Grain legumes (pulses) for profitable and sustainable cropping systems in WA

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Introduction

THE IMPORTANCE of grain legumes in improving the health of humans, the livestock they nurture and the soil in which they grow, and in mitigating greenhouse gases (Siddique *et al.* 2012) is increasingly recognised. Legumes are important because they fix atmospheric nitrogen in the soil through a symbiotic relationship with the bacterium of the genus *Rhizobium*, with some of this nitrogen available for the succeeding crop. Grain legumes have the added benefit of producing grains that are rich in protein (excellent human food) and can be commercially traded. The inclusion of grain legumes in a cropping system increases soil organic matter, provides a disease break for succeeding cereal and canola crops, and improves water use efficiency.

Nevertheless, grain legumes remain poor cousins to the major cereal crops (rice, wheat, maize) due to the ever-increasing global demand for cereals from increasing human populations. Globally, the priorities for cultivation, research and development in grain legumes remain secondary to those for cereals in most cropping systems. Contributing to this is the relatively greater sensitivity of grain legumes than cereals to various abiotic and biotic stresses, increasing their risk by cultivation, and the lower grain yield potential of legumes compared with competing cereal crops. While genetic improvement is required to address these problems, agronomic improvements can significantly contribute to closing the yield gap induced by various stresses (Siddique *et al.* 2012; Anderson *et al.* 2016). Practically, however, genetic and agronomic improvements should proceed in a complementary manner as a new variety often requires a change in agronomic practice to achieve potential yields.

Grain legumes in Australian cropping systems

The value of the contribution of grain legumes (pulses) to sustainable cropping has been amply demonstrated (Siddique *et al.* 2008, 2012), yet it took a significant part of the 20th century for these crops to rise to prominence in the Australian cropping system. The cool-season grain legume industry in Australia—comprising field pea (*Pisum sativum* L.), chickpea (*Cicer arietinum* L.), faba bean (*Vicia faba* L.), lentil (*Lens culinaris* ssp. *culinaris* Medik.) and narrow-leaf lupin (*Lupinus angustifolius* L.)—emerged in the last 40 years to

occupy a significant place in cropping systems. Development of the major grain legume crops — including field pea that has been grown for over 100 years — has been possible through the acquisition of genetic resources for breeding. Some varieties were initially released directly from these imports, but the past 25 years of grain legume breeding has recombined traits for adaptation and yield for various growing regions.

Many fungal disease threats have been addressed through resistant germplasm with varying success. Some threats (e.g. black spot in field pea caused by *Mycosphaerella pinodes*) require continued exploration of germplasm and new technology. The arrival of ascochyta blight in Australia threatened to destroy the chickpea industry in southern Australia but thanks to resistant germplasm it is now on its way to recovery. Many abiotic stresses, including drought, heat, salinity and soil nutritional toxicities, continue to challenge the expansion of the grain legume area, but recent research shows that genetic variation in the germplasm may offer new solutions. Just as the availability of genetic resources has been key to successfully addressing many challenges in the past two decades, it will also assist in the future, for example, in the adaptation to climate change and variability (Siddique *et al.* 2013).

Grain legumes in Western Australia

Historically, grain legumes were not included in Western Australian (WA) cropping systems until the domestication of lupin species (particularly *Lupinus angustifolius*) began at The University of Western Australia in the 1960s which led to the development of a significant lupin industry for sandy soils. Later, in the 1980s, more grain legumes gained attention. Within a decade, considerable research on more traditional grain legume species — in particular, field pea, chickpea and faba bean—had developed a vast pool of knowledge on adaptation to various soil types and agroecosystems in WA, agronomy and crop management (Siddique *et al.* 1999).

A comprehensive study on a range of cool-season grain legume species in WA identified the considerable potential for these species on soils unsuitable for narrow-leafed lupin (Siddique *et al.* 1999). In this study, adaptation of these grain legume species was compared by measuring phenology, growth and yield in field experiments at 36 sites (mostly on farmers' fields) over three seasons, to identify species with suitable adaptation and seed yield for specific environments (Figure 1).

The grain legumes examined appeared to fall into three categories:

