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Managing the establishment of productive perennial pastures

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Abstract: *The establishment phase of a perennial pasture is when the pasture is the most vulnerable. Farmers are often reluctant to invest in modern perennial pastures due to the perception they do not persist. This paper aims to simplify the decision-making process when deciding which perennial species to plant by outlining the importance of factors such as temperature, annual rainfall, rainfall distribution, soil type and expected insect pressure. It also outlines some of the key steps involved in successfully establishing temperate perennial pasture species such as planning, paddock preparation, sowing depth, soil temperature, insect control, weed control and early grazing technique. After taking note of these important factors, farmers should be able to renew pastures with increased confidence.*

Key words: Temperate grasses, C3 & C4 grasses, species selection, management, grazing, pest control.

Introduction

Temperate Australian grasslands experience a range of conditions that lead to pasture deterioration. These include drought, flooding, pest pressure, over grazing, lack of fertility, acidic soils, and poor grazing management. These all factors lead to a decline in dry matter yield and persistence. Pasture renewal is an important tool that farmers can use to increase the productivity of their farm, however many farmers see this process as a cost rather than an investment for the future. The economic benefits of pasture renewal are well documented (Scott, Lodge, & McCormick, 2000) (Fraser, Moss, Dale, & Knight, 1999) with benefits coming from increased forage yield and improved quality. Modern endophytes (NEA, AR37, Max P) are an example of improvements in modern pastures which provide insect protection whilst minimizing animal health concerns. Traits in legumes such as increased stolon density, grazing tolerance and red legged earth mite tolerance (RLEM) are examples of choices that farmers can make to help increase their profitability.

Degraded pastures in the high rainfall zone can be transformed from a carrying capacity of 6 dry sheep equivalents/ha (DSE/ha) to 20–25 DSE/ha by re-sowing a degraded pasture (reference to removing native pastures excluded because of legal issues (Biodiversity Conservation Act, 2016)) to a high-performance perennial pasture (Malcolm, Smith, & Jacobs, 2014). Personal experience of replacing old degraded pastures with continental tall fescue, cocksfoot and prairie grass (cv. Hummer, Savvy and Atom, respectively) in the New England (NSW) and Southern Tablelands (NSW) has shown this lift on a large scale across multiple sites, despite challenging growing conditions in the previous 5 years.

Despite the benefits on offer from perennial pasture renewal, many farmers view it as too risky. This paper aims to provide insight into key establishment factors, helping farmers minimize the risk associated with establishing perennial pastures.

Discussion

Planning

Underperforming paddocks should be identified 12 to 18 months prior to sowing. Whether pasture decline is due to invasion of undesirable grass species [bent grass (*Agrostis capillaris*), silver grass *(Vulpia* sp), paspalum (*Paspalum dilatatum*) *etc*], too many broadleaf weeds or the sown species don't grow enough forage, the problem needs to be identified.

'Break crops' are an essential tool for pasture renewal as they lengthen the pasture reversion time. Renewing paddocks from an old degraded pasture straight to a perennial pasture rarely succeeds as the original weed species quickly become dominant again (Lane, Addison, & Van Plateringen, 2009), an outcome that is usually very frustrating and costly for farmers. One way to minimise this is to use at least 3 'label rate' glyphosate sprays over a 12-month period, with two of the sprays being in separate autumns. Weed grasses like kikuyu (*Pennisetum*

clandestum), couch (*Agopyron repens*), bent grass and paspalum are rhizomatous, meaning they have underground stems. The initial glyphosate spray won't kill every plant. Reversion rates back to kikuyu are shown in Table 1 below, paddocks that received 3 glyphosate treatments over 12 months all had significantly less kikuyu reversion in year 3 compared to treatments that had 1 or 2 sprays respectively. A break crop will enable multiple glyphosate sprays, therefore planning and break crops are an essential part of pasture renewal (Lane, Addison, & Van Plateringen, 2009).

Planting Suitable Species

Choosing the correct species for a paddock will have more effect on performance and persistence than cultivar choice. Factors affecting species suitability for any farm include; temperature (both maximum and minimum), total rainfall, rainfall distribution, soil type, expected insect pressure and fertility. If farmers can identify the best species and cultivars to suit their farm system, they should achieve a perennial pasture that will be robust enough to handle their conditions.

