NITROGEN MANAGEMENT FOR ENHANCED VALUE OF IRRIGATED BARLEY

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ABSTRACT

Waxy barley (*Hordeum vulgare* L.) with high amylopectin has value as a food crop, but information on optimal nitrogen (N) fertilization of furrow-irrigated waxy barley is limited. Furrow-irrigated field studies were conducted at Parma, ID with 'Merlin' and 'Salute' spring genotypes planted fall or spring during the 2006, 2007, and 2008 seasons as the main plots and N treatments were subplots. "Early" N as dry urea was applied preplant or late winter (0, 60, 120 and 180 lb/A) and "Late" N was applied at heading (0 or 40 lb N/A) to selected Early N treatments. Late N was applied as top-dressed dry urea (DU), foliar fluid urea (FU), or foliar urea-ammonium nitrate (FUAN). Enhanced quality traits measured included total protein, B-glucan soluble fiber (B-glucan), and starch content as well as starch viscosity. Increasing Early season N, as well as Late N, increased protein, B-glucan concentrations in two of three years, and starch viscosity, but reduced starch concentration. Foliar Late N tended to be more effective for increasing protein in two years, but less effective in the third year. Late foliar N sources did not differ in their effects on other barley traits. Protein was positively correlated with B-glucan and both were inversely related to starch concentrations. Hull-less Merlin was higher in starch and protein concentrations, and lower in B-glucan concentrations. With added N the yields of protein, B-glucan, and starch were as high or higher for Merlin than for Salute. Both fertilizer N management and waxy variety selection can be critical depending on the barley food quality trait of interest. Increasing N will improve quality of some traits but reduce others.

INTRODUCTION

Waxy barley value can be enhanced as a whole grain food, or as fractionated protein, starch, or soluble fiber, but how enhanced value traits are affected by nitrogen (N) management have not been extensively studied for irrigated systems. Nitrogen management for higher protein in irrigated hard wheat is a challenge and has been studied (Brown et al., 2005). While much of the information for protein enhancement in wheat may be applicable to barley, data is lacking. Starch content might be inferred from protein data but viscosity has seldom been measured as a function of N management in irrigated waxy barley. Likewise, Beta-glucan soluble fiber (B-glucan), the primary justification for the USDA-FDA approved Heart Healthy food claim has not been examined in relation to N rate, timing and source. The objective of this study was to evaluate early and late season N management influence on enhanced value traits of protein, soluble fiber, starch, and starch viscosity of irrigated waxy spring barley.

METHODS

Furrow-irrigated field studies were conducted at Parma, ID with 'Merlin' and 'Salute' spring waxy genotypes fall or spring planted for the 2006, 2007, and 2008 seasons. Varieties were the main plots and N treatments were subplots in a randomized complete block - split plot

design with three or four replications. "Early" N as dry urea was applied pre-plant or late-winter (0, 60, 120 and 180 lb A^{-1}) and "Late" N was applied at heading (0 or 40 lb A^{-1}) to 60 and 120 lb A^{-1} early N treatments. Late N was applied as top-dressed dry urea (DU), foliar fluid urea (FU), or foliar urea- ammonium nitrate (FUAN). Plots were 10' by 25'.

Agronomic parameters of yield, lodging and plant height were previously reported (Norberg et al., 2010). Enhanced quality traits measured included total protein, B-glucan, and starch content as well as the starch viscosity profile. Data were analyzed using Analysis of Variance and orthogonal contrasts for determination of late season N treatment effects.

RESULTS AND DISCUSSION

Barley protein concentration increased linearly with increasing Early N rate (Fig 1). Late N increased grain protein concentration in all years when averaged across varieties (Fig 2). Foliar Late N tended to be more effective than dry urea for increasing protein in the first two years, but less effective in the third year. Late N at 40 lb A^{-1} was typically as effective for increasing protein, or more so, than an additional 60 lb A^{-1} rate of Early N. Merlin had higher protein than Salute (12.1 vs 11.5%).

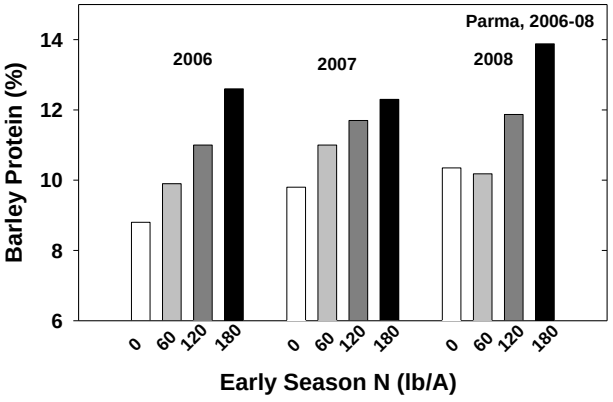

Fig. 1. Barley protein response to Early urea N rate in each year. Values are averaged across varieties.