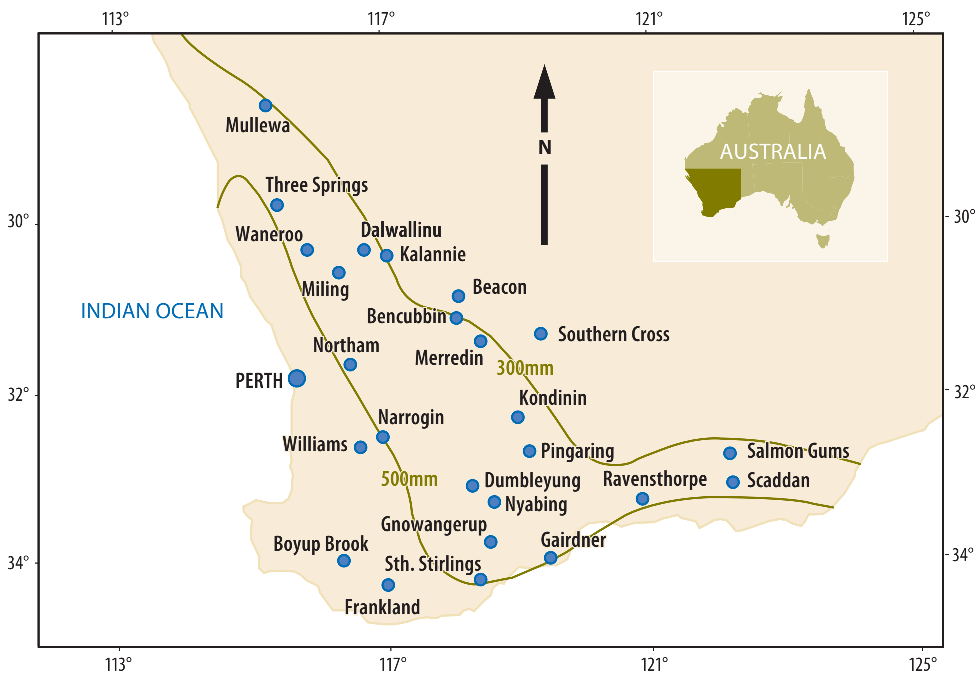
(i) field pea, faba bean, common vetch and narbon bean clearly had superior seed yields to the other species over a wide range of sites and years across south-western Australia (mean 1.0–2.3 t/ha);

(ii) albus lupin, desi chickpea and *Lathyrus* spp. produced seed yields of 1.0–1.3 t/ha; and

(iii) red lentil, bitter vetch and kabuli chickpea generally produced the lowest yields (0.6–1.0 t/ha).

There were clear species x environment interactions.

Figure 1. Location of the experimental sites in south-western Australia (from Siddique *et al.* 1999)



At low-yielding sites (<1.4 t/ha), field pea produced the highest yields, while faba bean often produced the highest yields under more favourable conditions at high-yielding sites (Figure 2). Soil pH, clay content and rainfall were important environmental factors in determining the adaptation and seed yields. Seed yields were positively correlated with dry matter production at maturity across many sites. The above studies were conducted using germplasm accessions and varieties available at that time. Future improvement in adaptation and seed yields of these grain legumes species is likely to come from breeding and agronomic practices.

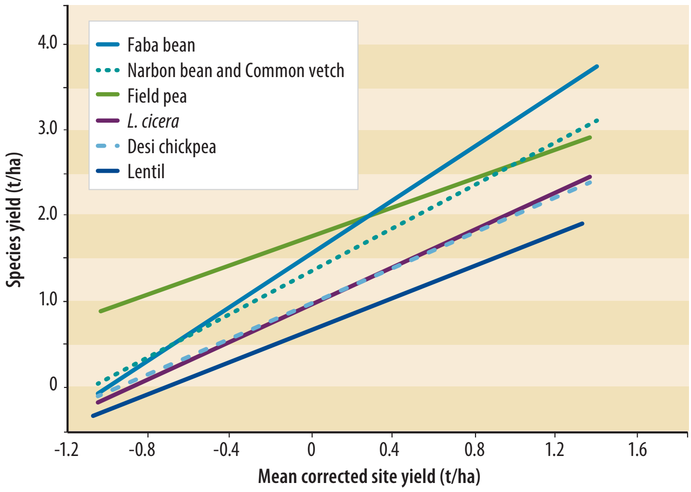


Figure 2. Plot of linear regressions between mean species yield (selected species only) and mean corrected site yield (from Siddique *et al.* 1999)

Based on the above research, three species — field pea (*Pisum sativum*), chickpea (*Cicer arietinum*) and faba bean (*Vicia faba*) — were adopted, and in 1999 their combined sown area had increased to 134,000 ha in WA; sadly only 41,000 ha was grown in 2015, which was mainly field pea (32,000 ha). There have been many reasons for the decline including limited knowledge of production packages, adverse weather conditions and, above all, damage due to fungal diseases which became an increasing threat as the crop area expanded — little was known on how to manage these diseases at that time. Each of these three crops peaked at various times: chickpea in 1999 at 72,000 ha, field pea in 2004 at 99,000 ha and faba bean in 1997 at 38,000 ha; this demonstrated a conservative potential sowing area of more than 200,000 ha. A more realistic potential is around half a million hectares.

References

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conclusions

The United Nations declared 2016 as the International Year of Pulses (grain legumes) under the banner 'nutritious seeds for a sustainable future'. The international year of pulses (grain legumes) in 2016 provides an excellent opportunity to reflect on the status of global grain legume production, consumption and potential opportunities for future expansion. In Australia, during the past decade, significant advances have been made in developing genetic resistance to the key diseases in chickpea, faba bean and lentil varieties, and in developing production technologies to minimise disease damage in field peas (Siddique *et al.* 2013). Robust agronomic packages are now available.

With a strong focus on lupin production in WA and the developing food market for lupins, the current focus on other grain legumes species (chickpea, field pea, faba bean and lentil) in WA is almost unresourced. There is an urgent need to re-kindle grower interest in these crops through demonstration, extension and training to restore these grain legume crops to their full potential and help crop sustainability, especially on the fine-textured neutral to alkaline soils of WA.

A coordinated research, development and extension strategy in partnership with selected grower groups on the above grain legumes in WA will have the following outcomes:

1. More sustainable cropping systems with greater inclusion of grain legumes in WA.
2. Increased export of WA-grown quality and high-value grain legumes to international markets.