Temperature

Temperature regimes affect grasses in different ways, C4 (warm season growth) grasses (e.g. kikuyu and paspalum) start growing around 10°C but optimum growth rates occur near 30°C, whereas C3 (cool season growth) grasses (ryegrass (Lolium perenne), tall fescue (*Festuca arundinacea*), cocksfoot (*Dactyylis glomerate*), phalaris (*Phalaris aquatica*)) start to grow at temperatures around 5°C, reach maximum growth near 18–25°C and will slow down to zero when temperatures reach 27°C–35°C (depending on the species) (Sharpe & Rayburn, 2019). In warmer regions, there may be a benefit from having separate areas of C3 and C4 grasses to complement each otherThey should not be mixed together in a pasture if a long-term perennial pasture is desired. In areas where the day time temperatures get above 35°C degrees and night time temperatures aren't below 20°C perennial ryegrass should not be planted.

Native pastures across temperate NSW differ, the New England is dominated by warm season perennials, due to its 'summer dominant' rainfall pattern which leads to feed deficits in cooler months (Reid, 2017). Southern Tablelands pastures tend to revert to Wallaby grass (*Austrodanthonia* spp.), Microlaena (*Microlaena stipoides*), Red grass (*Bothriochloa macra*), barley grass (*Hordeum leporinum*), silver grass and brome grasses (Clements, *et al.* 2003). Most of these native species will have a short growing window and provide low quality forage throughout the year with limited carrying capacity. For the large parts of the New England, central and southern Tablelands areas in NSW, the limiting temperature for growth is low temperatures from April – September (Clements, *et al.* 2003), which makes pasture species such as cocksfoot, tall fescue, perennial ryegrass, prairie grass and phalaris ideal perennial species.

Rainfall

When deciding between the temperate perennial species above, rainfall and its distribution throughout the year must be considered. Locations where rainfall is distributed through autumn, winter and spring suit species that

Table 1: Kikuyu reinvasion after various glyphosate treatments in Whangarei, Northland NZ (adapted from Lane, Addison and van Planteringen, 2009)

Treatment	No. of sprays	Season of spray	Peak % kikuyu in late summer/autumn		
			2005	2006	2007
1. Kikuyu Pasture	0	-	91	88	88
2. Flat, Perennial ryegrass sown	1	Autumn (A)	13	77	80-90
3. Flat perennial ryegrass sown	2	Spring (S), A	7	43	80-90
4. Flat perennial ryegrass sown	3	A, S, A	0	8	0
5. Hill, perennial ryegrass sown	3	A, S, A	0	2	9
6. Hill, Tall Fescue sown	3	A, S, A	0	17	40

have summer dormancy mechanisms such as phalaris (cv. Holdfast GT, Australian, SF Mate), Hispanica cocksfoot (cv. Uplands) and Mediterranean tall fescue (cv. Flecha and Temora). These species can persist where annual rainfall is as low as 400mm/year (Easton, Lee, & Fitzgerald, 1994). Due to their dormancy mechanism, farmers should not expect growth from these species over summer.

If annual rainfall is above 600 mm with an even distribution throughout the year, continental (summer active) cocksfoot or tall fescue can be used, providing high quality feed throughout the year (Easton, Lee, & Fitzgerald, 1994). When annual rainfall gets above 750 mm per annum perennial ryegrass can be used. Perennial ryegrass is the least robust species due to its sensitivity to high summer temperatures so if true perennialism is required, perennial ryegrass is limited to small geographical pockets in NSW. It can however can provide high quality DM production for 3–5 years in more marginal areas. Sparse sporadic summer rainfall can cause tiller bud dormancy to break in perennial ryegrass which can lead to high plant death rates (Clark, 2011), therefore consistent summer rainfall or irrigation is ideal for persistence. Prairie grass can be used to increase cool season growth of pastures and will persist in 650mm+ rainfall areas, however as it is not a true perennial species, it needs to set seed every 2–3 years to remain persistent over time.

Soil type

If a soil type is not suited to a sown species it will not persist. Drainage, pH, soil fertility and water holding capacity of soil are determining factors for both production and persistence. Both pH and fertility can be altered, however drainage and water holding capacity are more difficult to change. Cocksfoot, phalaris and tall fescue all grow in similar climatic conditions but have very different soil requirements. Tall fescue and phalaris prefer deeper soil types with high water holding capacity as they have extensive root systems that can survive in water logged soils over winter (Easton, Lee, & Fitzgerald, 1994). Cocksfoot will not persist in these waterlogged soils but will perform well in light soil textures with lower water holding capacity (Lolicato & Rumball, 1994). Shallow free draining soil types reduce the advantage given to tall fescue and phalaris, hence cocksfoot will persist and perform better in these environments. Perennial ryegrass can handle a wider range of soil conditions, however it is very prone to pugging damage in waterlogged soil types (Clark, 2011). Perennial ryegrass will also require more frequent rainfall events on light shallow soil types due to the lower water holding capacity. If a paddock has a mixture of soil types (i.e. wet areas and dry areas) consider the drainage conditions that are the most common and plant the species that suit most of the paddock.

