NSW GOVERNMENT | Department of Primary Industries

FACTSHEET

Summer dormancy in temperate forage plants

Mark Norton, Research Scientist, Climate and Water Research

Introduction

The droughts experienced by southern Australia over the last three decades have sent pasture scientists on the hunt for traits that will significantly improve the drought tolerance of pasture crops.

One of the most potent of these drought survival traits is summer dormancy. Plants that give either nil or minimal growth after rainfall or irrigation in summer are expressing summer dormancy. There have been several field experiments conducted over the recent drought periods where grasses with the summer dormancy trait have had much better survival over extended and intensely dry periods than other grasses without the trait. For example, at Barellan, NSW in the late 1990's Norton et al (2001) demonstrated a significant survival advantage for grasses with this trait, and similar advantages were shown in droughts of the current decade at Barmedman, NSW, Wagga Wagga, NSW and Warrak, Victoria by Hackney et al (2006), Hayes et al (2010) and Nie (2009). In further research Norton et al (2006a; 2006b) quantified the survival advantage given by the summer dormancy trait over long, severe summer droughts and showed in cocksfoot that the dormant cv. Kasbah had 28 % greater survival than non-dormant cv. Medly and in tall fescue the dormant cv. Flecha had 30 % greater survival than the non-dormant cv. Demeter.

What is Summer dormancy?

Summer dormancy is a plant trait occurring in a number of pasture species native to the Mediterranean Basin. These species are important to the Australian grazing industries and include cocksfoot (*Dactylis glomerata*), phalaris (*Phalaris aquatica*) and tall fescue (*Festuca arundinacea*). The trait has also been shown to occur in a number of grasses found in those parts of North America with a Mediterranean climate, including *Poa scabrella. P. bulbosa, P. secunda* and *Stipa cernua* (Laude 1953). Very little research has been attempted among Australian native grasses to identify germplasm with this trait although recent indications suggest the trait may occur in grasses such as *Austrodanthonia caespitosa,* from drier inland regions of Southern Australia (C. M. Waters pers. comm. 2011).

In early studies, Cooper (1963) observed that summer dormancy tended to be seen in plants that originated from regions experiencing an annual summer dry season of at least 4 months. Phalaris, cocksfoot and tall fescue originate over a very large area across Eurasia with the southern extremities of their zones of origin bordering the Sahara Desert in North Africa where annual summer droughts typically exceed four months or longer. This means that populations of these species coming from North Africa often express summer dormancy. Conversely, germplasm of these same species originating from regions further to the north in Europe which do not experience a significant period of summer dry are usually not able to express summer dormancy.

Fig1. Fully irrigated trial in mid-summer of alternating plots of the summer-active cocksfoot cv Medly (vigorous green colour) and the summer-dormant cocksfoot cv Kasbah (brown, dead herbage). Green matter in Kasbah plots are weeds. Note that even though the trial is fully irrigated the dormant Kasbah has stopped growth and shed all its leaves appear deadherbage.

Dispelling myths about summer dormancy

The true nature of summer dormancy in our common temperate perennial pasture grasses has been poorly understood until recent research clarified most of its characteristics (Volaire & Norton 2006).

Myth 1 – Drought Imposed Dormancy

This is a common misconception. The term, 'drought-imposed dormancy' or 'facultative dormancy' ignores the fact that no plant is able to grow in the absence of moisture. Associated with the recent research it has become obvious that summer dormancy can only reliably be identified and measured in plants that are not experiencing drought, i.e. when they are well watered (Norton et al*.* 2009).

The best way to understand this concept is to ask, "Why should we consider the dormant state in an adult plant to be necessarily any different from the dormancy occurring in a seed?" When testing a seed for the presence of dormancy, water must always be added, so to consider that testing the dormancy of an adult plant could occur without water is, in the same way, a fallacy (Junttila 1988).

