In-Season Prediction of Yield Potential in Winter Wheat

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Nitrogen fertilization rates in cereal production systems are usually determined by subtracting soil test N from a specified yield goal-based N requirement. In general, the yield goal represents the best achievable yield in the last 4 to 5 years. This method of determining N fertilization rates has gone largely unchanged over the last 25 years.

Researchers are studying techniques for predicting wheat grain yield potential as a method for refining topdress nitrogen (N) rates.

Our work has focused on predicting wheat grain yield potential using in-season spectral measurements collected from 10 sq. ft. areas between Feekes growth stages 4 and 5 (early jointing). At two locations where wheat was planted at different times, a modified normalized difference vegetative index (NDVI) was determined from multi-spectral reflectance measurements under daytime lighting.

$$\text{NDVI} = \frac{[(\text{NIR down/NIR up}) - (\text{Red down/Red up})]}{[\text{NIR down/NIR up}) + (\text{Red down/Red up})]}$$

In-season estimated yield (INSEY) was computed using the sum of NDVI at Feekes 4 and 5, divided by the growing degree days over that same time period.

$$\text{INSEY} = \frac{(\text{NDVI Feekes 4} + \text{NDVI Feekes 5})}{\text{Growing Degree Days}}$$

Grain yield was determined from the same plots where spectral reflectance readings were recorded during the growing season, and regression analysis was used to evaluate various relationships.

INSEY versus Grain Yield

The relationship between wheat grain yield and INSEY computed from spectral reflectance readings collected at Feekes growth stages 4 and 5 is illustrated in **Figure 1**. Because NDVI was known to be correlated with plant biomass, the sum of NDVI at any two early physiological stages was expected to be an indicator of forage yield and growth rate and is likely to be correlated with potential yield. The use of growing degree days in the computation of INSEY allowed us to consider both growing conditions and time (between the readings) and, thus, the influence of growth rate.

The 1998 growing season was unique since adequate moisture was present at planting and continued throughout the growing season. Only limited moisture stress was present, and both sites received timely rainfall near flowering. For this reason, yield and yield potential were expected to be similar, and thus INSEY was highly correlated with grain yield. In general, we would not expect the INSEY index to be highly

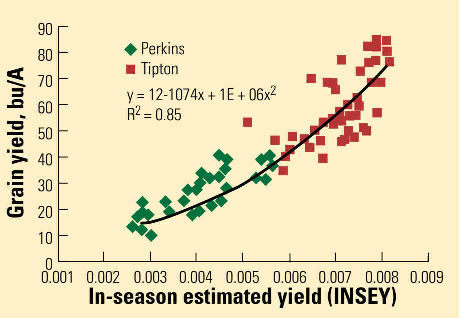

Figure 1. Relationship between INSEY computed from NDVI at Feekes growth stages 4 and 5, divided by growing degree days and observed grain yield, Perkins and Tipton, Oklahoma, 1998.

correlated with grain yield in all growing seasons since so many factors can negatively impact the wheat crop from Feekes 4 to maturity. However, our interest was in developing a yield goal parameter that was "seasonal-sensitive", intrinsic, and that would more accurately reflect yield potential likely to be realized in that season. If growth was poor from planting to Feekes 5, it is unlikely that a high yield potential would be realized. Similarly, if growth was excellent from planting to Feekes 4, but declined from Feekes 4 to Feekes 5 (drought, frost damage, etc.), yield potential would be expected to be lower.

In-season estimates of yield potential need to be viewed as refined estimates of yield goal. We are presently evaluating topdress N fertilization rates based on the in-season estimate of yield potential. Nitrogen fertilizer rates are estimated using the following equation:

$$\text{N rate} = \frac{[(\text{Predicted grain yield x \% N in the grain}) - (\text{predicted forage N uptake at Feekes 5})]}{0.70}$$

Predicted grain yield was estimated from INSEY, percent N in the grain was obtained from average values associated with winter wheat at different yield levels (higher percent N at low yield and lower percent N at high yield), and predicted forage N uptake at Feekes 5 was based on the published relationship with NDVI. This method is aimed at increasing yield (recognizing the need for increased N rates in areas with increased yield potential) and N use efficiency (decreased N applied where forage N uptake was already high). Our work assumes that the production system allows for in-season application of fertilizer N and that failing to apply preplant N has no adverse effect on grain yield. However, we recognize that using yield goals combined with soil nitrate-N (NO_3-N) testing remains as one of the more useful tools in establishing fertilizer N rates when preplant fertilizer N application is the only option.

If accurate estimates of yield potential are to be realized, these estimates will be needed at resolutions (10 sq. ft.) where differences in soil test parameters are found. If a coarser resolution (>100 ft.) is used, the variation in yield potential will be masked by averaging, and benefits that may be realized in treating the variability can be lost. In summary, the use of INSEY offers an alternative method of refining topdress N rates by basing N fertilizer need on in-season prediction of yield potential.

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Research Notes

California: Nickel – A Micronutrient Essential for Higher Plants

Research has established nickel (Ni) as an essential element for cereal crops. Using barley, the researchers satisfied the criteria of essentiality that (1) the plant cannot complete its life cycle without Ni and (2) no other element can substitute for it. They report: "Under Ni-deficient conditions, barley plants fail to produce viable grain because of a disruption of the maternal plant's normal grain-filling and maturation processes that occur following formation of the grain embryo. Since Ni was previously shown to be essential for legumes in unrelated research, it is concluded that Ni is essential for growth and reproduction of all higher plants.

Various researchers have shown that Ni deficiency affects plant growth, plant senescence, nitrogen (N) metabolism, and iron (Fe) uptake and may play a role in disease resistance. Nickel is the first micronutrient to be discovered as essential since chloride (Cl) was added to the list in 1954.

Source: Brown, Patrick H., Ross M. Welch, and Earle E. Cary. 1987. Plant Physiol. 85:801-803.