Science Societies

Malt barley yield and quality response to nitrogen and irrigation termination timing

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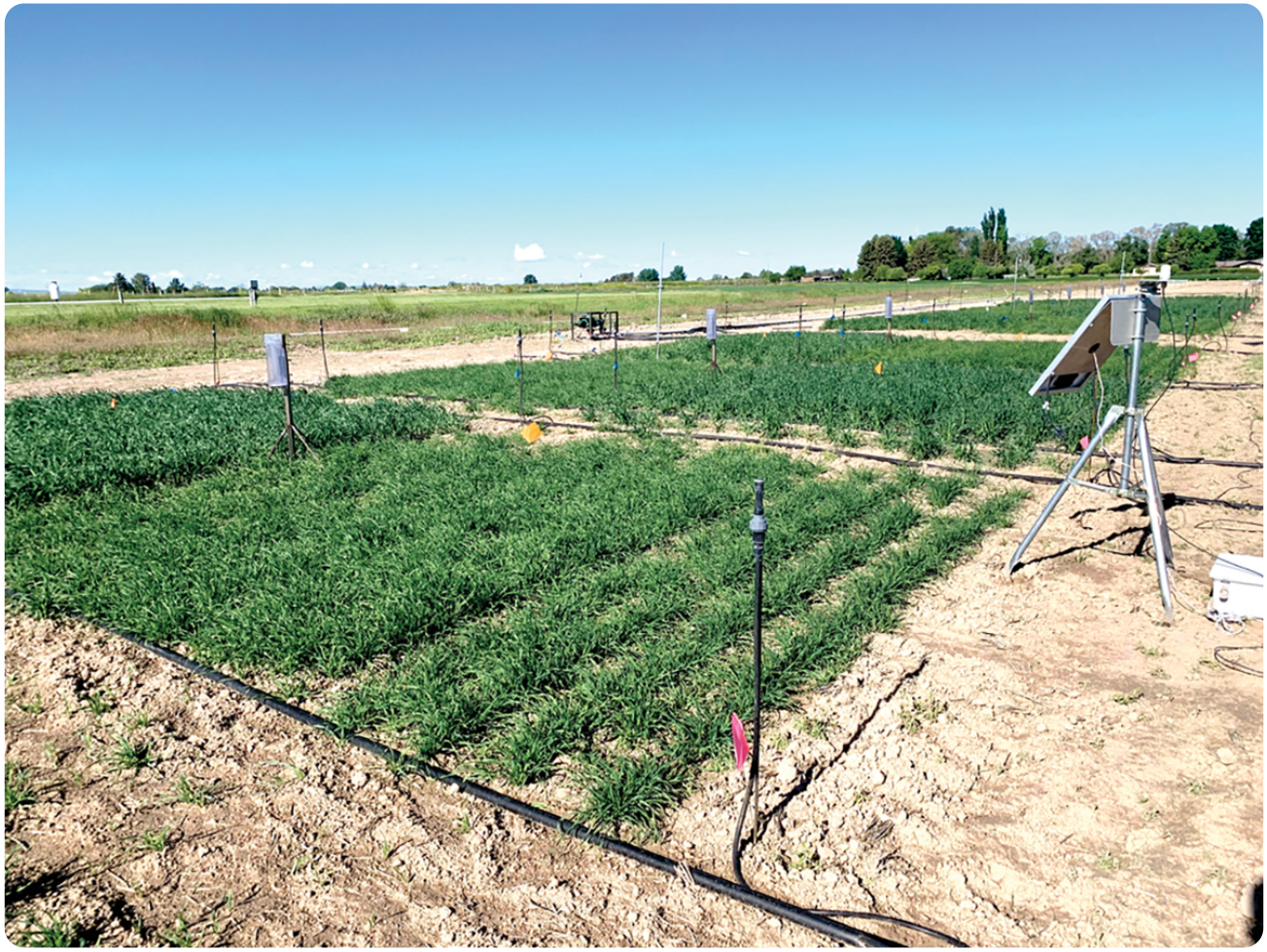

Small-plot barley irrigation research rate trial at the USDA-ARS Northwest Irrigation and Soil Research Laboratory Kimberly, ID. Photo by Dr. Christopher W. Rogers.