One important reason why this misunderstanding continues is because when grasses are experiencing drought, the appearance of a summer dormant grass can be very similar to that of a grass which isn't summer dormant. The only way to differentiate between the two is to observe the response of the subject grass to the application of water. The non-dormant grass will always regrow rapidly in summer when water is applied, whereas the summer dormant grass will not respond, or respond only minimally, to summer irrigation. Figure 1 shows the contrasting responses of cocksfoot cvv Kasbah and Medley to full summer irrigation. The summer dormant Kasbah is not growing at all and almost looks dead, whereas Medly is growing actively.

Myth 2 – Summer dormant plants alone shed their leaves under drought

Another common misconception is the belief that summer dormancy is being expressed when in response to drought the grass stops growth rapidly and sheds its leaves. In fact the common response of all pasture grasses to drought is to stop growth more or less rapidly and then to begin shedding leaves, with the oldest leaves generally being those shed first and the youngest being the last to die. Nevertheless, variation in the rate at which growth stops and leaves are shed is observed between grass populations. However, this behaviour is due to a different drought resistance strategy, termed dehydration avoidance (Turner 1986; Turner 1997), and it is characterised by plants which seek to avoid the deleterious effects of drought by maintaining a high water content in their tissues. Plants using this strategy typically do this by reducing their rate of water loss by shedding leaves etc and /or increasing their water uptake by developing bigger root systems. The surest way to tell the difference between dehydration avoidance and summer dormancy is to irrigate a plant that has been droughted over summer. When water is added to the dehydration avoiding plant it will take up the water and grow vigorously, whereas the summer dormant plant will not grow, or grow only very slowly. In fact the summer dormant plant will even commonly shed leaves over summer under well-watered conditions (Figure 1). In Figure 2a the cocksfoot cv Medly has allowed almost all of its leaves to dry off and be shed as it adapts itself to summer drought whereas it is clear from Figure 2b that if moisture becomes available its non-dormant nature allows it to recommence growth rapidly.

Figure 2. Cocksfoot cv Medly rapidly sheds all top growth under severe summer drought (a) but can respond with new herbage quickly after a mid-summer irrigation (b).

Little research has been done to study the environmental factors that cause summer dormancy in temperate pasture grasses although observations link the factors that induce summer dormancy to those that cause flowering, i.e. short days, low temperatures. In cocksfoot and tall fescue the experience of these cool, winter-type conditions leads to a stronger level of summer dormancy expression than if those same cultivars had not experienced the winter conditions (Norton et al. 2006a; 2006b). However, it has also been noted that when the phalaris cultivar Atlas PG was sown in spring it was able to express a level of summer dormancy just as strong as if it had experienced winter conditions before the onset of summer and in this case it seems that the key point was that the spring-sown Atlas PG had flowered just as strongly as its autumn-sown counterparts prior to the onset of the summer.

To summarise, we can define summer dormancy as, "the absence or reduction of plant growth occurring under adequate moisture conditions over summer". It is common also that, "summer dormancy is accompanied by a heightened level of shedding of foliage under adequate summer moisture." Summer dormancy is NOT the absence of growth under dry summer conditions because NO plant grows without moisture. Finally, summer dormancy is of course only ever expressed under summer conditions, which means long days and high temperatures. So if plant dormancy is seen in another season of the year, it cannot be summer dormancy.

How to measure summer dormancy

The strongest and most consistent expression of this trait can be observed in Mediterranean climates. The measurement of summer dormancy is therefore, best undertaken in these climates; typically winter-moist, and summer-dry.

This has been confirmed through the recent, abnormally wet, cool summers in South-eastern Australia because summer dormancy has not been expressed to the same degree as when the conditions were hotter and drier. It's also recommended that plants should generally be sown in autumn to ensure prior exposure to the dormancy-inducing conditions of winter (short days, low temperatures).

In cocksfoot and phalaris the highest level of dormancy expression has been observed early in the summer so it is wise to undertake measurements early in the season and before mid January (Norton et al. 2006a; 2006b; Norton 2007).

