Integration of tetraploid ryegrass into phase-farming systems:

Can we capture the benefits without jeopardizing subsequent crop yield?

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KEY MESSAGES

To successful integrate tetraploid ryegrass into phase-farming systems aim to:

1. Reduce naturalized ryegrass competition prior to tetraploid establishment - consider crop topping or brown manure the year before sowing a tetraploid, and apply a knockdown in the establishment year.
2. Reduce the weed seedbank size towards the end of the pasture phase (e.g. brown manure, spraytop, make hay or silage).
3. Establish competitive crops in the subsequent cropping phase - consider lifting seeding rates, adequate nutrition and judicious use of selective herbicides.

Grazed pasture phases (three or more years) combined with non-selective seed-set control depletes herbicide-resistant annual ryegrass seedbanks.

OVERVIEW

This paper briefly clarifies the genetic difference between ryegrass cytotypes, suggests a role for tetraploid ryegrass in fighting herbicide resistance and gives a brief overview of the seedbank dynamics of ryegrass. Knowledge of the reproductive, seedbank and dormancy dynamics of ryegrass is essential to successfully establish tetraploid ryegrass at the start of a pasture-phase and to sufficiently deplete seed reserves prior to a subsequent crop.

Herbicide-resistant diploid ryegrass in WA

Ryegrass (Lolium rigidum) that is present across the WA wheatbelt is annual and is a diploid (2x = 14). It is extremely well adapted to the Mediterranean-type climate in WA, is an excellent pasture species, and historically was widely sown (e.g. Wimmera ryegrass) to support sheep/wool enterprises. However, as cropping intensified from the 1960s onwards, diploid ryegrass has become Australia's most important crop weed.

Selective herbicides initially provided excellent control of annual diploid ryegrass infesting cropping paddocks but with recurrent herbicide use herbicide resistance developed rapidly and now multiple resistance is very widespread in naturalized ryegrass across the WA wheatbelt. As a consequence most farmers have developed an extreme aversion to ryegrass. This is unfortunate because the benefits of an early, nutritious feed source and NRM benefits, such as soil binding properties, are generally forgone by seeking to remove ryegrass from mixed farming systems. The use of tetraploid ryegrass might restore the balance.

What is a tetraploid?

Though all ryegrass species are naturally diploid (2n = 14), tetraploid varieties (2n = 28) have been produced by plant breeders and are commercially available. Tetraploid ryegrass varieties have twice the number of chromosomes—twice the amount of genetic information (DNA)—as diploid ryegrass varieties. Duplication of the entire genetic code has been possible by using chemicals (i.e. colchicine) which disrupts cell division during the production of gametes. This breeding technique has produced a number of tetraploid varieties that have greater early vigour, leaf size and nutritional attributes relative to diploid varieties. Currently tetraploid varieties all have a late maturity and are routinely sown in high rainfall areas to improve pasture production and, in turn, the productivity of intensive animal industries.

Tetraploid ryegrass – productive pasture and defeating herbicide resistance

Tetraploid ryegrass might also be used in mixed farming systems to specifically target diploid herbicide-resistant ryegrass in two ways: through competition and through a genetic block between cytotypes. As tetraploid ryegrass has larger seeds and, in turn, greater early vigour than diploid ryegrass, this could provide a competitive advantage over the naturalized diploid component during the growing season. What must also be appreciated is that tetraploid ryegrass will freely cross with diploid ryegrass in spring to produce a sterile seed if flowering coincides. This offers the possibility of using a genetic trick to diminish herbicide-resistant diploid ryegrass. Where a cropping paddock infested with herbicide-resistant diploid ryegrass is rotated to pasture and herbicide susceptible tetraploid ryegrass is seeded, both tetraploid and diploid (herbicide resistant) ryegrass will be present during the growing season, but the more vigorous tetraploid will dominate. Thus, during a managed pasture phase the herbicide-resistant diploid population will be replaced by a herbicide susceptible tetraploid. Of course, numbers of the tetraploid ryegrass will need to be reduced before a subsequent cropping phase.

Phase farming systems

It is now recognized that a useful strategy to manage herbicide-resistant ryegrass is to rotate into short or longer term pasture phases in which value is obtained from the ryegrass by grazing, and seed production is minimised by seed-set control in spring (Roy 2005). Introducing a sequence of non-crop years (2-5) to break up continuous cropping also widens the range of tools for managing diploid ryegrass at economically tolerable levels. Some options provide a direct economic return (e.g. hay, silage) while others deliver flow on benefits to subsequent crops, such as biologically fixed nitrogen (Revell and Thomas 2004). A pasture phase also provides an opportunity to drive down weed seedbanks by scrupulously preventing seed-set over a number of years (see the CRC Weed Management Factsheet attached).

