What we know and don't know about annual ryegrass ecology and biology in northern New South Wales and southern Queensland

Bhagirath S. Chauhan, Professor in Weed Science, The University of Queensland, Gatton

Key words
dormancy, phenology, seed bank, seed biology, temperature, annual ryegrass, ARG, *Lolium rigidum*

GRDC code

US00084

Take home message

- Comprehensive information regarding the ecology and biology of annual ryegrass (ARG) remains limited for northern New South Wales (NSW) and southern Queensland (Qld) (referred to as the 'northern region' in this paper)
- Insights drawn from the southern and western regions may offer some understanding. However, the distinct environmental and soil factors, and cultural practices unique to the north emphasise the need for a further comprehensive study of all aspects of ARG ecology and biology in this region
- ARG in the north might exhibit a lower level of dormancy and a shorter seed bank life
- In the north, ARG demonstrates a wide germination temperature range, spanning from 15/5°C to 35/25°C (day/night temperatures), implying potential year-round germination possibilities in the northern region
- Recent observations indicating its growth in cotton and fallow fields signal a potential seasonal expansion of ARG habitat.

Background

Weeds impose a significant financial burden on Australian grain growers, costing over $3.3 billion annually (Llewellyn *et al.,* 2016). Among these weeds, annual ryegrass (ARG; *Lolium rigidum*) stands as the most prevalent nationwide, infesting over 8 million hectares of grain crops, causing a staggering annual revenue loss of $93 million. This weed poses a substantial challenge in winter cereals, oilseed crops, and legumes, with reported reductions in wheat grain yield of up to 80% due to its infestation (Lemerle *et al.*, 1996).

Presently, ARG represents the most severe weed problem in the southern and western grain-growing regions of Australia. It has developed resistance to nearly all herbicide groups, including Groups 1, 2, and 9. In contrast, in northern New South Wales (NSW) and southern Queensland (Qld), it is an emerging issue in winter crops and fallows. In this paper, northern NSW (north of Narrabri) and southern Qld will be referred to as the northern region. Growers and consultants have observed an increased presence of ARG in southern Qld, suggesting a need for a regional survey to identify the extent of ARG's geographical spread.

To proactively address the potential emergence of ARG as a challenging weed in the north, it is crucial to establish integrated weed management (IWM) strategies. However, the development of such strategies hinges upon a comprehensive understanding of the ecology and biology of ARG specific to northern regions. While the ecology and biology of this weed encompass broad areas, this paper aims to delve into key aspects while identifying gaps in understanding ARG ecology and biology in the northern NSW and southern Qld grain regions compared to the southern and western regions.

Dormancy and germination

Diverse levels of dormancy have been observed in various ARG populations. For instance, in Western Australia (WA), reported dormancy levels ranged from 0% to 90% among different populations (Steadman *et al.,* 2003a; Steadman *et al.,* 2003b). Similarly, populations collected from Roseworthy in South Australia exhibited over 98% dormancy (Chauhan *et al.,* 2006). Knowledge of dormancy levels can be useful when developing control strategies based on when weeds are likely to be germinating. Understanding that a weed with low levels of seed dormancy tends to germinate predominantly in a sizable group at the beginning of the season implies a preference for early-season management techniques. These methods include commencing with a weed-free seedbed and employing early-season knockdown measures. Conversely, in regions where weed emergence occurs across multiple cohorts throughout the season would favour the use of pre-emergent herbicides and early sowing for enhanced crop competition. However, corresponding information for northern populations is limited. In an ongoing GRDC project (US00084), dormancy was no longer observed in half of the 10 NSW ARG populations 45 days after seed collection, while the remaining half lost dormancy 90 days after seed collection. Notably, these populations primarily originated from southern NSW. Predicting dormancy in northern populations based on other regions is challenging due to genetic influences and maternal environmental factors. Notably, plants experiencing warmer temperatures in WA have been found to produce seeds with lower dormancy levels compared to those in cooler temperatures (Steadman *et al.,* 2004). Given the relatively warmer average temperatures in the north, especially in QLD during winter, it is plausible that ARG in the north may exhibit lower dormancy levels compared to the other regions, but this requires further research.

Light, temperature and moisture significantly influence weed seed germination, with light stimulating but not being an absolute requirement for ARG germination. Some seeds can germinate in the dark, indicating that ARG seedlings can emerge from shallow depths and under crop canopies. While findings from South Australia demonstrated optimal seedling emergence at a burial depth of 1 cm, a depth of 10 cm completely inhibited ARG emergence (Chauhan *et al.,* 2006). While similar trends may prevail in the north, differing soil types, especially texture, could impact ARG seedling emergence from various depths. Consequently, studying burial depth effects on ARG seedling emergence in different northern soil types is imperative. Knowledge about the impact of burial depth on ARG emergence can assist in developing improved cultural practices. Farmers can modify their tillage techniques or implement seedbed preparation methods that manipulate burial depth to suppress ARG emergence, thereby reducing the seed bank in the soil.

ARG seeds exhibit germination across temperatures ranging from 5 to 35°C, with the surface seeds' optimal temperature noted at 27°C (Gramshaw, 1976). Most studies utilise constant temperatures, which differ from field conditions. A recent study reported >90% germination at alternate temperatures ranging from 20/10°C to 35/25°C in populations collected from NSW (Thompson *et al.,* 2021). However, an optimal germination temperature regime was not identified, especially concerning higher temperatures. Evaluating the effect of temperature and light conditions on ARG germination, specifically with populations from northern NSW and southern Qld, would be beneficial. Insights gained from temperature studies on weed seed germination aid in preventing or reducing weed spread. By understanding the temperature conditions favourable for germination, interventions can be designed to disrupt these conditions or implement preventative measures to limit weed expansion. Understanding how temperature influences ARG seed germination will help predict the potential geographical range of ARG. By studying temperature effects, researchers can predict and anticipate when specific weed species are most likely to emerge during the growing season. This knowledge can assist farmers in timing their weed control measures more effectively. Farmers can adapt their management practices, such as altering planting dates or employing specific weed control methods, based on the predicted germination patterns influenced by temperature.

