Nitrogen and moisture regimes for genotype differentiation in breeding for consistently low grain protein concentration in barley.

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Abstract

Grain protein content (GPC) is arguably the most important factor when marketing malting barleys. Maltsters prefer grain protein concentrations close to 10.5 per cent, and barley delivered by growers outside a protein range of 9.0 – 12.0 per cent is likely to be discounted or rejected from malting classification. However, breeding cultivars with consistent and low grain protein is difficult, due to low trait heritability and marked genotype-environment interaction. In field trials, differentiating between lines that have the low-protein factors from those that do not is often difficult, particularly in environments favouring low protein. Since grain protein concentration in barley is known to increase with increases in N application, it could be used to create artificially high protein environments for selecting inherently low protein genotypes. Our aim in this study was therefore, to determine the N rate that would be optimal for differentiating among genotypes in breeding and genetic studies. We found that, in breeding and genetic studies on barley grain protein concentration, different rates of N application would be required for irrigated or dryland trials in order to differentiate among genotypes. The optimal rates were 60 Kg ha-1 under dryland conditions, and 30 Kg ha-1 under irrigated conditions.

Keyword

Malting barley; nitrogen rate; genotype differentiation.

Introduction

Barley used for malt in Australia should have a grain protein concentration (GPC) close to 10.5 per cent, with a range of 9.0 – 12.0 per cent. Grains delivered by growers outside this range are likely to be discounted or rejected from malting classification. Under field conditions, however, it is often difficult for growers to maximise grain yield whilst producing grain meeting industry specifications for both grain plumpness and grain protein.

The central role of soil fertility in determining yield and premium malting quality has made nitrogen (N) supply the focus of numerous research studies into malting barley production. Previous experiments have shown significant yield increases with N application, but applying rates to achieve maximum yields may cause grain protein to exceed the maximum acceptable value for malting barley (1, 2, 3, 4, 5). As an additional management tool, Weston *et al*. (2) advocates the use of inherently low grain protein cultivars. Such cultivars may increase the likelihood that a grower will be able to maximise yield while maintaining grain protein within the acceptable range.

The capacity for inherently low GPC has long been recognised in barley varieties such as the six-rowed variety, 'Karl' (6, 7) and the two-rowed variety, 'Arapiles' (3, 8, 9). However, breeding such cultivars is not an easy task, due to low trait heritability (10, 11, 12) and marked genotype-environment interaction. Differentiating between lines that have the low-protein factors from and those that do not is often difficult, particularly in environments favouring low protein (Horsley, unpubl.).

Since grain protein concentration in barley is known to increase with increases in N application, it could be used to create artificially high protein environments for selecting inherently low protein genotypes. Our aim in this paper was to determine the N rate that would be optimal for differentiating among genotypes in breeding and genetic studies.

Materials and Methods

Genotypes used in this study were 'Arapiles', 'VB9524', 'Gairdner', 'WI2875*17', 'WI2808', 'Schooner', 'Logan' and 'ND11231*12'. Field trials were carried out between 1998 and 1999 at Horsham (Lat. 36.4? S, 142.1? E) in the Wimmera region of Victoria. The trials in both years were carried out under dryland and irrigated conditions. In all cases, treatments comprised four levels of N application (0, 30, 60 and 120 Kg N ha^{-1}) and eight barley genotypes. Each experiment was arranged in a randomised complete block design with a split-plot arrangement and three replications. Nitrogen treatments were assigned to the main plots, and applied immediately before sowing, while genotypes were assigned to sub plots. Plots measured 4 m in length, with six rows of plants spaced 15 cm apart.

Results

In all studies, grain protein concentrations were significantly ($P < 0.001$) influenced by moisture regimes, N rate and genotypes (data not shown). However, interaction of genotypes with N rate was rarely significant even when experiments were analysed separately. These results indicate that, in general, malting barley genotypes respond similarly to applied nitrogen. However, at the same rate of response, genotypes with inherently low protein concentration maintained the protein advantage over those with higher grain protein at the different rates of N application (Fig. 1).