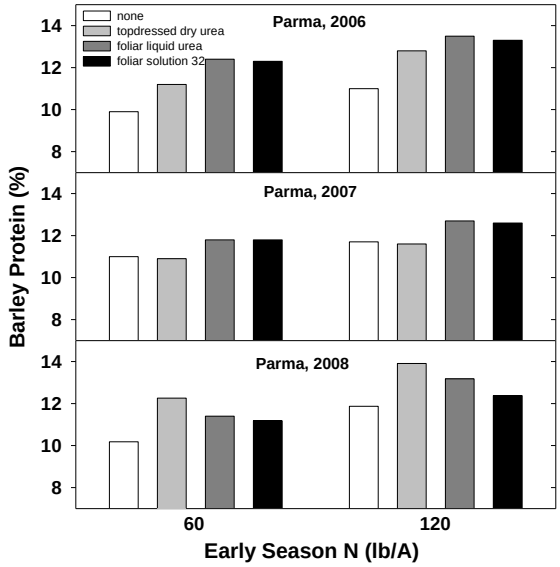

Fig. 2. Barley protein response to 40 lb Late season N/A as affected by fertilizer form at two Early N rates.

Increasing Early N rate also linearly increased B-glucan concentrations in two of three years (2006 and 2007) when averaged across varieties (Fig. 3). Late N over the three years increased B-glucan when averaged across the three N forms but effects from dry urea were not as consistent as foliar N (Fig. 4). Foliar late N at 40 lb A^{-1} was consistently as effective as a 60 lb A^{-1} rate of additional Early N. Merlin was lower in B-glucan than Salute.

For some barley food uses it may be desirable to have both high protein and high soluble fiber. Protein concentration was positively correlated with B-glucan in two of the three years (Fig. 5). The trend in the third year (2008) was similar but not significant. The data suggest that similar N management may be appropriate for both protein and B-glucan enhancement in this irrigated system. In particular, Late N may be critical.

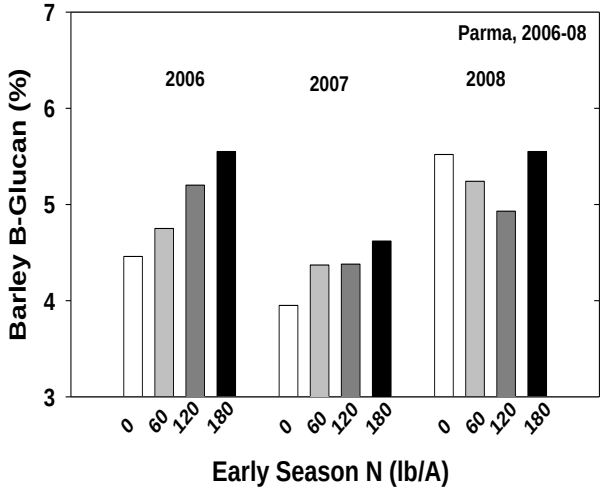

Fig. 3. Barley B-glucan response to Early N in each year. Data is averaged across varieties.

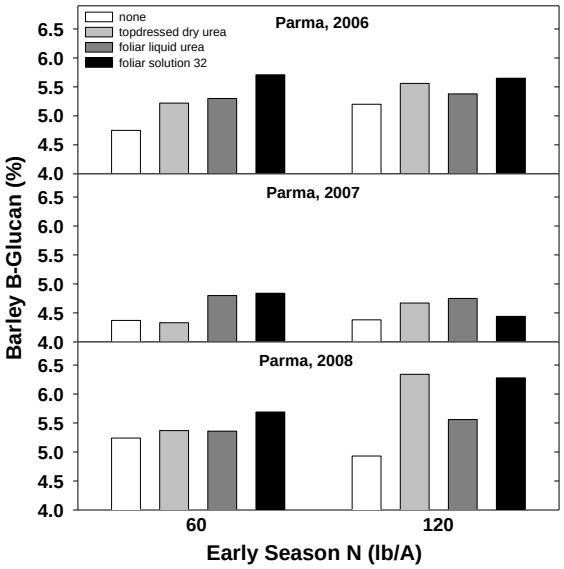

Fig. 4. Barley B-glucan response to 40 lb Late N/A at two Early N rates as affected by N form.

Higher Early N rates reduced starch concentrations (Fig. 6) due likely to both higher protein and lodging (poorer grain fill) in some years. Late N had similar effects (Fig. 7). Early or Late N did not affect starch concentrations as much in Merlin as in Salute. Also, N effects were greater in 2006 than in 2007. Hull-less Merlin had higher starch concentrations than Salute (56.8 vs 50.4%).

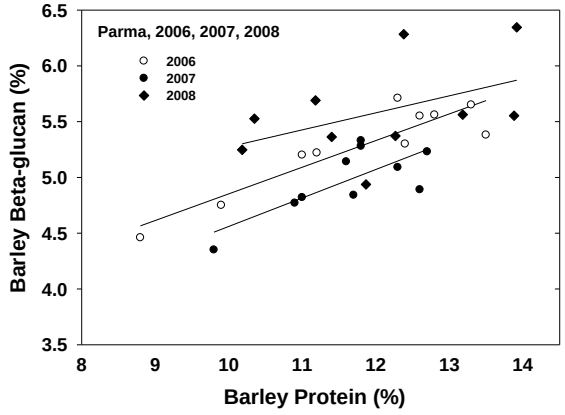

Fig. 5. Barley B-glucan relation to grain protein in each year.