Droughts in the western United States have led to an increased and pressing need to consider how to manage crops with less water for the future sustainability of production in the region. Fertilizer nitrogen (N) recommendations in the western United States have often been determined where irrigation was a non-limiting factor. However, when irrigation is a limiting factor, it is critical to consider the interrelationship with irrigation amounts and N applications rates as crop yield and quality can be heavily influenced in both positive and negative ways. An irrigation termination and N fertilizer rate study was conducted to investigate malt barley yield and quality response in Kimberly, ID.

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Droughts in the western United States have led to an increased and pressing need to consider how to manage crops with less water for the future sustainability of production in the region. The low-rainfall irrigated environment of southern Idaho is a primary characteristic of crop production in much of the major production areas in the

western United States. In Idaho, reduced snowpack in the Tetons have, in some years, led to early irrigation shutoffs for those supplied by canal systems. Additionally, groundwater pumpers in the region have seen increased monitoring due to concerns over groundwater recharges in the Eastern Snake River Plain Aquifer.

The southwestern United States has seen even larger issues arise during the past 20 years that are likely the worst conditions seen in the region in nearly 12 centuries. The historically low water levels in Lake Mead located along the Colorado River in Nevada and Arizona convey common concerns across the western United States (NASA, **2022**). In July of 2022, the reservoir was at 27%, a level only previously seen during the initial filling of the reservoir in the 1930s. Across the western United States, 74% of nine western states face drought to some degree or another, and 35% of the states are classified as being under extreme drought.

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An irrigation termination and N fertilizer rate study was conducted to investigate malt barley yield and quality response in Kimberly, ID located within the Snake River Plain. Irrigations were managed to match calculated evapotranspiration rates until irrigation termination timing using the Penman–Monteith equation obtained from the United States Bureau of Reclamation Agrimet Cooperative Agriculture Weather Network (Allen & Wright **2002**; Allen et al., **1998**; USBR, **2016**).

Yield Response

Irrigations were terminated at Feekes 10.0 (late boot), Feekes 11.2 (soft dough), and seven days (one irrigation) after Feekes 11.2 (+7F11.2). Termination of irrigation at Feekes 10.0 is considered water stressed, and termination of irrigation at F11.2 and +77F11.2 is considered well watered. Water-stressed conditions in the F10.0 treatment resulted in a more than 30% reduction in grain yields, and N fertilizer provided little benefit to a net negative effect under water-stressed conditions (Figure 1; Rogers et al., 2022). Maximum yield in the study occurred well below the maximum rates of fertilizer N applications for both F11.2 and +7F11.2, which did not differ.