Expected insect pressure

The last major consideration to think about is the expected insect pressure throughout the lifetime of the pasture. Root feeding insects like the red and yellow headed cockchafer can cause widespread damage to the root system of shallow rooted species such as perennial ryegrass, so if they are likely to be present, perennial ryegrass will not persist (Berg, Faithful, Powell, & Bruce, 2013). Deeper and stronger rooted species like tall fescue, phalaris and cocksfoot have a higher tolerance to these pests but are still susceptible to damage under high pest loading. Other pasture pests of significance to NSW are pasture mealy bug, root aphid, African black beetle (BB) and Argentine stem weevil (ASW), studies have shown these can negatively affect production and persistence to susceptible cultivars (Kemp, *et al.* 2020).

Modern perennial ryegrass and tall fescue species can be protected by modern novel endophytes such as AR37 and NEA in ryegrass and Max P in tall fescue, which is displayed in Table 2. When perennial ryegrass and continental tall fescue are the appropriate species to plant, choose a cultivar that can be protected by novel endophyte for increased production and persistence.

Companion Species

Perennial pastures need diversity but will typically be dominated by one major species (70% ground cover) a secondary species (20% ground cover) and 2-3 other species (remaining 10%). Legumes are great companion species

to a grass sward as they are high quality and can fix their own nitrogen. Legumes will also reach peak growth periods when grasses are slowing down or reducing in quality. Sub clover (*Trifolium subterraneum*), red clover (*Trifolium pratense*), white clover (*Trifolium repens*) and lucerne (*Medicago sativa*) can be used as a secondary component of a pasture mix. Herbs such as plantain (*Plantago lanceolata*) and chicory (*Cichorium intybus*) can also act as a companion species to a perennial pasture mix, they offer similar quality benefits to legumes. Herbs have also been shown to increase pasture utilisation when grazed by cattle due to their inability to selectively graze (Pembleton, *et al.* 2016). These species will persist in combination with the temperate grasses mentioned above. Mediterranean fescue and Hispanic cocksfoot are the exception as their climatic requirements mean that short season sub clover, lucerne and chicory should be considered as companion legumes.

Paddock preparation

Preparing paddocks for planting occurs 12–18 months before the perennial pasture is sown. Using break crops like barley, canola, wheat or a forage crop such as oats, vetch, grazing wheat, forage brassica, chicory, plantain or forage sorghum provides the opportunity to remove perennial weeds. They also provide an alternative source of cash flow or bulk forage to bridge a feed deficit. (Suggested inclusion) The choice of break crop can work against a good outcome if for example species such as forage brassicas, chicory and plantain exclude the use of broadleaf herbicides in-crop to remove weeds. Sowing winter cereals such as wheat, barley and triticale on the other hand increases herbicide options, in particular the use of grass selective pre-emergent herbicides, as well as broadleaf herbicides.

The establishment phase of a perennial pasture is the time when the new pasture plants are at their most vulnerable. The window of ideal germination conditions is often short lived

Table 2: Endophyte insect control ryegrass & continental tall fescue (adapted from NZPBRA, 2020)

Endophyte brand	Argentine stem weevil	Pasture mealy bug	African black beetle	Root aphid	Field cricket
Diploid perennial ryegrass					
AR1	++++	++++	+	–[2]	Not tested
NEA2	+++	(++++)	+++	++	Not tested
NEA4	+++	(++++)	+++	++	Not tested
AR37	++++[1]	++++	+++	++++	Not tested
Standard endophyte	++++	++++	+++	++	Not tested
Without endophyte	–	–	–	–	Not tested
Continental tall fescue					
Max P	Not tested	Not tested	+++	(++++)	Not tested
Without endophyte	–	–	–	–	Not tested

– No control.
\+ Low level control: Endophyte may provide a measurable effect but is unlikely to give any practical control.
++ Moderate control: Endophyte may provide some practical protection, with a low to moderate reduction in insect population.
+++ Good control: Endophyte markedly reduces insect damage under low to moderate insect pressures. Damage may still occur when insect pressure is high.
++++ Very good control: Endophyte consistently reduces insect populations and keeps pasture damage to low levels, even under high insect pressure.
( ) Provisional result: Further results needed to support the rating. Testing is ongoing.
[1] AR37 endophyte controls Argentine stem weevil larvae, but not adults. While larvae cause most damage to pastures, adults can damage emerging grass seedlings. In Argentine stem weevil prone areas, it is recommended to use treated seed for all cultivars with novel endophyte.
[2] AR1 plants are more susceptible to root aphid than plants without endophyte.