The point that needs to be most strongly emphasised is not to attempt to measure summer dormancy under dry conditions where plants have reduced their potential growth rates and are stressed for lack of water. Under dry conditions, summer dormancy is easily confused with the drought resistance response 'dehydration avoidance' (Norton et al. 2008) and the two responses can only be separated when water deficit is relieved (Norton et al. 2009).

The expression of summer dormancy can be measured reliably either as:

1. The level of growth response (regrowth) to a significant (40 mm) summer storm (or irrigation) occurring after a +30 day period of dry conditions, or

2. The total herbage production under fully irrigated conditions over the entire three month summer period. Herbage production over this period would be best measured in three separate harvests undertaken one month apart (Norton et al. 2008; 2009).

Using the summer dormancy trait to build more persistent pastures

If we are to adapt to climate change we must develop agronomic systems that productively use the plants which we find to be best adapted to expected drought and heat stresses. This means that we will have to find a way of fitting summer dormant plants into our pasture systems while also optimising their productivity.

While summer dormancy improves drought survival and therefore persistence of pasture plants, it has the disadvantage that it does not use the rainfall that might be received over summer for forage production very efficiently. Indeed, the potential for forage production over summer is reduced from pastures dominated by summer dormant plants. Another consequence of this is that when the available water is not used by useful plants it could lead to other problems including extra weed infestation or waterlogging.

A strategy to overcome this problem could involve growing summer dormant grasses in mixtures with a summer active companion such as lucerne. In particular we should evaluate mixtures with winter dormant lucernes because in Australia winter dormant lucernes are hardly used even though evidence suggests they could have higher drought tolerance (Pembleton et al. 2010). We are excited with this concept because we believe that the summer dormant grasses will grow and use resources in the cooler months most efficiently while the lucerne will grow in the warmer seasons, using resources at that time best. The different growth rhythms of the two species should minimise inter-species competition and this will theoretically translate into a pasture with greater long term stability and resilience.

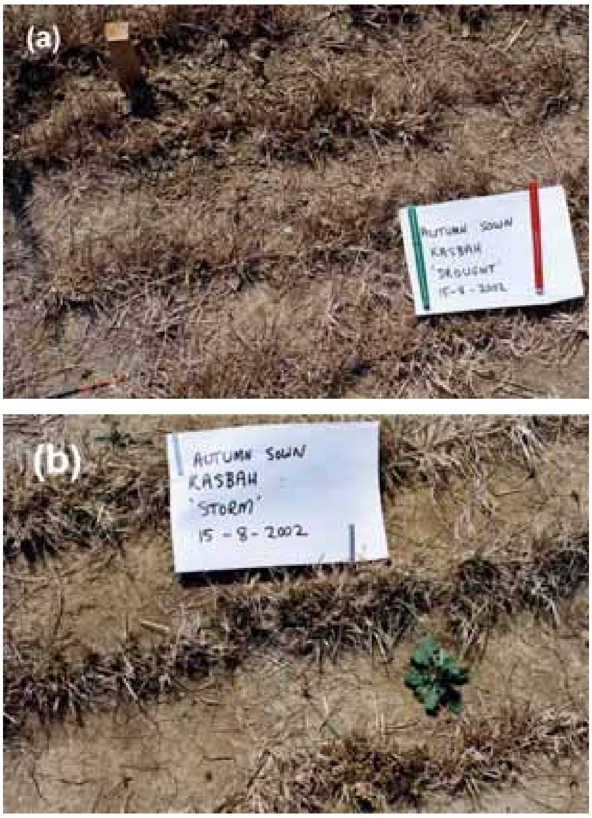

Fig. 3 . Two photos of cocksfoot cv Kasbah on the same date after (a) prolonged (68 days) summer drought, or (b)12 days after a mid-summer irrigation had interrupted a 2 month long drought. Note there is no growth in Kasbah after the irrigation.