In the southern region, late summer and autumn rainfall events have been linked to influencing ARG germination behaviour (Gill, 1996). Scant or no rainfall during this period might lead to staggered germination during the winter growing season. Conversely, the north experiences frequent summer rainfall events whose intensity and quantity could significantly influence ARG germination behaviour. Nevertheless, data on how summer rainfall impacts ARG in the northern grain region are currently not available.

Seed bank persistence

While ARG possesses a short-lived soil seed bank, a fraction of seeds remains dormant in the soil for subsequent years. In South Australia, over 30% of ARG seeds persisted after 18 months on the soil surface or when buried at a 5 cm depth; however, decay rates were notably higher for surface seeds than for buried ones (Chauhan *et al.,* 2006). Information regarding ARG seed bank persistence in the northern grain region is not available. Factors such as soil conditions, crop types, residue amounts, environmental variables (temperature, light, nutrients), dormancy levels, and cultural practices (e.g., tillage, crop rotations) may distinctly impact ARG seed bank persistence in the north. Comprehensive knowledge of weed seed viability is pivotal for devising long-term control strategies, targeting germination windows, timing cultural practices, preventing seed bank replenishment, and formulating site-specific weed management plans for ARG.

Phenology

Phenological patterns of ARG might vary due to differing temperature, moisture, and photoperiod conditions in the north compared to the south and west. Previously, it was widely acknowledged that a cold requirement (vernalisation) influenced the rate of development of ARG for flower initiation (Gill, 1996). However, recent observations challenge this notion, particularly with populations in the north. Instances of ARG emerging during summer crops and fallows in NSW, displaying high resistance to various herbicides, have been reported (Chauhan and Walsh, 2022; Thompson and Chauhan, 2022). Notably, some ARG plants cultivated in mid-October 2023 in Gatton flowered by mid-December 2023 without requiring vernalization (Bhagirath Chauhan, unpublished data). These observations suggest the need to investigate ARG phenology in northern populations concerning planting times. Understanding ARG phenology offers crucial insights into its growth stages, timing, and behaviour, facilitating more effective control measures, including cultural practices and optimising herbicide application during susceptible growth stages.

Conclusions

Comprehending the seed ecology, phenology, and biology of ARG is indispensable for formulating and executing effective weed management strategies in northern cropping systems. Although information is available on the ecology and biology of ARG populations from southern and western grain regions, its applicability in the north remains uncertain due to differential environmental soil characteristics and cultural practices unique to the northern region. Timely research is essential to examine the ecology and biology of ARG populations in the north, enabling the development of proactive weed management programs for ARG before it becomes a challenging weed. While research on populations from southern NSW has shed some light on the ecology of ARG in the northern region, information is still limited. The issue of ARG emergence in summer crops and fallows, along with the geographical spread into Qld, may be of particular concern in the coming years.

References

Chauhan BS, Gill G, Preston C (2006) Influence of environmental factors on seed germination and seedling emergence of rigid ryegrass (*Lolium rigidum*). Weed Science 54:1004-1012

Chauhan BS, Walsh M (2022) Differential response of winter- and summer-emerging accessions of rigid ryegrass (*Lolium rigidum* Gaudin) to postemergence herbicides in Australia. Weed Technology 36:663-670

Gill GS (1996) Why annual ryegrass is a problem in Australian agriculture. Plant Protection Quarterly 11:193-195

Gramshaw D (1976) Temperature/light interactions and the effect of seed source on germination of annual ryegrass (*Lolium rigidum* Gaud.) seeds. Australian Journal of Agricultural Research 27:779-786

Lemerle D, Tang H, Murray G, Morris S, Tang H (1996) Survey of weeds and diseases in cereal crops in the southern wheat belt of New South Wales. Australian Journal of Experimental Agriculture 36:545-554

Llewellyn RS, Ronning D, Ouzman J, Walker S, Mayfield A, Clarke M (2016) Impact of weeds on Australian grain production: the cost of weeds to Australian grain growers and the adoption of weed management and tillage practices. Report for GRDC. CSIRO, Australia. In., 112.

Steadman KJ, Bignell GP, Ellery AJ (2003a) Field assessment of thermal after-ripening time for dormancy release prediction in *Lolium rigidum* seeds. Weed Research 43:458-465

Steadman KJ, Crawford AD, Gallagher RS (2003b) Dormancy release in *Lolium rigidum* seeds is a function of thermal after-ripening time and seed water content. Functional Plant Biology 30:345-352

Steadman KJ, Ellery AJ, Chapman R, Moore A, Turner NC (2004) Maturation temperature and rainfall influence seed dormancy characteristics of annual ryegrass (*Lolium rigidum*). Australian Journal of Agricultural Research 55:1047-1057

Thompson M, Chauhan BS (2022) Changing seasonality of *Lolium rigidum* (annual ryegrass) in southeastern Australia. Frontiers in Agronomy 4. 10.3389/fagro.2022.897361

Thompson M, Mahajan G, Chauhan BS (2021) Seed germination ecology of southeastern Australian rigid ryegrass (*Lolium rigidum*) populations. Weed Science 69:454-460

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support. The author would also like to thank the University of Queensland for partial funding this research through students' projects.

Contact details

Bhagirath Chauhan
The University of Queensland
Building 8115, Gatton, Queensland 4343
Ph: 0427923272
Email: b.chuahan@uq.edu.au

Date published

March 2024