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Nitrogen Utilization by Malting Barley Under Varying Moisture Regimes

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The management of N fertilizers in the root zone is an important consideration for developing best agricultural management practices which minimize impacts on water quality. Under irrigated conditions, the highly mobile nitrate (NO_3^-) ion may move out of the root zone prior to significant plant uptake. Nitrogen which moves out of the root zone is not available for plant uptake and could potentially move into shallow groundwater systems. Furthermore, applied fertilizer N and mineralized N which is not utilized during the current growing season may be available for transport out of the root zone during subsequent fallow or noncropped periods. The primary objective of this study was to evaluate the potential contribution of applied N to water quality problems under varying moisture regimes.

We conducted a field study at a site 25 miles west of Bozeman, MT on a Brocko silt loam soil. This soil has a deep well-drained profile with a soil surface pH of 8.3 and an organic matter content of 16% Nitrogen as uniformly applied at a rate of 150 lbs N/acre using 11-52-0 and 34-0-0 to meet an expected yield goal of 100 bu/acre for malting barley under irrigated conditions based on preplant soil tests. Four irrigation treatments were established to provide 17 (high), 14 (medium), 9 (low) and 5 (dryland) inches of water from seeding to harvest. 'Klages' malting barley was seeded on 24 May 1991 and irrigation treatments commenced on 10 June 1991, continuing on roughly 7 day intervals until the start of inflorescence. Soil and plant samples were taken seven times throughout the growing season to determine soil NO_3^-N, soil NH_4-N and plant N uptake as a function of time.

Barley dry matter production increased with increasing water application throughout the growing season. The grain yields at harvest were 84, 69, 41, and 4 bu/acre for the high, medium, low and dryland water application treatments. Grain protein contents were adequate for malting barley quality in all but the dryland treatment. The uptake (dry matter x %N in plant) of N (lbs/acre) over the growing season was similar for barley grown under the high, medium and low water application treatments (Figure 1). However, by 35 days after emergence (flag leaf stage), N uptake under dryland conditions dropped considerably and was significantly lower than the other irrigation treatments for the remainder of the growing season. The period of maximum plant N uptake occurred between mid-tiller (27 days, after emergence) and initial boot stage (48 days after emergence). During this period, plant N uptake rates were 5.8, 5.1, 5.4, and 2.0 lbs N/acre/day on the high, medium, low and dryland water application treatments, respectively (Figure 1).

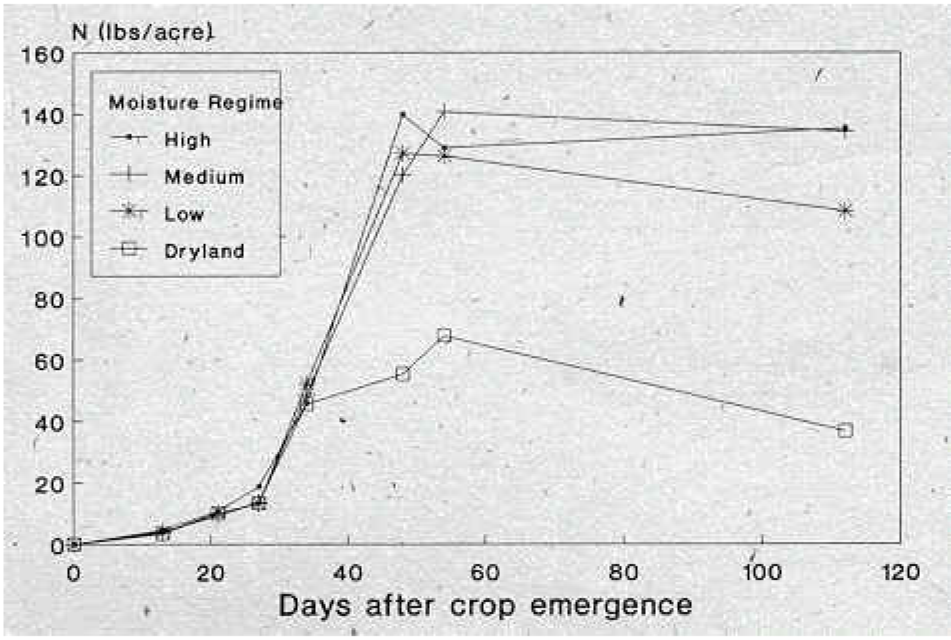

Figure 1. Changes in plant N uptake during the growing season.

