BREEDERS PURSUE MORE DURABLE LUCERNE

A lucerne breeding stalwart is leading the bid to create winter-active lucernes that are just as tough and persistent as the more traditional, dormant varieties

BY REBECCA THYER

At an age when many of his colleagues are looking to retirement, one of the University of Queensland’s leading agricultural scientists, Professor John Irwin, is tackling a tough new plant breeding challenge – to create a high-yielding lucerne that is active all year and doesn’t lapse into dormancy.

It is a difficult task because winter-active lucernes – those needed in southern Queensland – are not as tough as the dormant varieties that ‘sleep’ during winter.

Professor Irwin, one of Australia’s lucerne-breeding pioneers, has a long history with this perennial legume, often the only one suited to southern Queensland’s alkaline clay and alluvial soils. In particular, his work on disease resistance during his 37-year career has seen yields increase by 300 per cent.

However, new breeding goals to focus on increasing yield and persistence, while keeping the legume’s important disease-resistant qualities, could increase lucerne production by another 20 to 30 per cent, based on results from new breeding material at Queensland’s Gatton Research Station.

Professor Irwin says a new breeding focus was needed because lucerne yields have plateaued. “We still need to keep up disease resistance, but our breeding work also has to look at inherently higher-yielding material.”

For this material, Professor Irwin has turned to two different sources – Oman in the Middle East for its lucerne, and to the Mediterranean for the traits of a shrubby perennial called Medicago arborea.

M. arborea is used as forage in Mediterranean countries and has a reputation for longevity, drought tolerance and high winter activity.

“We wanted to introduce new genes from M. arborea to the lucerne gene pool,” Professor Irwin says. “The way we did this was to cross them – they do not hybridise naturally.” Working with Dr E. T. Bingham from the University of Wisconsin, rare hybrids were made between lucerne and M. arborea.

Material from Oman could also prove important in solving lucerne’s dormancy dilemma because it is highly winter-active and high-yielding.

Oman, a country on the south-east coast of the Arabian Peninsula, is close to the ‘Fertile Crescent’ – the area often referred to as modern agriculture’s birthplace. Its lucerne has large seeds at twice the size of Australian lucernes’ seeds. (Theoretically, larger seeds lead to better establishment, especially in difficult soils.)

Lucerne’s activity or dormancy is rated on a scale of one to 10. Those with a low rating are more dormant, are usually grown in north America and sleep during winter. “It has to because of the freezing winters,” Professor Irwin says. At the other end of the scale are those with a high rating, which are active all year.

Queensland research has shown that growing anything less than a nine-rated lucerne produces yield penalties because it is inactive for periods during winter.

It is this need for winter-active material that creates a breeding challenge: “Unfortunately, a lot of winter-active material is not as persistent as the more dormant varieties,” says Professor Irwin. “It is not as long-living or tough – to withstand grazing animals for example – so the challenge is to breed a non-dormant lucerne which is.”

Other breeding goals to develop large seed, drought tolerance and water-use efficiency could also be helped with the Omani material and M. arborea hybrids.

Both are winter active (rated 10), have big seeds (220 seeds per gram compared with the usual 400 per gram), are high yielding and have a greater water-use efficiency than most of the varieties grown in Australia, Professor Irwin says.

Along with a change in breeding goals, so too is the means of getting there. Usually lucerne cultivars are developed as a population of out-breeding plants – leading to synthetic cultivars. If too few plants are in the founding population, inbreeding depression can arise causing plants to lose vigour and yield.

However, the more parents that are used to generate a population, the more likely they are to dilute the good effects that a small number of plants may have. “At the moment there is a tendency to work with large populations of plants, so a lot of bad genes are in there as well as the good ones. The whole aim is to maximise the frequency of favourable genes.”

Professor Irwin says that many common
Australian lucerne varieties have up to 100 parents to minimise inbreeding yield depression. “But there is also a lot of theoretical data to indicate that you can get down to six or eight unrelated parents without being troubled by inbreeding depression. So we are now trying to concentrate on individuals and not populations.”

He says one way of achieving this is to use diallel crosses, where up to 50 individual lucerne clones are crossed to test for general and specific combining ability, called GCA and SCA respectively. Individuals with high GCA perform well in all crosses, whereas those with high SCA perform well in some crosses, but not others. For lucerne, where commercialisation is through synthetics, it is essential to use parents with high GCA.

Being able to identify this inherently high-yielding material via molecular (DNA) markers would be highly useful, Professor Irwin says. DNA markers help speed up the breeding process because they mark the presence of a useful or desirable gene, allowing this material to be included in any progeny. It is where work by Professor Irwin’s PhD student David Armour, a GRDC Grains Research Scholar, is important. Mr Armour’s PhD objective is to develop markers that identify disease resistance in lucerne plants and, ultimately, the genes that encode resistance to the lucerne pathogens Phytophthora medicaginis (which causes root rot) and Colletotrichum trifolii (which causes crown rot).

“Having these markers would help with our objective to increase yield because any new cultivars still need to have adequate disease and pest resistance levels,” he says.

Mr Armour says specific DNA segments contribute to plant performance including yield and persistence — and it is these that he ultimately wants to identify. “We want to keep and/or increase the frequency of these segments in the progeny of these plants while maintaining adequate disease and pest resistance levels.”

During the next three years and by using a number of approaches, including genomics and genetic mapping, Mr Armour aims to develop molecular markers that are linked to the gene or genes encoding disease resistance, or ideally find the actual DNA sequence of the gene that confers resistance.