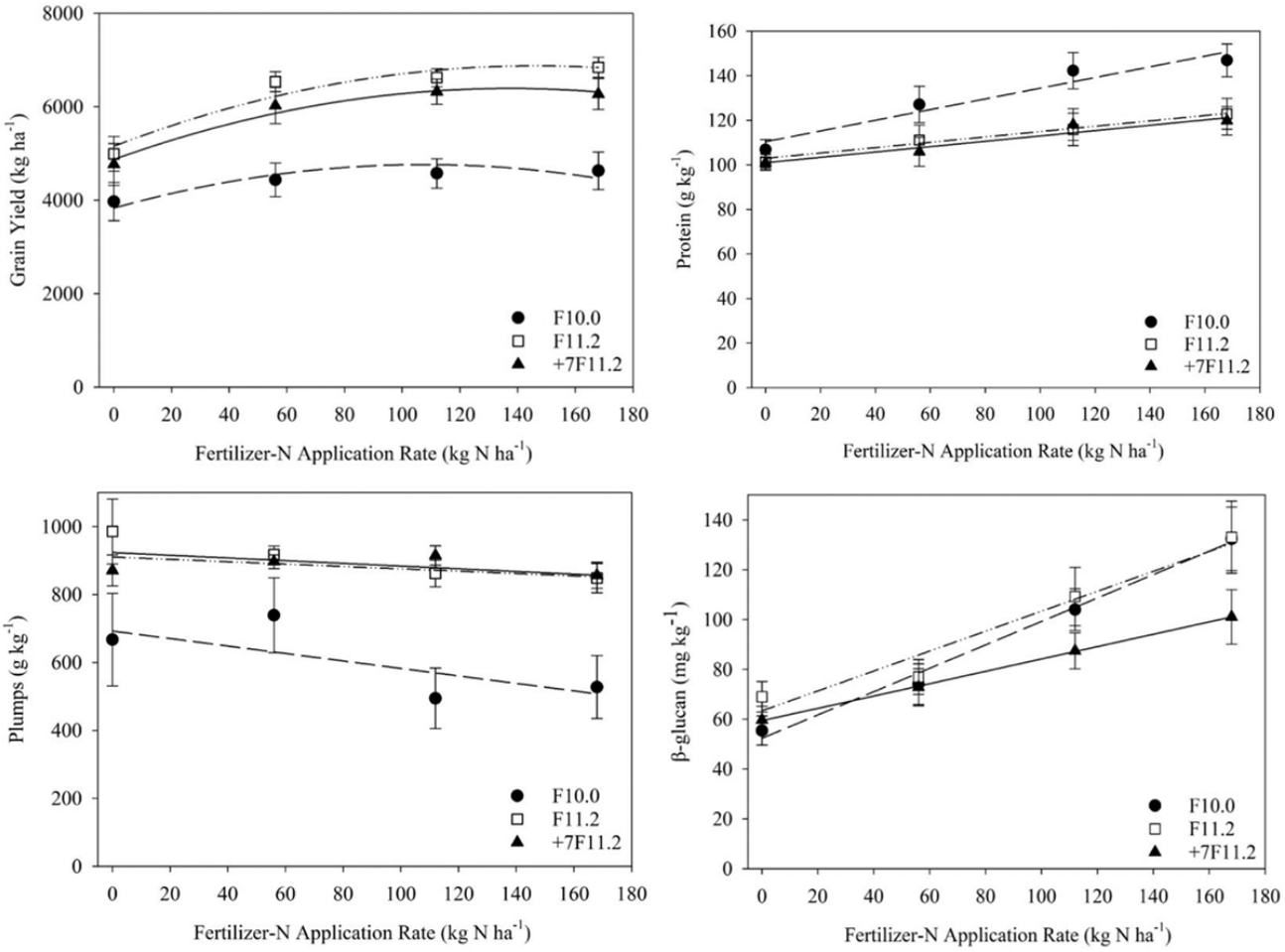

Figure 1, *Malt barley grain yield, protein, plump kernels, and malted grain ?-glucan as affected by final irrigation timing and fertilizer N application rate, where 93 kg N ha?1 of additional soil inorganic N was measured in pre-season soil testing. For yield, kg ha?1 × 0.019 = bu ac?1; for N rate, kg ha?1 × 0.892 = lb ac?1; and for protein and plumps, g kg?1 × 0.100 = %.*

Quality Response

Malt barley is a unique crop as it has specific acceptable varieties with very strict grain quality parameters that determine whether it will be accepted for higher-value malt barley or if it will be reduced to lower-value feed grain. The American Malting Barley Association publishes targets for acceptable ranges for both barley grain and malt quality that provide valuable general levels across the industry (AMBA, **2020**). Key barley grain and malt quality parameters were above optimal levels from the early irrigation termination treatment. Grain protein above target levels of 13% has negative impacts during the malting process. This target protein level was exceeded when fertilizer was applied at any rate under water-stressed conditions. Well-watered fields maintained their protein levels below the 13% target regardless of N application rate. Nitrogen generally has a net negative effect on plump kernels even under well-watered conditions. Despite plumps being greatly under targets at all N levels for water-stressed conditions, the magnitude of reduction is increased as indicated by the more rapid decline in the slope for water-stressed barley.

Beta (□)-glucans are soluble fiber compounds that are used as a quality indicator for malted barley. This was the only measured quality factor where the well-watered F11.2 treatment behaved similar to the water-stressed F10.0 termination across N rates. Malted barley grain □-glucan targets should be below the threshold of 100 ppm. Increased N application at the highest rates applied in the research study resulted in elevation of □-glucan above the published target rate for both the F10.0 and the F11.2 irrigation terminations. Additional irrigation from the +7F11.2 treatment resulted in decreased □-glucans at all N rates compared with the other termination times.

Conclusions

Western U.S. droughts have and will likely continue to have major negative impacts on crop production; therefore, it is important that we continue looking for ways to improve the management of our most critical production resources with a goal of meeting or exceeding production goals with less. Our study defined concerns of excess N, particularly under water-stressed conditions, that can result in elevation of grain protein, reduction in plump kernels, and elevation of malted grain □-glucans. Also, it was determined that irrigation past F11.2 did not generally improve production, while at the same time, it negatively increased water use and the potential for N loss from the system. Future research defining threshold levels of water stress and N fertilizer rates that can meet quality as well as yield goals are needed to achieve high agronomic yields, optimize quality, maintain sustainability, and ensure environmental stewardship through proper understanding of genetics × environment factors of production.

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