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Tropical perennial grasses – root depths, growth and water use efficiency

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Tropical perennial grasses offer high water use, high production and improved sustainability outcomes.

Water use efficiency (WUE) is a measure of plant growth per mm of water used – including rainfall and soil water.

Tropical grasses show high WUE with values ranging from 13.7 (Swann forest bluegrass) to 28.8 kg DM/ha.mm (Premier digit).

Annual dry matter production from these grasses may be up to 16.5 t DM/ha with growth rates of up to 148 kg DM/ha per day.

For high water use efficiency adequate levels of nutrition and high green leaf area and root density are required.

Tropical grasses are best grown on soils with at least 150–200 mm of plant available water capacity (PAWC) or where pastures can develop root depths up to 1.6 m.

In northern NSW, rainfall storage in winter can be high. This can potentially be used by tropical grasses in spring and summer, provided it is not used by other species.

Over recent times, availability of water in irrigated and rain fed agriculture has decreased. This reduction has renewed interest in both water use efficiency of different pastures, and how pasture systems can be modified to more efficiently use water.

Recent research on a Red Chromosol soil south of Tamworth has shown that tropical perennial grasses can produce more growth from the water that is available than other species, while at the same time providing natural resource benefits such as high ground cover. The added bonus is that pasture species that have deep root systems and an increased ability to use available soil water may also produce more herbage mass to boost livestock production.

Root depth is an important hydrological parameter that has substantial implications for the use of soil water rainfall by pasture plants. Species that have deep root systems can exploit higher reserves of stored soil water to both drive pasture growth in dry conditions and protect against water losses by deep drainage in wetter conditions.

On a Red Chromosol soil three tropical perennial grass species had deeper roots than a mixture of C_3 and C_4 native perennial grasses as shown in the table on page 3. The plant root depth of Katambora Rhodes grass was comparable with that of Venus lucerne, while both Premier digit and Swann forest bluegrass had deeper root systems than the native perennial grass pasture. Katambora Rhodes grass was also able to more quickly reach its maximum root depth, but all grasses achieved their maximum root depth in the second year after sowing.

Plant available water content (PAWC) is a soil parameter that indicates how much water is available for plant growth and is usually measured in mm of water. PAWC is a measure of the difference between the upper water storage limit of the soil and the lower drying limit that can be achieved by a pasture.

PAWC is largely driven by plant root depth, but it also depends on plant density, the capacity of different species to extract water from the soil, and any soil physical or chemical constraints that may be present.

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All the tropical grass species had greater values of PAWC (e.g. 153–193 mm) than the native perennial grasses (140 mm). Of these, Katambora Rhodes grass had the maximum value of PAWC (193 mm) but it was less than that of lucerne (213 mm) as shown in the table below. However, this does indicate Katambora Rhodes grass has a high water requirement, similar to that of lucerne, and this should be considered when selecting paddocks and soil type on which to sow these species.

Water use efficiency (WUE) is an index of dry matter (DM) produced per millimetre of water used (i.e. rainfall plus the change in soil water content) over a known period of time. It is expressed as kg of DM per mm of water (kg DM/ha.mm), but since it is a measure of total evapotranspiration it should not be confused with the commonly quoted index of rainfall efficiency (kg of DM per mm of rainfall). The reason that the change in stored soil water content is included when calculating WUE is that not all of the rain that falls is available for plants to use.

WUE is best used to compare the relative efficiency of different species to produce plant dry matter at the same site each year. WUE depends on the amount of water available in the soil, plus the amount of water that enters the soil after rainfall. Species with greater plant root depth can access more water, and others are more efficient at converting available water into plant dry matter. If the overall goal of a pasture system is to maximise the production from each millimetre of water used (rainfall and stored water), then species with deep plant roots and high WUE are desired.