Unlike traditional ley-farming systems, in phase-farming systems the pasture legume base is not expected to self-regenerate after a cropping phase; rather the pasture base is reseeded after each cropping phase (>3 years). This offers the opportunity to re-sow a wider array of pasture species such as tetraploid ryegrass to capture feed quality and NRM benefits. The challenge is to develop phase-pasture systems which are profitable without jeopardizing the productivity of subsequent crops. We believe tetraploid ryegrass together with pasture legume species have a role to play. However, a sound knowledge of the seedbank dynamics of ryegrass will be essential to successfully integrate tetraploid ryegrass into phase farming systems.

Seedbank dynamics

Two key factors determine how many weeds will appear in a given season. The first is the amount of seed-set in the previous year. The second is the extent to which new and older seed can survive over summer and successfully germinate in subsequent seasons. At harvest, most annual ryegrass seeds are dormant but lose their dormancy over summer in a process called 'after-ripening'. Dormancy loss occurs at high temperatures and low seed moisture content and is an adaptation to prevent germination in summer when survival prospects are low. Ideally (from a farm managers perspective), every seed would be non-dormant at the break of the season and would germinate together so control would be highly effective. Unfortunately, this is not the case and many ryegrass seeds remain dormant and germinate after the crop/pasture has been sown or emerge in future years. Understanding the seedbank and dormancy release dynamics of annual ryegrass can help to estimate the potential weed problem in a given year and over time.

The conditions under which seeds mature (the previous spring) have an impact on the rate of dormancy release over summer (Steadman et al. 2004). When seeds mature under warm spring temperatures, dormancy release is quicker than if they mature during a cooler spring. Likewise the conditions experienced over summer influences the timing of dormancy release and the number of seeds that remain dormant after the break of season. A hot summer promotes early dormancy release, whereas cooler summer temperatures result in fewer seeds germinating at the break of season. However, this is less pronounced when the break is later in the year, as seeds have had more time to become non-dormant.

An early season break combined with a mild summer may mean more dormant seeds and a greater longer term problem. Long term benefits arise, however, when annual ryegrass is prevented from setting seeds in the first place as there are no increases to the seedbank and less potentially dormant seeds in the future. The following trial results illustrate this point. In 1997, a seedbank decline study was established in a Group A resistant population of approximately 500 annual ryegrass plants/m2. More than 10,000 seedlings/m2 emerged over the next 5 years where no seed-set was allowed from year to year. The average seedbank decline rate of annual ryegrass was 70 to 80% per annum. This compares to barley grass which has very little dormancy and the majority of seedlings (over 99%) emerge from soil within 2 months of the break of the first season.

Diploid herbicide-resistant annual ryegrass can also be decimated within a grazed pasture phase (Table 1; Ferris 2008). In 2003 a rotation experiment was implemented at Avondale research station across a site with over 1000 resistant ryegrass plants/m2; various pasture legume plots were sown and resulted in a significant reduction in the mid winter seedbank over the 3 years period (i.e. initially 350 dormant seeds/m2). The grazed subclover phase was the most effective treatment; here the annual ryegrass seedbank fell below 40 seeds/m2 and the legume content rose from below 20%, in the establishment year, to greater than 90% in the third year of the pasture phase.

Table 1. Select weed control treatments evaluated during grazed pasture phases at Avondale research station, and the average number of dormant, ryegrass seeds (mid winter) in the subsequent crop (2006)A

		Key management inputsA			
Treatments	2003	2004	2005	SeedbankB	
	Pasture	Pasture	Pasture	seed/m2 (2006)	
	Biserrula	K, Casbah, G	Casbah, G, ST	G, BM	211 b
	Lucerne	K, L69, G	G, K, L69(Sept)	G, BM	75 ab
	Subclover	K, Dalkeith, G	G, ST	G, BM	37 a
	Ryegrass	K, Safeguard	G, ST	G, BM	620 c

A Pasture and crop species/varieties were sown in the years mentioned; inputs are given in chronological order.

BM – brown manured; G – grazed; K – knockdown herbicide; ST - late spraytop with paraquat.

Note - Lucerne did not persist and this phase resembled a fallow.

B Values followed by the same letter do not differ significantly (P=0.05).

Collectively the results suggest that introducing a non-crop phase can provide an opportunity to improve the pasture base and decimate weed seedbanks to lift animal performance and minimize the detrimental impact of weeds on subsequent crops.

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