in temperate NSW so ground preparation is essential. Sowing depth (discussed below) needs to be precise with pasture species due to their small seed size so paddocks need to be as smooth as possible. If 'no-tillage' planting is desired, the paddock needs to be sprayed out several weeks prior to planting to ensure the current species dies off and the roots of the current plants 'let go' of the soil (root release). If the paddock has been pugged or is uneven it may require cultivation to develop a fine firm seed bed to ensure even seed depth placement.

Planting

Seed depth needs to be accurate with perennial pasture species, their seed size is much smaller than cereal crops like barley and wheat. Tall fescue, ryegrass and plantain are most successful when planted at 15–25 mm depth (Thom, Fraser, & Hume, 2011) where as white clover and cocksfoot emergence is reduced when sowing depth in increased from 5 mm to 25 mm (Peri, Brown, & McKenzie, 2000). Chicory emergence is reduced when sowing depth is increased from 5 mm to 15 mm, suggesting it is very sensitive to sowing depth (Peri, Brown, & McKenzie, 2000). Table 3 below summarizes the ideal sowing depth for certain species. When sowing perennial pastures, do not drive too fast. The ideal drilling speed for most small seeds is around 8km/h (Brock, McKenzie, & Pound, 2005), if planting speed is faster than this, seed depth will start to vary, causing uneven or poor germination.

Soil temperature at sowing will also affect speed of establishment. Figure 1 shows how long it takes various temperate species to reach 75% germination at 5°C, 10°C and 15°C. All species are slower to germinate at 5°C however tall fescue and cocksfoot are significantly quicker at 15°C than 5°C, getting to 75% germination 20 and 13 days quicker, respectively (Charlton, Hampton, & Scott, 1986). The warmer the soil temperature the quicker the perennial pasture will get to complete ground cover and reach first grazing, minimising weed pressure and susceptibility to insect attack. For this reason, it is recommended that tall fescue, cocksfoot and phalaris should only be planted if soil temperature is above 10°C, whereas ryegrass can be planted at 8–10°C. Ideally temperate pasture species should also be planted in the autumn, due to the risk of soils drying out over summer. However, lower rainfall locations or dryer than normal seasons better establishment can be achieved by sowing in late May/June when soil moisture is less likely to be limiting. If irrigation or high rainfall summers are likely, pastures can be spring sown, however broadleaf and summer grass weed growth competition may be stronger.

Pest Control

The establishment phase is the most vulnerable stage of a perennial pasture's life, so even small numbers of insects can cause significant damage to establishing pastures. This is particularly the case if germination conditions are slow and the pest pressure is high. Red legged earth mite (RLEM), blue oat mite (BOM), lucerne/clover flea typically target legumes and herbs, however these pests can also damage grass species. Other pests include ASW, black beetle, yellow headed

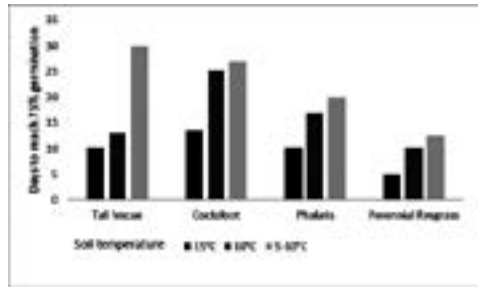

Figure 1 Germination rates of grass species at 3 different soil temperatures (adapted from (Charlton, Hampton, & Scott, 1986))

Table 3: Showing the ideal sowing depths for various perennial pasture species ((Peri, Brown, & McKenzie, 2000) (Thom, Fraser, & Hume, 2011) (Brown, Hampton, & Lill, 1998)

Species	Ryegrass	Tall fescue	Cocksfoot	Phalaris	Prairie grass	Chicory	Plantain	Red/ white clover	Sub clover
Sowing depth (mm)	15–25	15–25	5–15	5–15	10–20	5–10	5–25	5–15	5–15

cockchafer and cutworm can all cause significant damage. Best practice for insect control is to use label rates of a broad-spectrum insecticide such as chlorpyrifos with the final glyphosate spray to kill the current population of adult insects. The next step is to treat seed with Poncho® Plus seed treatment. Seed treatment will provide up to 6 weeks protection against the insects above that arrive after planting. Slugs and snails can also be a problem, especially in non-tillage systems. Monitor paddocks for these pests and if present, look at using a grain-based slug/snail bait to control as they can destroy large areas of a paddock very quickly.

