of new or second hand units for use in pastoral situations. Astute Leucaena growers have significantly improved establishment with these planters via accurate seed-depth control and seed spacing, pressing the seed to the side rather than over the top with press-wheels, as well as being able to fertilise, spread beetle bait and apply herbicides at planting if required. Developments in direct-drill planting

equipment have also provided opportunities for large scale pasture plantings without prior preparation, particularly for sowing legumes into existing grass-pastures. For successful direct drilling, water use by existing grasses must be reduced with strategic use of herbicides or cultivation. Accurate seed-depth and placement, robust press-wheels and the ability to fertilise (with phosphorus for example) all provide an effective machine to sow seed into no-till situations.

Conclusion

Broadcasting pasture seeds from an aeroplane, blade plough or spreader results in more failures than successes, lost production for extended periods, and disillusionment with sowing pastures in the harsh and variable climates of northern farming systems. However, the will and commitment of growers and scientists to use better agronomy for Leucaena establishment has been impressive. As a result, establishment of Leucaena is no longer as risky or troublesome as it once was.

The key to the improvement in establishment has been the mindset of treating a pasture like a crop, where good agronomic techniques of adequate ground preparation, weed control, soil-moisture storage, and planting quality seed at the right depth, are strictly adhered to. These lessons can be applied to other pasture systems, potentially improving establishment 10-fold. While graziers need not be cutting edge farmers, following key agronomy principles will significantly improve the reliability of pasture establishment northern farming systems.

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