While the mixing of perennial species in a pasture is not a new idea, utilising species with complementary patterns of dormancy is. We believe that this should reduce problems with grass-legume competition and slow down the ultimate domination of the pasture by one species (i.e. a failure in the mixture) that has often been observed in the past. However, to ensure that these mixtures can be successful a better understanding of the summer and winter dormancy traits and how they relate to drought tolerance and affect the compatibility of plants in mixtures is essential.

There is a pressing need to undertake research to develop agronomic systems such as these to adapt to climate change.

References

Cooper JP (1963) Species and population differences in climatic response. In 'Environmental control of plant growth'. (Ed. Evans LT) pp. 381-403. (Academic Press: New York)

Hackney B, Dear B, and Hayes R (2006) Summer dormant temperate grasses are productive and persistent in the medium - low rainfall cropping region of New South Wales. http://www.regional.org.au/au/asa/2006/poster/systems/4498_hackneyb.htm

Hayes R, Dear B, Li G, Virgona J, Conyers M, and Hackney B (2010) Phalaris and cocksfoot prove superior to tall fescue in two drought prone environments of southern NSW. http://www.regional.org.au/au/asa/2010/pastures-forage/dryland-perennials/7051_hayesrc.htm#TopOfPage

Junttila O (1988) To be or not to be dormant: some comments on the new dormancy nomenclature. *HortScience* 23, 805-806.

Laude HM (1953) The nature of summer dormancy in perennial grasses. *Botanical Gazette* 114, 282-292.

Nie, Zhongnan, Norton, Mark. (2009) Stress tolerance and persistence of perennial grasses - the role of the summer dormancy trait in temperate Australia, *Crop Science*, 49 (6) 2405-2411.

Norton MR (2007) 'The role of summer dormancy in improving survival of temperate perennial pasture grasses in drought-prone environments.' PhD Thesis. (University of Queensland: Brisbane, Australia)

Norton MR, Koetz EA, and Stewart G (2001) Perennial grass evaluation for southern mixed farming systems. http://www.grasslands.org.au/gsv/grasslandsNSW/news/5Summer%20Dormant%20Perennial%20Grasses%20nswgc01.html

Norton MR, Lelievre F, Fukai S, and Volaire F (2008) Measurement of summer dormancy in temperate perennial pasture grasses. *Australian Journal of Agricultural Research* 59, 498-509.

Norton MR, Lelievre F, and Volaire F (2006a) Summer dormancy in *Dactylis glomerata* L., the influence of season of sowing and a simulated mid-summer storm on two contrasting cultivars. *Australian Journal of Agricultural Research* 57, 565-575.

Norton MR, Volaire F, and Lelievre F (2006b) Summer dormancy in *Festuca arundinacea* Schreb., the influence of season of sowing and a simulated mid-summer storm on two contrasting cultivars. *Australian Journal of Agricultural Research* 57, 1267-1277.

Norton MR, Volaire F, Lelievre F, and Fukai S (2009) Identification and measurement of summer dormancy in temperate perennial grasses. *Crop Science* 49, 2347-2352.

Pembleton KG, Cunningham SM, and Volenec JJ (2010) Effect of Summer Irrigation on Seasonal Changes in Taproot Reserves and the Expression of Winter Dormancy/Activity in Four Contrasting Lucerne Cultivars. *Crop & Pasture Science* 61, 873-884.

Turner NC (1986) Adaptation to water deficits: a changing perspective. *Australian Journal of Plant Physiology* 13, 175-190.

Turner NC (1997) Further Progress in Crop Water Relations. *Advances in Agronomy* 58.

Volaire, F, and Norton, MR, (2006) Summer dormancy in perennial temperate grasses. *Annals of Botany*, 98: 927-933.

ISSN 1832-6668

Published by the Department of Primary Industries, a part of the Department of Trade and Investment, Regional Infrastructure and Services.