Soil samples were analyzed for profile NO_3-N and NH 4-N throughout the growing season on plant sampling dates. The majority of inorganic soil N was NO_3 -N at all sampling dates. The total NO_3-N in the four foot soil profile declined significantly in the high, medium and low water regimes from 27 to 48 days after barley emergence (first node to initial -boot stage) (Figure 2). The rate of NO_3-N loss from the soil profile was approximately 6 lbs N/acre/day which is consistent with the rate of plant uptake of N during this same period. These results indicate that the majority of NO_3 -N losses from the soil profile were due to plant uptake, even under the high water regime. Soil profile NO_3-N remained high under dryland conditions consistent with the lower plant N uptake rates.

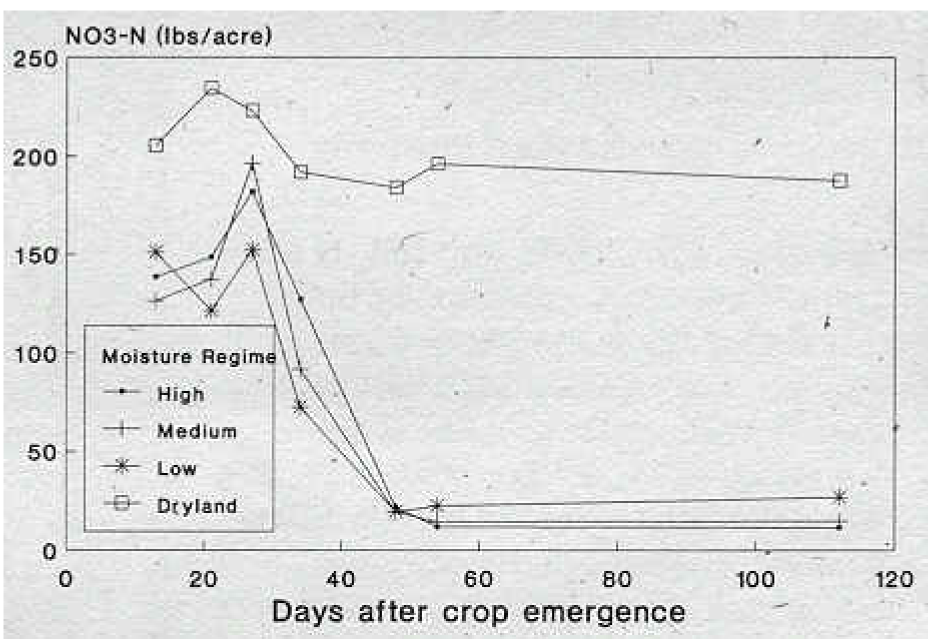

Figure 2. Changes in NO_3-N content in the soil profile during the growing season.

Soil samples were also analyzed for NO_3-N. and NH 4-N at four depths (0-6, 6-12, 12724, 24-48 inches) throughout the growing season to determine the extent of NO_3-N leaching under the different water regimes. The amount and rate of NO_3-N leaching was directly related to the amount of water applied and the amount of N utilized by the plant. For example, significant amounts of NO_3-N moved into the 12-24 inch depth by 27 days after crop emergence in the high water regime (Figure 3A). However, very little NO_3-N moved deeper in the profile due to plant uptake, and by 48 days after crop emergence less than 20 lbs NO_3-N per acre remained in the soil profile. Conversely, very little NO_3-N moved below the 12 inch depth in the low water regime. Under dryland conditions, a significant amount of the, 1991 applied N remained in the 0 - 6 inch depth (Figure 3B). In addition, although the leaching rate is lower under dryland conditions, higher levels of NO_3-N are distributed in the 12 - 24 and 24 - 48 inch depths as a result of minimal plant uptake and residual NO_3-N from previous year additions (Figure 3B).