WUE values for pasture species studied over two seasons ranged from a low of 7.5 for a native perennial grass pasture to a high of 28.8 kg DM/ha.mm for Premier digit (see table below). Venus lucerne also had a high WUE of 25.0 kg DM/ha.mm, with Katambora Rhodes grass and Swann forest bluegrass being intermediate with values of 17.7 and 13.7 kg DM/ha.mm, respectively. WUE values were highest in the second year after sowing, when the plants were more developed and so better able to exploit reserves of plant available water.

Rainfall storage efficiency represents the proportion of rainfall that is retained in the soil and about 55% of rainfall in winter is stored in the profile compared with just 25% in summer (Murphy *et al.* 2010). The lower efficiency in summer is related to high temperatures and high evaporation rates that occur at that time of the year, as well as the fact that many rainfall events occur as high intensity storms and losses from surface runoff are high.

Using a neutron moisture meter to measure stored soil water in a native grass pasture at 'Dunreath', Gowrie, with a Premier digit plot in the foreground.

Growth and dry matter production

Tropical perennial grasses have the potential to produce large amounts of plant dry matter in a growing season, provided that they have adequate soil water and nutrients. As shown in the table, Premier digit produced 16.5 t DM/ha per year averaged over two seasons, while Katambora and Swann produced lower amounts of 10.9 and 11.6 t DM/ha, respectively. For the same seasons, native perennial grasses and lucerne produced 8.5 and 14.4 t DM/ha, respectively. Production from the native perennial grass pasture was boosted in late winter and spring by growth of winter annual grass weeds.

These high production values indicate that appropriate grazing management and livestock systems are required to effectively utilise the dry matter. Peak growth rates for Premier digit were as high as 148 kg DM/ha per day in early summer (late November to mid-January) when both adequate stored soil water and nutrition were available (see table below).

Careful planning is required to match stocking rate with pasture growth rate to utilise the plant dry matter and maintain green leafy growth.

Species	Root Depth (m)	PAWC (mm)	Annual dry matter (kg DM/ha)	Peak growth rate (kg DM/ha/d)		WUE (kg DM/ha.mm)
				Year 1	Year 2	
Premier digit	1.2	153	16529	119	148	28.8
Katambora Rhodes grass	1.6	193	10900	79	100	17.7
Swann forest bluegrass	1.4	167	11610	74	97	13.7
Native perennial grasses	1.0	140	8495	50	80	7.5
Venus lucerne	1.6	213	14382	83	121	25.0

Comparative values for root depth (m), water use efficiency (WUE, kg of dry matter (DM)/ha per mm of water, plant available water capacity (PAWC, mm) and peak growth rates (kg DM/ha/day) and average annual dry matter production (kg DM/ha) for three tropical perennial grasses, a C_3 and C_4 native perennial grass pasture and Venus lucerne.

Management tips to maximise WUE

To achieve high WUE it is important to maintain high levels of ground cover and to maximise PAWC at all times. High levels of ground cover increase rainfall capture efficiency by reducing losses through surface runoff and evaporation of soil water.

About 40% of total annual rainfall falls from April to October. This rainfall can benefit tropical perennial grasses because it allows PAWC to be replenished when the grasses are dormant. However, recent research at Tamworth has shown that sown companion species such as subterranean clover or lucerne will also utilise this water as can weedy species that grow in winter and early spring, so under these conditions there will be little long-term benefit for the tropical grasses.

To maximise WUE, tropical grasses need a high level of nutrition, high amounts of green leaf and dense root systems. These can best be managed by ensuring that nitrogen levels are adequate either from a companion legume or by applying fertiliser and that rotational grazing is used to avoid overgrazing and plants being weakened, particularly in dry periods.

Further reading

Hatfield JL, Sauer TJ, Pruegar JH (2001) Managing soils to achieve greater water use efficiency: A review. *Agronomy Journal* **93**, 271-280.

Murphy SR, Lodge GM, Brennan MA (2010) Tropical grass pastures capture winter rainfall. In 'Proceedings of the 25th Annual Conference of the Grassland Society of NSW'. *In Press*. (NSW Grassland Society Inc.: Orange).

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