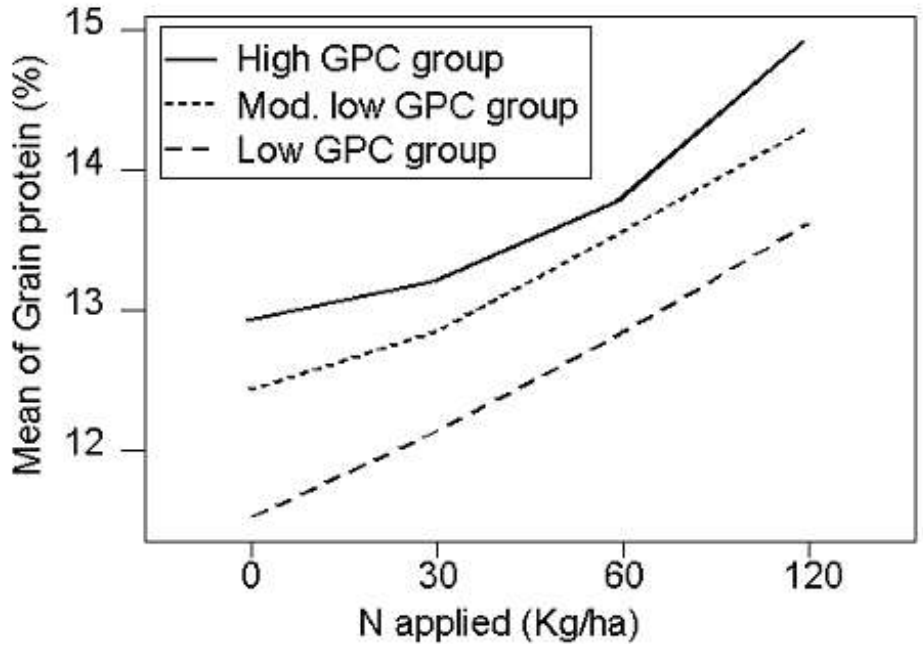

Fig. 1. Response of genotypes with inherent difference in grain protein content to rates of N application under dryland and irrigated conditions. The side bar indicates the standard error of difference.

This supports results from earlier studies by Eagles *et al*. (3) which showed that the likelihood of producing premium malting barley while using N fertiliser to increase grain yield is greater with the low protein cultivar, 'Arapiles' than with 'Schooner'.

The N rates for differentiating among genotypes differed with moisture regime (Fig. 2). Under dryland conditions, there was an increase in precision of 45% by doubling N rates from 30 Kg ha-1 to 60 Kg ha^{-1}. In contrast, doubling the rate of N application reduced precision by 39%. Therefore, for differentiating among genotypes in genetic studies, N at the rates of 60Kg and 30 ha^{-1} N would be optimal under dryland conditions and irrigated conditions, respectively.

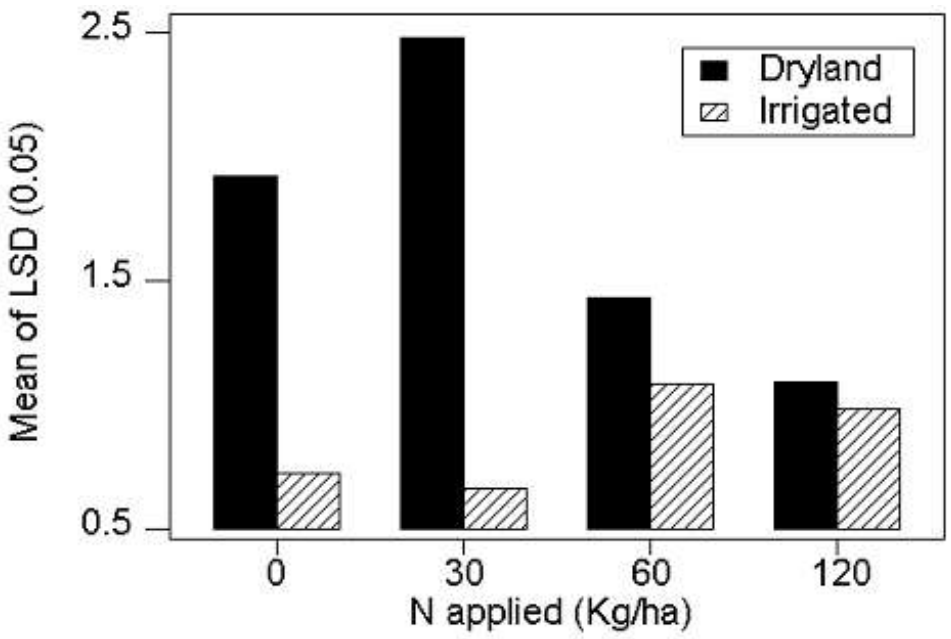

Fig. 2. Observed LSD for grain protein concentration at different levels of N application.

Conclusion

In conclusion, we found that, in breeding and genetic studies on barley grain protein concentration, different rates of N application would be required for irrigated or dryland trials in order to differentiate among genotypes. The optimal rates were 60 Kg ha^{-1} under dryland conditions, and 30 Kg ha^{-1} under irrigated conditions.

Acknowledgments

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