Weed control

Broadleaf weeds are another cause of perennial pasture failure during the establishment phase. An important point here is that the inclusion of a well-managed break crop prior to sowing should have reduced weed seed banks to very low levels. If weeds occur they must be sprayed as early as possible before they start competing with pasture species for nutrient and moisture. Spraying weeds early means they are smaller requiring 'softer' herbicide chemistry than larger weeds, reducing the impact on companion legume species. Chemicals such as MCPB and flumetsalum need to be sprayed when clovers have at least 2 true trifoliate leaves, but weeds can't be bigger than the 8-leaf stage. Igran and Dicamba are registered to spray over plantain and most grass pastures. Clopyralid and MCPA are options to spray over grass only pastures, as they will be harmful to legumes and herbs. In New Zealand flumetsalum is registered to spray over chicory crops from the 2 true leaf stage onwards. It is recommended to talk to your agronomist for a post emergence spray regime and to spray when the weeds are smaller than the 8 true leaf stage.

First grazing

First grazing timing is very important for persistence, the intended outcome of a first graze is to remove the tips of grasses to encourage growth and tillering, not to feed animals. All perennial species need to be lightly grazed, leaving 4–5cm of growth behind, this encourages plants to tiller out and increase root depth. Do not graze below 4–5 cm until the pasture starts to hit its first 'spring flush' and keep the paddock in a grazing rotation. Early rotational grazing also prevents shading of companion species, particularly in fast establishing pastures like perennial ryegrass and prairie grass.

Grass pastures are ready for their first graze when they pass the 'pull test'. To carry out the pull test, pinch the plant 4–5 cm from the ground with your thumb and forefinger and pull upwards. Pastures are ready for a light first graze when the plant is anchored enough to not be pulled from the ground. The time taken to reach first grazing will be different amongst all species, typically the quickest will be perennial ryegrass and prairie grass, then tall fescue, cocksfoot and phalaris. Use young cattle or lambs for the first grazing as they have sharper teeth and are less likely to cause damage.

Conclusions

Establishing modern temperate perennial pasture species can significantly increase the carrying capacity of NSW Tablelands farms, which will increase the profitability of these farms. It is important to maximise the survival of the planted perennial pasture species to maintain farmer confidence in the renewal process. For perennial pastures to survive, farmers need to plan their renewal programme so that they are planting a species that will suit their climate and farm system. Planning starts 12–18 months prior to planting and the renewal process starts with a break crop. This break crop can be used to fill a feed deficit or to supply alternate source of income. Most importantly a break crop enables 3 glyphosate sprays across the paddock, ensuring a complete kill of problematic perennial weeds that don't contribute to production or profitability.

Selecting the right species is more important than selecting the correct cultivar, this is done by acknowledging annual rainfall, rainfall distribution, average seasonal temperatures, soil type and expected pest pressures of any individual paddock. Temperate perennials such as cocksfoot, tall fescue, phalaris and perennial ryegrass are suited to large areas of

the NSW Tablelands environment and can suit most farms in this environment. Prairie grass is not a perennial species but has a significant fit in many perennial pastures and will persist through its reseeding mechanism.

When establishing a perennial pasture, make sure the paddock is prepared for planting by spraying out with a glyphosate-based spray in the lead up to planting. Sowing depth is very important for most perennial pasture species because of their seed size and should never exceed 25 mm in depth, some species shouldn't exceed 10 mm. If the paddock is uneven or has been pugged, it can lead to seed being placed at variable depth, so you may need to cultivate to create an even seed bed. Ensure drilling speed isn't too fast, ideal speed is 8 km/h. Species such as tall fescue, cocksfoot and phalaris are sensitive to soil temperature at establishment, so ensure soils are above 10°C when planting. When the paddock is ready for its first graze, perform a pull test on the grass. If the pasture passes the pull test it can be grazed down to 4–5 cm, preferably with a light stock class like lambs or young cattle. The goal of the first graze is to remove some leaf to encourage tillering creating a stronger plant, not to feed animals.

The final aspect to monitor during pasture establishment are weeds and insects. Best practice control for insects is a pre-plant broad spectrum insecticide and seed treatment to control insects that arrive after planting. Broadleaf weeds may also need to be controlled as they will compete with your perennial pasture for light, water and nutrients. Spraying weeds when they are small is preferable because you can use chemicals which will be less harmful on legumes and herbs.

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