For quality related to higher starch concentrations there is no advantage for N management practices that maximize protein or B-glucan. The results show for highest starch concentrations that N management should focus on optimizing N for yield rather than protein or B-glucan.

Starch final viscosity increased linearly with added Early N and there were both year x N and variety x N interactions (Fig 8). Late N also increased final viscosity, possibly more so than Early N (Fig. 9). Late dry urea N in 2007 tended to have less effect than foliar N sources (FU and FUAN). Starch final viscosity of Merlin was lower than for Salute when averaged across years and it was less affected by either Early or Late N.

CONCLUSIONS

Both fertilizer N management and waxy variety selection can be critical depending on the barley food quality trait of interest. Increasing N, particularly Late N, will improve protein and

enhancement. Late N appears to be as critical for waxy barley protein as it is for hard wheat protein enhancement.

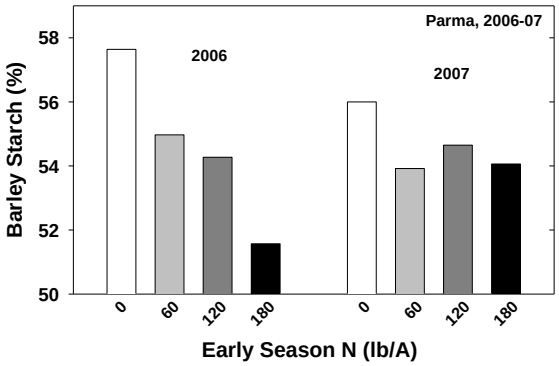

Fig. 6. Barley starch concentration response to Early N rate in 2006 and 2007. Values are averaged across varieties.

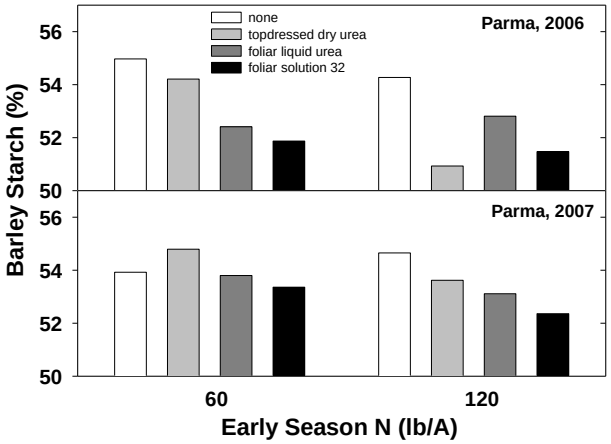

Fig. 7. Barley starch concentration response to 40 lb late season N/A at two early N rates as affected by N forms.

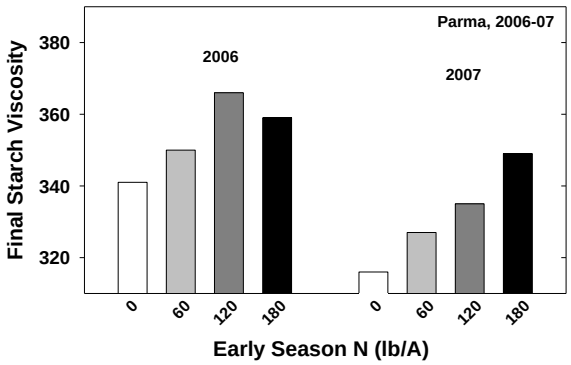

Fig. 8. Barley final starch viscosity response to early season N rate in 2006 and 2007. Values are averaged across varieties.

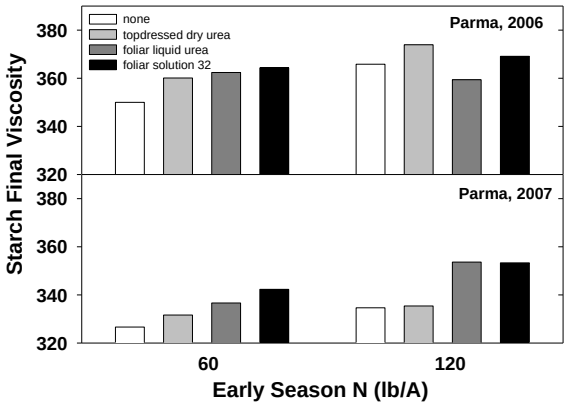

Fig. 9. Barley final starch viscosity response to 40 lb late season N/A at two early N rates as affected by N forms.

REFERENCES

Brown, B., M. Westcott, N. Christensen, B. Pan, and J. Stark. 2005. Nitrogen Management for Hard Wheat Protein Enhancement. PNW Extension Bulletin 578.

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