responded to different nitrogen rates and timings.

Both varieties are of similar maturity and yield, but differ in growth habit (Baudin is semi-dwarf and Vlamingh tall) and grain plumpness.

Blakely said small plot trials were planted over three seasons (2005–07) at medium to high rainfall locations in WA. Nitrogen, as urea, was topdressed by hand, at different rates and timings.

According to Blakely, the main determinants of grain protein levels in the 19 barley trials were site and application rate. Rate was more important than application timing in achieving grain protein between 10 and 11 per cent.

"It's important to match yield potential with level of nitrogen required to reach that yield," he said.

Tools available

"And there are a number of decision support tools available to help growers determine nitrogen requirements for a given rotation, soil type and expected grain yield."

"These include *Select Your Nitrogen*, developed by DAFWA and *Yield Prophet*, developed with GRDC support."

Blakely said a useful approach was to split nitrogen applications by initially applying a starter rate and delaying the second application to stem elongation or beyond.

This provided time to better assess the yield potential before the second application. In this study, late applications did not increase grain protein or screenings levels, compared with the same rate applied earlier.

Blakely said splitting nitrogen did not change screenings risk in malting barley.

Splitting only decreased screenings risk if it resulted in less nitrogen being applied in seasons where grain yield outlook was declining.

Variety response to nitrogen application was related to grain shape.

Screenings in narrow grained varieties, such as Baudin and Gairdner, are more sensitive to nitrogen application than screenings in plumper grain varieties such as Hamelin and Vlamingh.

"As there is a lower screenings risk, it should be easier for growers to meet the malt barley specification of 10 to 11 per cent protein in varieties such as Vlamingh, than in varieties such as Baudin," Blakely said.

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Waxing ways of wheat

A novel technique with potential to identify wheat cultivars that will perform well in drought and compacted soil conditions offers hope to Australian graingrowers.

The thin wax layer technique, pioneered in the US, has been further developed at The University of Western Australia (UWA) to determine the effects of soil physical constraints on wheat.

GRDC supported Research Fellow, Dr Xinhua He, of the UWA School of Plant Biology, is assessing the hardpan penetration ability of wheat roots, using a thin wax layer to simulate soil hardpans.

Dr He said that wheat plants growing above a hardpan layer were less able to access water and nutrients, leading to poor shoot growth and reduced grain yield.

In WA alone, of 18 million hectares of cropping land, one quarter is susceptible to soil compaction and more than 40 per cent is moderately susceptible, which indicates the magnitude of the problem Australia-wide.

Former GRDC Professor of Agronomy at UWA and now of Charles Sturt University, NSW, Professor Len Wade, in collaboration with Dr Tina Botwright-Acuna of The University of Tasmania, are supervising the research.

Len indicated Dr He's research demonstrated that the wax layer technique was a good measure of a wheat line's ability to handle soil physical constraint, as shown by the promising relationship between penetration of the wax layer and root depth in the field.

"Using the wax layer technique will identify lines better adapted to hostile soils and help identify promising lines for future breeding programs," Len said.

Dr He assessed 24 wheat cultivars and breeding lines under drought stressed and well watered conditions in controlled environments.

Field experiments also related differences in root penetration ability, through the wax layer technique, to wheat rooting depth and above ground dry matter production in contrasting sandy duplex and red clay soils, at the Department of Agriculture and Food WA (DAFWA) Merredin Dryland Research Station.

Dr He indicated the sandy duplex soil had a hardpan at 20 cm and the red clay, with no hardpan, increased in soil strength with depth, especially on soil drying, thereby resisting root penetration.

Dr Xinhua He with drought stressed and well-watered wheat cultivars in the greenhouse at UWA. His GRDC supported research identifies wheat cultivars with good root penetration in compacted soil.

Differences in root penetration in thin wax layers observed in the laboratory were compared to rooting depth in the field to determine if the wax layer method could reliably predict hardpan penetration ability.

Wheat dry matter was weighed and the long, fibrous, seminal roots on each plant which penetrated to depth were counted as a measure of root penetration ability.

Superior root penetration

Dr He said EGA Bonnie Rock, Camm, Carnamah, Halberd, Janz, Machete, Stiletto and Wilgoyne had superior root penetration ability in well watered and drought stressed conditions.

Cranbrook, C18 and Karlgarin didn't penetrate the wax layer and died shortly after under drought conditions. Their inability to access additional soil water from deeper layers demonstrated the importance of root penetration ability in drought conditions.

Dr He said more work was needed to understand what mechanisms drove hardpan penetration.

"Also, we need to determine consistency of trait expression over soil types and identify genetic control of hardpan penetration ability to select better varieties.

"Hardpan penetration ability should directly impact yield under drought," Dr He said. ■