

'The Stripe Rust Race: from State to Nation to World'

Colin Wellings

NSW Department Primary Industries
seconded to The University of Sydney, Plant Breeding Institute

Summary

Winter cereal crops represent a significant economic contribution to the Australian economy, averaging \$5 billion in annual earnings in recent years. Diseases currently rob the annual value of the wheat harvest by an estimated twenty percent. The stripe rust pathogen (*Puccinia striiformis*) of wheat (principally) has caused significant economic losses during its relatively brief history in Australia since 1979. The value to farming communities arising from controlling stripe rust of wheat in the decade to 2008 has been estimated at \$431million.

The oration will present aspects of stripe rust biology that have dictated changing approaches to disease management. The race to contain stripe rust has been a story of change, encompassing movements in pathogen evolution; climatic variability influencing crop and pathogen survival; fluctuating market environments; and alterations in public/private investments in wheat breeding. In order for cropping enterprises to flourish in the midst of these biological and economic dynamics, an effective research program underpinning the delivery of practical outcomes must be continually articulated, supported and communicated.

Introduction

William Farrer (1845-1906) developed wheats adapted to Australian conditions through a series of experiments that convinced him of the value of hybridisation and selection. His initial aim from 1886 was to provide rust resistance to farmers, although his methods also led to further developments in bread making quality, regional adaptation and yield improvement. Farrer's responsibilities and resources were extended in 1898 with his appointment to the fledgling NSW Department of Agriculture, established in 1890. In addition to Farrer's unique qualities of observation and perseverance, he was also active in collaborating with colleagues in developing concepts, confirming opinions, sourcing germplasm and sharing observations. He was convinced he had a contribution to make, and he was certain he could not do it alone.

The 'Rust Race'

Despite Farrer's optimism, rust resistance proved to be ephemeral. Stem rust (caused by *Puccinia graminis*) and leaf rust (*Puccinia triticina*) continued to cause problems to growers as both pathogens were shown to have an intrinsic capacity to change and develop new races capable of overcoming resistance. The

race between breeder and pathogen has continued unabated in Australia for more than a century.

Stripe Rust in Australia: 'State to Nation'

Stripe rust was a serious disease of wheat in Europe and the Americas, but it remained unreported in Australia. Indeed Prof WL Waterhouse, who began a systematic study of the cereal rusts at The University of Sydney in the 1920s and who was an early Farrer Medallist, predicted that this third cereal rust would not survive the heat of Australia. However, the disease was reported for the first time in September 1979 in southern NSW, and then survived and caused serious seasonal problems over the subsequent 30 years throughout eastern Australia. Early work predicted that stripe rust came from Europe, and studies showed that the pathogen was capable of adaptation and evolution that resulted in the periodic demise of commercial varieties and advanced breeding lines, the loss of quality and quantity of grain in certain seasons, and the imposition of increased costs of production in fungicide application. Stripe rust epidemics in Australia from 2003-2008 were estimated to have imposed \$40-90 million annually in fungicide costs.

Annual surveys of the pathogen population across the entire Australian winter cereal production zones have been a component of the Australian Cereal Rust Control Program, hosted by The University of Sydney (Cereal Rust Lab, Plant Breeding Institute) and funded by GRDC. The data provided evidence for sequential mutation, a further two instances of exotic introduction, and support for the role of naturalized weedy communities of *Hordeum spp.* in pathogen evolution. The data from the pathogen survey has been critical in predicting the response of commercial varieties. Efforts to communicate these outcomes in a timely manner have been an important component in developing a whole-of-industry response in stripe rust management.

International Studies: ‘Nation to World’

Stripe rust epidemics are a recurring threat to wheat yield in the majority of wheat growing regions of the world, with potential to inflict regular regional crop losses ranging from 0.1 to 5%, with rare events giving losses of 5 to 25%. Regions with current vulnerability include North America (particularly Pacific North West USA, Mexico), East Asia (China, north-west and south-west), South Asia (India, Pakistan, Nepal), Oceania (Australia, New Zealand), East Africa (Ethiopia, Kenya), the Arabian Peninsula (Yemen), Middle East (Syria, Turkey), Central Asia (Uzbekistan) and Western Europe. A basis for these epidemics has been the progressive emergence of pathogen races in similar patterns to that experienced in Australia. Collaborative work funded by ACIAR in association with international agencies CIMMYT and ICARDA allowed the development and deployment of genetic stocks to monitor race changes in the field across wheat regions in the developing world.

The Way Forward for the ‘Stripe Rust Race’

The state, national and international importance of stripe rust demands the same focus on observation, collaboration and genetic resources that Farrer required more than a century ago in his seminal battle with the cereal rusts. Modern advances, such as in molecular technologies, are assisting in addressing important questions of pathogen variation and

host resistance, but care must be taken not to be distracted from the primary objective. Farrer was distracted, for a time, by the less important but recurring leaf rust while the devastating stem rust was lost from focus; this was a deep regret for him. Likewise the study of contemporary stripe rust pathogen dynamics needs to be continually set in the context of breeding for resistance and disease management that together deliver practical farming outcomes.

Fungicides are being used increasingly in the management of foliar cereal diseases across large cultivated areas. The availability of off-patent generic products has brought an economic advantage to this management strategy, although a concern with the increasing usage of fungicides is the potential appearance of insensitive pathogen isolates. This concern becomes more focused with the awareness that the same mode of action applies to the entire suite of curative fungicides currently in the market place.

Breeding for resistance remains the most practical and cost effective means for containing stripe rust on farm, across states and within broader international regions. The approach to achieving resistance that is commercially successful is clear. However, the means of securing the necessary genetic diversity of resistance are becoming increasingly tenuous with the demands of protecting private investments in plant breeding and the increasing barriers that impede international exchange of germplasm.

Investments in public-good research and development have been a mainstay for advances in sustainable agricultural production in NSW and Australia. A long term, relevant and focussed research program has delivered services to the cereal breeding and farming communities that have addressed practical disease control strategies for stripe rust and shown global leadership in the pursuit of genetic solutions to the cereals. Commitment to build on this base will allow the cereal industries to maintain rust control while maximising seasonal opportunities.