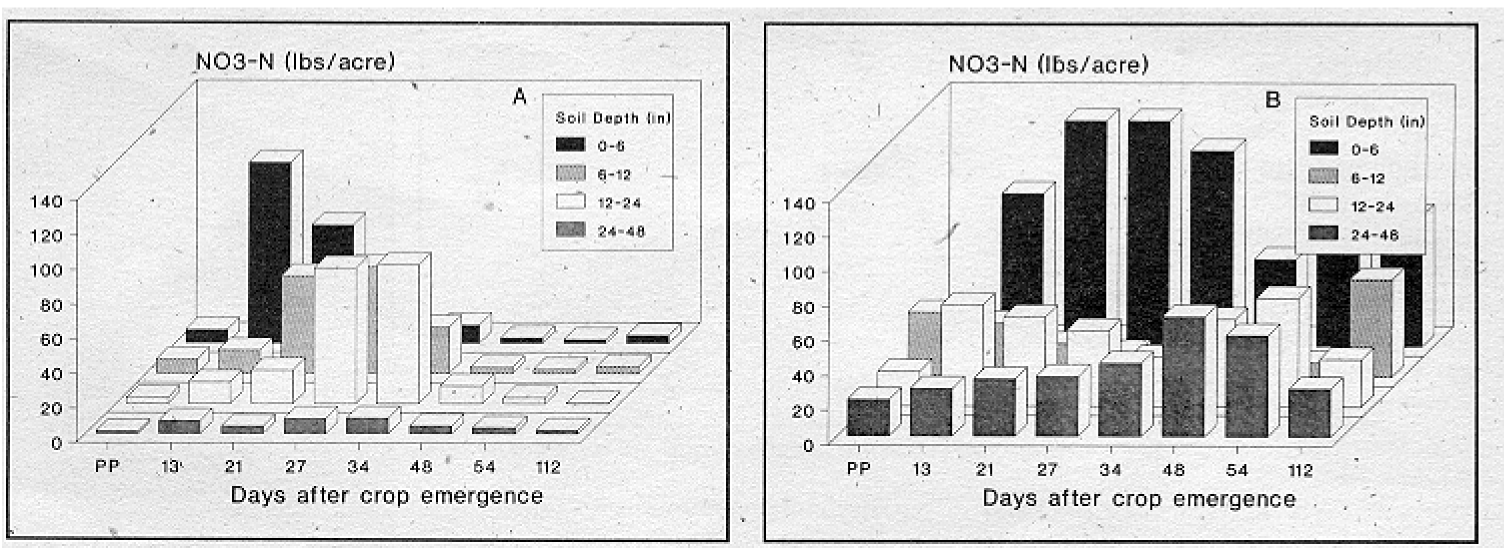

Figure 3. Distribution of soil NO_3-N as a function of time and soil depth for the high (A) and dryland (B) moisture regimes. PP stands for preplant and represents residual NO_3-N levels prior to seeding.

Although this study was conducted at a single site, several conclusions can be made regarding best management practices which minimize the potential for leaching of NO_3-N below the root zone. Under irrigated conditions, application of water to meet evapotranspiration demands and application of fertilizer N to meet the expected yield goal did not contribute to significant NO_3-N movement out of the root zone. Under dryland conditions, application of N above the expected yield goal resulted in high levels of profile NO_3-N which may move out of the root zone during fall and spring moisture recharge. Furthermore, fallow or noncropped periods which follow a season of poor soil profile N utilization may cause undesirable leaching of NO_3-N out of the root zone. A proper combination of applied water and fertilizer N to meet a realistic yield goal is critical to minimizing leaching of fertilizers out of the root zone and eventually into groundwater systems.

(In cooperation with the Department of Health and Environmental Sciences - Water Quality Bureau non-point source program)